OFFICE FILE COPY
DO NOT REMOVE

The Wall Lake Water Quality Study Area

Report

Prepared by

South Dakota Department of Water and Natural Resources
Water Quality Management Section

March 1985

The preparation of this report was financed through a section 208 Area-Wide Waste Treatment Management Planning Grant from the U.S. Environmental Protection Agency

The Wall Lake Water Quality Study Area

Report

Prepared by

South Dakota Department of Water and Natural Resources
Water Quality Management Section

March 1985

The preparation of this report was financed through a section 208 Area-Wide Waste Treatment Management Planning Grant from the U.S. Environmental Protection Agency

CONTENTS

Wall Lake WQSA Summary..... 1

I. Wall Lake Water Quality Study Area Description..... 4

A. General Description..... 4

B. Beneficial Uses and Impairments..... 6

C. Land Use.....10

D. Climate, Geology, Major Soils, and Hydrology.....11

1. Climate.....11

2. Geology.....12

3. Major Soils.....13

4. Hydrology of Wall Lake.....14

II. Wall Lake Water Quality Study Area Selection and Study Coordination.....16

III. Soil Loss and Sediment Yield Summary.....18

IV. Wall Lake: Water Quality Summary..... 20

Summary of the Water Quality in Wall Lake..... 34

Conclusions and Recommendations..... 35

V. Watershed Problems and Recommendations..... 39

A. Nutrient and Sediment Loading from Cropland/Grassland/Feedlot Runoff..... 39

B. Individual Septic Tank/Drainfield Systems..... 41

VI. In-lake problems and recommendations..... 43

A. Eutrophication..... 43

B. Lake Sediment..... 45

C. Shoreline erosion..... 48

VII. Implementation..... 49

VIII. Summary and Conclusions..... 49

IX. Literature Cited..... 51

X. Appendices.....

Wall Lake WQSA Summary

The Wall Lake Water Quality Study Area (WQSA) encompasses about 3,072 acres in southwestern Minnehaha County and is situated at the southern end of the Prairie Coteau, a glacial lake region. Wall Lake was formed by glacial action during the late Wisconsin glacial period some 13,000 years ago. The lake has a surface area of 225 acres, an average depth of 9 feet and a maximum depth of 12 feet. Wall Lake is classified under the South Dakota Water Quality Standards for the beneficial uses of warmwater semipermanent fish life propagation, immersion recreation, limited contact recreation, and wildlife propagation and stock watering. Aquatic weeds are not common in Wall Lake; but annual blooms of blue-green algae during summer and fall constitute evidence of eutrophication. The South Dakota Department of Game, Fish and Parks manages Wall Lake for walleye and yellow perch. Complete winter fish kills have been reported at about 10-year intervals and partial fish kills have occurred on numerous occasions.

About 49% of the Wall Lake watershed is cropland, 37% grassland, 10% water and wetland areas, and 4% is in farmsteads and homesites. The Soil Conservation Service (SCS) estimated that only 35% of the drainage area was adequately treated with erosion control practices in 1980.

Lake shore development includes approximately 70 homes, 40 of which are year-round residences. The remaining undeveloped land around the lake, about 30% of the shoreline, is zoned "rural residential" and therefore has potential for development. Wall Lake has extensive public use as a recreational area and there is local interest in the lakes as evidenced by the existence of the Wall Lake Association, the formation of a sanitary district in 1974, and local support for the Wall Lake WQSA program.

To determine water quality characteristics and identify water quality problems within the Wall Lake watershed, samples were taken at six (6) sites. Three sites were on major intermittent tributaries entering the lake, two were in-lake sites, and one was situated at the lake outlet. Samples were collected after rainfall events and during snow melt runoff.

In-lake sampling indicated Wall Lake to be hypereutrophic as evidenced by extremely high concentrations of total phosphorus and elevated total nitrogen levels.

The principal problem at Wall Lake appears to be extensive nutrient loading from the watershed. Data collected from tributary Sites 2 and 3 indicate that the lake has been receiving extremely high loads of total phosphorus and nitrogen. Nutrient loads retained in Wall Lake (net loads) during 1979 amounted to 4.63 g/m^2/year for phosphorus and 21.25 g/m^2/year for nitrogen. These values are far in excess of permissible loading levels which for shallow bodies of water such as Wall Lake are estimated to be less than 0.13 g/m^2/year P and 2.0 g/m^2/year N (Wetzel, 1975).

Watershed erosion, primarily from cropland, provided 1,049 tons and shoreline erosion contributed 156 tons of sediment to Wall Lake. Total sediment yield amounted to about 0.9 acre-feet per year or about .06% of lake water capacity.

Excessive fecal coliform levels were observed in-lake on only one occasion at Site 2A in 1981 (2,200/100 ml). Generally, fecal coliforms are not a problem in the lake. Excessive fecal coliform levels were observed 8 times at tributary Sites 3 and 4 and 13 times at tributary Site 2. Observations ranged from 23,000/100 ml to 3/100 ml.

Non-point sources of pollution from the watershed as indicated by high nutrient loading are primarily from inadequate crop cover and lack of fertilizer management practices on agricultural land. SCS estimated that 65% of the watershed is in need of treatment to minimize erosion. Secondary sources of nutrients to the lake may be

falling individual septic tanks. In the past, feedlots may also have contributed nutrients and fecal coliforms to the lake.

Recommendations

Nutrient loading to Wall Lake from the watershed may be reduced by utilizing Best Management Practices on the land such as fertilizer management practices, and conservation tillage. Pasture and hayland management and feedlot waste management systems will help in the reduction of nutrients, particularly phosphorus, and possible bacterial contamination to the lake. A septic tank survey to pinpoint leachate to the lake should be conducted around Wall Lake to identify any problem areas. Technical assistance should then be provided to control identified problems. Shoreline and streambank stabilization is recommended in rapidly eroding areas.

After the above measures are implemented, a dredging program and chemical phosphorus flocculation may serve to improve water quality and the overall recreational potential of the lake.

I. Wall Lake Water Quality Study Area Description

A. General Description

Wall Lake is a natural lake in southeastern South Dakota situated at the southern end of a glacial lake region termed the Prairie Coteau (Figure 1). Specifically, Wall Lake is located in Minnehaha County ten miles west of the City of Sioux Falls in section twenty-one of Wall Lake Township (longitude 96°58', latitude 43°32'). Wall Lake derives its name from the high, wall-like shore on the lake's west and north sides.

The area was first explored in 1683 by LeSeur, a French fur trader, who followed the Big Sioux River as far south as present day Sioux Falls. Fur trading was the early economic activity for the area until Dr. Joseph Nicollet described the area in "Travels in the Northwest". As a result, two land development companies established a permanent settlement at the present site of Sioux Falls in 1857. The area was the domain of the Dakota Sioux just prior to settlement.

The Wall Lake area economy rests primarily on agriculture in spite of diversification to non-agricultural business and industry in recent years. The area economy has remained stable with unemployment between four and seven percent. "Money" magazine, October 1980, rated Sioux Falls as one of the ten best small cities in the United States, based on: rapid expansion of employment, good public schools, a college or university in the community, low State taxes, and an attractive setting.

Carbon-14 dating techniques indicate that Wall Lake was formed during a subadvance of the late Wisconsin glacial period, 13,000 years ago (U.S. Army Corps of Engineers (COE), 1980, Appendix A). As a result of

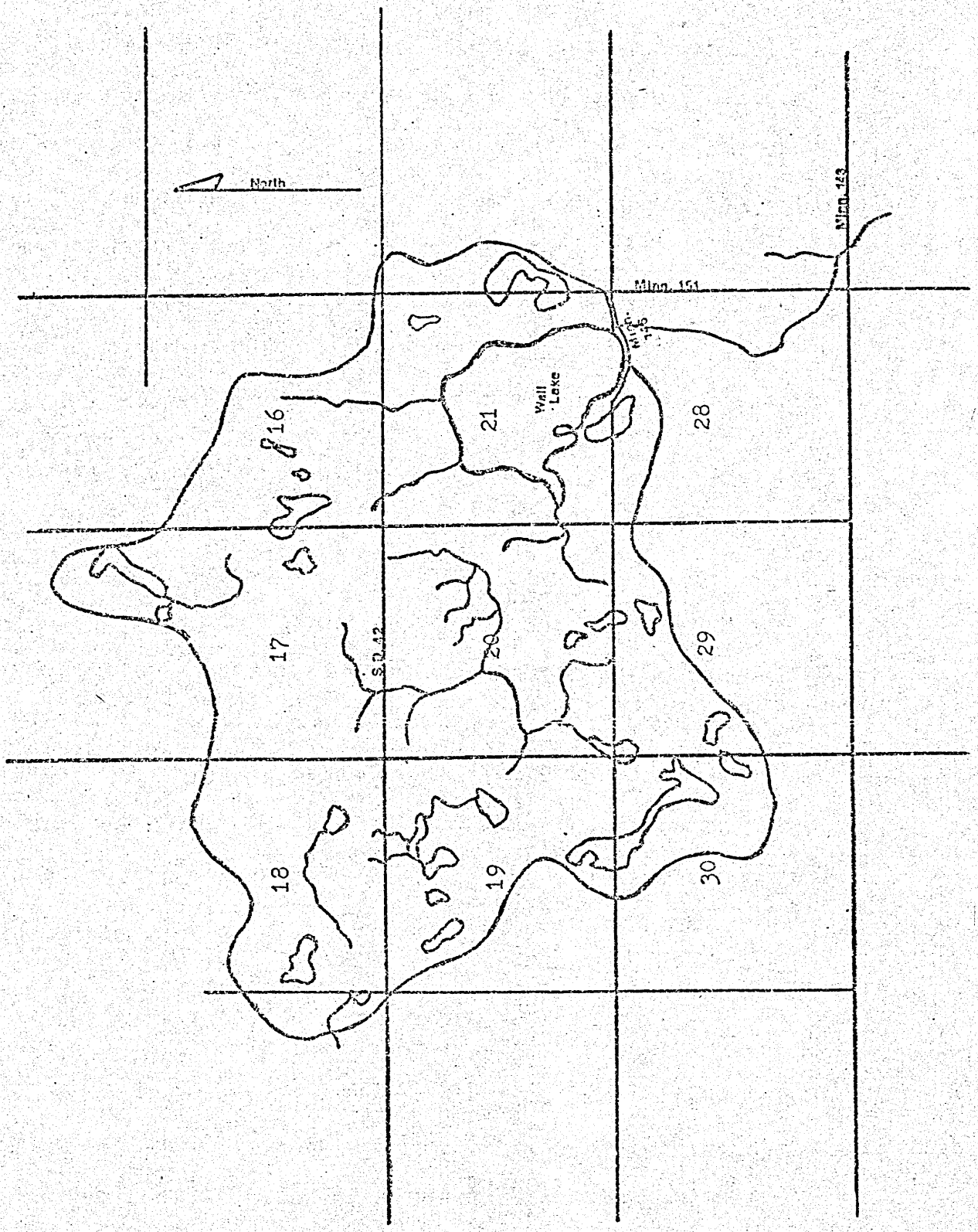
Location of Minnehaha County and Wall Lake in South Dakota

Figure 1

glaciation, the area is composed of nearly flat to gently rolling topography with numerous pot holes and wetland areas. The Wall Lake watershed encompasses approximately 1,243 hectares (3,072 acres). The streams in the watershed are recent in geologic age and therefore not well developed. However, lake water elevations respond quickly to precipitation in the watershed. The lake is fed by three intermittent streams from the north, northwest and west sides of the lake (Figure 2). On the southeast end, the lake discharges intermittently to a tributary of Skunk Creek which joins the Big Sioux River at Sioux Falls. Wall Lake has a surface area of 91 hectares (225 acres), an average depth of 2.7 meters (9 feet), and a maximum depth of 3.7 meters (12 feet) at a pool elevation of 475 meters (1,559 feet) mean sea level (Appendix A). The original glacial lake was 7.6 meters (25 feet) deep, therefore, the original lake bottom is covered with a maximum of 4.87 meters (15 feet) of sediment (Appendix B). The bottom sediment is mainly consolidated silt and muck with numerous patches of sand and gravel in the shallow inshore areas.

Although no major groundwater connections have been found, locations are known for some minor groundwater connections to the lake (South Dakota Department of Water and Natural Resources, Office of Geological Survey, 1980, Appendix B).

Higher aquatic plants are not common in Wall Lake but for at least 27 years lake-wide blooms of blue green algae, primarily Aphanizomenon flos-aquae and Microcystis aeruginosa, have been a regular occurrence during summer and fall (R.E. Koth, 1981, South Dakota Lakes Survey).



WALL LAKE WATERSHED

Figure 2

B. Beneficial Uses and Impairments

All lakes in South Dakota are classified as to their beneficial uses and, based on these uses, water quality standards criteria are assigned. The beneficial uses assigned to Wall Lake in South Dakota's "Surface Water Quality Standards" ARSD 74:04:02 are: warmwater semipermanent fish life propagation; immersion recreation; limited contact recreation; and wildlife propagation and stock watering. A summary of water quality criteria for Wall Lake, listing parameters and the maximum concentration allowed for the above listed beneficial uses is found in Table 1.

Wall Lake serves the recreational needs of four counties: Lincoln, McCook, Minnehaha, and Turner which have a combined population of 139,076 (1980 Census). Minnehaha County alone has 109,435 people (ibid). Approximately 20% of the State's population is within easy driving distance of Wall Lake. Sioux Falls, which is the major city in Minnehaha County, is a Standard Metropolitan Statistical Area (SMSA) with a population of 81,182. According to both the U.S. Bureau of Outdoor Recreation and the State Department of Game, Fish and Parks (GF&P), this area of the State is in short supply of water-based recreation (Figure 3). Restoration of Wall Lake may help alleviate this shortage.

The importance of Wall Lake as a fishery can be seen in Figure 3 which is a map compiled by GF&P listing user day fishing opportunity surpluses or deficiencies by county. Minnehaha County streams and lakes provide a fishing opportunity of 15,557 user days; however, user day demand in Minnehaha County is 556,169, which leaves a deficiency of 540,612 user days. Surrounding counties are also deficient in user day fishing opportunity. This deficiency is due to the large population that depends

TABLE 1. SURFACE WATER QUALITY STANDARDS FOR WALL LAKE

Parameter:	Warm water semipermanent fish life propagation	Immersion recreation	Limited contact recreation	Wildlife propagation and stock watering
Beneficial Use Rating Number	5	7	8	9
Alkalinity, Total/$CaCO_3$ - mg/l				750
Chlorine, Total Residual - mg/l	<0.02			
Coliform Fecal - organisms/100 ml		200	1000	
Conductivity - micromhos/cm at 25° C				4000
Cyanide, Free - mg/l	0.005			
Cyanide, Total - mg/l	0.02			
Hydrogen Sulfide - Undisassociated - mg/l	0.002			
Nitrogen, Ammonia Unionized (as N) - mg/l	0.04			
Nitrogen, Nitrates (as N) - mg/l				50
Oxygen, Dissolved - mg/l	>5.0	>5.0	>5.0	
pH - Units	6.3<pH<9.0	6.5<pH<8.3	6.0<pH<9.0	6.0<pH<9.5
Polychlorinated Biphenyls - mg/l	.000001			
Sodium Absorption Ratio (SAR)				
Solids, Suspended - mg/l	90			
Solids, Total Dissolved - mg/l				2500
Temperature - °F	90			

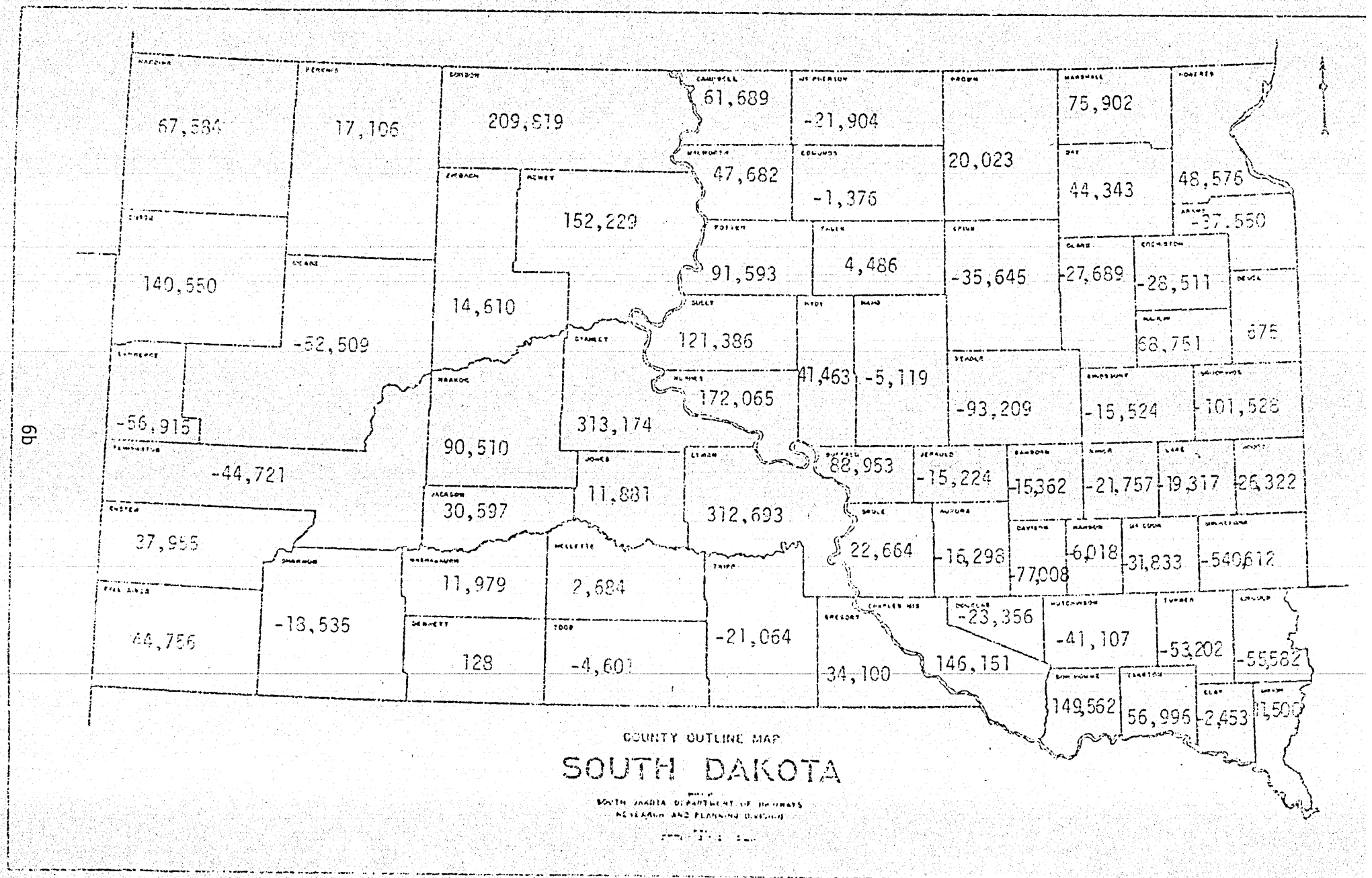


Figure 3. Statewide Fishing, User-day, Surplus or Deficiency, Opportunity Map.

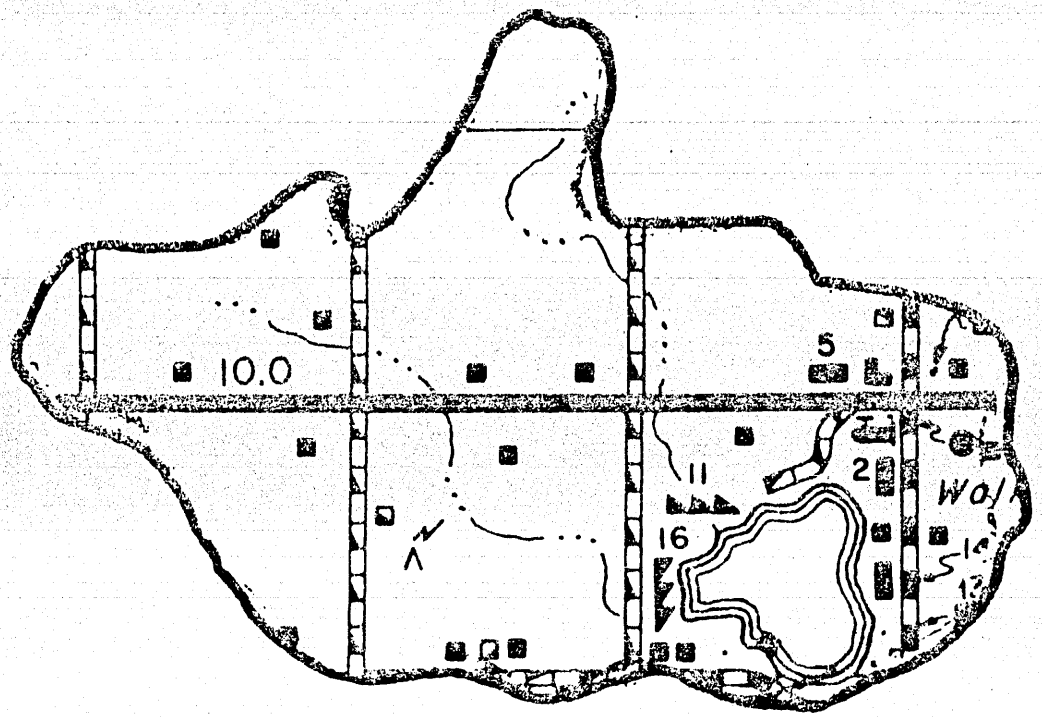
heavily for recreational use on seven area lakes within 25 miles (40 km) of Sioux Falls.

In 1978, regional GF&P personnel gathered data for evaluation of the warmwater semipermanent fish life propagation use assigned to Wall Lake. The fish population of Wall Lake is primarily composed of black bullheads, (Ictalurus melas) (86.2%), yellow perch (Perca flavescens) (10.8%), and walleye (Stizostedion vitreum) (2.9%) based on 12 trap net sets during 1978. Shoreline seining activities were also conducted during this same time period with similar results except that 1 northern pike (Esox lucius) and 28 fathead minnows (Pimephales promelas) were found. Numerous young of the year (YOY) bullheads and perch were also found during seining activities, corroborating the GF&P assessment of spawning habitat availability. Spawning conditions were assessed as excellent for bullhead and fair for yellow perch and walleye.

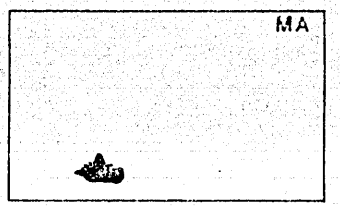
Public access to Wall Lake is along the southwest and southeast shores (Figure 4). The southeast portion of the lake contains a county owned beach open to the public. Transportation to the lake from Sioux Falls is possible via two paved routes. State Highway 42 and County Highway 148 lead to within one mile north and one mile south of the lake, respectively. From these points, County Highways 151 and 146 lead directly to the public use areas along the southern shoreline.

Wall Lake has a rich history of recreational use by the residents of the surrounding area (W. Bradwisch, GF&P Regional Supervisor, personal communication). Recreational uses include: swimming, fishing, water skiing, boating, picnicking, and snowmobiling. Powerboating on Wall Lake is extremely heavy. It is common to have one boat per four acres on the

Wall Lake Watershed



1,118 acres



Scale

0 1 2 3 4 5

Miles

lake during the weekends (Ibid). GF&P maintains approximately five acres on the southwest shore of Wall Lake for public access. The access area has a boat ramp, picnic tables, a paved parking area, dock, restroom facilities and an island with a pedestrian bridge to it. Recently some individuals have discussed private development of additional camping facilities at the lake. Wall Lake also serves the recreational needs of local Girl Scouts who have a camp on the southeastern shore. In spite of the need for recreational facilities for the Sioux Falls area, recreational activities at the lake have declined in recent years due primarily to poor water quality (Ibid).

High concentrations of blue-green algae leave the lake with an unappealing color and odor throughout the entire summer when recreational usage should be highest. Immersion recreation is the most observable beneficial use adversely affected. Drought periods exacerbate the algal bloom problem when reduced lake water elevations result in heavier concentrations of algae.

The Wall Lake Association, comprised of home and cabin owners on the lake, treated the lake with copper sulfate crystals from 1957 to 1978 to reduce the algal concentrations. The resultant accumulation of copper in Wall Lake sediment as measured at six sites in 1980, ranged from 5.7 to 37.2 mg/kg. Although these concentrations are considered high, they are not expected to be detrimental to plants or animals should the bottom sediment dredged from Wall Lake be utilized for agricultural purposes (Appendix C). However, the possible harmful effects of these residual copper levels on indigenous aquatic organisms have not been determined.

Algicide treatments in Wall Lake were discontinued in 1979 due to rising costs of the copper sulfate crystals.

Poor water quality also impairs warmwater semipermanent fish life propagation in Wall Lake. Winter kill, either partial or complete, plays an important role in the dynamics of indigenous fish populations. Complete winter kills have been recorded during 1968-69, 1978-79 and partial fish kills have occurred on numerous other occasions including most recently the winter of 1983-1984 (W. Bradwisch, GF&P Regional Supervisor, personal communication). Wall Lake is especially susceptible to winter fish kills when snow cover limits light penetration and decaying plant material causes oxygen depletion and high un-ionized ammonia levels. As a result, there are few fish, fewer fish species and a poor quality of fish in the lake according to GF&P studies and reports. GF&P reports also indicate the lake was overpopulated throughout the 1950's and 1960's with a few stunted fish species. Periodic, minor, species limited, fish kills occur frequently. Species such as bullhead which are quite resistant to winter kill and lowered oxygen concentrations are maintaining higher population levels than less resistant species such as perch and walleye. Due to the frequent occurrences of winter kill and the lack of spawning habitat, the GF&P is currently maintaining Wall Lake fish populations with periodic stockings of walleye and yellow perch. Dredging the lake would increase the depth and thereby help decrease the numbers of fish lost to winter kill. The contour map (Figure 4) shows the lake bottom to be extremely flat and as a result the maximum and average depths are nearly equal, generally offering poor fish habitat diversity. Improving the water quality would also enable a greater variety of fish species to survive in the lake.

C. Land Use

The 1,243 hectares (3,072 acres) in the Wall Lake watershed are broken down into six types of land use. (U.S. Department of Agriculture, Soil Conservation Service (SCS), 1981, Appendix D).

1. Agricultural land - this area includes pastureland, cropland, farmsteads, etc. There are 1,306.4 hectares (2,636 acres) or 85.8% of the watershed in agricultural land. Major crops grown in the watershed include corn, small grains, soybeans, and alfalfa.

2. Commercial land - this consists of businesses within the watershed. This segment is comprised of 2.4 hectares (6 acres) or 0.2% of the watershed.

3. Girl Scout Camp (county owned) - this area is found in the southeast corner of Wall Lake (Section 21). It consists of 10.9 hectares (27 acres) or 0.8% of the watershed.

4. Housing development - there are 24.3 hectares (60 acres) of developed area or 1.8% of the watershed.

5. Public area - this consists of a park and picnic area, parking space, boat docks, beach area, nature trails and fishing sites adjacent to Wall Lake. There are 6.1 hectares (15 acres) of public areas or 0.4% of the watershed.

6. Wildlife area - there are 21.4 hectares (53 acres) or 1.6% of the watershed in food plantings, water areas and other habitat areas which are maintained specifically for wildlife use.

There are approximately 70 homes and cabins on the Wall Lake shoreline, 40 of which are year-round residences. Recent home construction has occurred back from the lake. The remaining undeveloped land around the lake is zoned "rural residential" and therefore has potential for development. Undeveloped areas around Wall Lake account for 30% of the shoreline area.

Figure 5 lists watershed land uses for nine categories. These figures, gathered by the South Dakota State Planning Bureau (SPB) using remote sensing techniques, differ from the SCS figures in both category groupings and on the size of the watershed due to the exclusion of non-contributing acreage by the SCS survey. The SCS on-site investigation is considered the more reliable of the two. The SPB figures indicate that row crops and pasture are the predominant agricultural land use in the watershed accounting for 58% of the total land area. SCS estimates that 49% of the watershed is utilized as cropland and 37% as grassland and pasture.

D. Climate, Geology, Major Soils, and Hydrology

1. Climate

The climate of the Wall Lake watershed is continental with warm summers and cold winters. Maximum precipitation occurs in late spring and early summer (75% of the total annual rainfall). Minimum precipitation occurs in the winter. However, winter precipitation accumulates and results in spring runoff to Wall Lake. The area has an average annual precipitation rate of 23 inches. Mean annual lake evaporation is 36 inches.

Wall Lake Water Quality Study Area

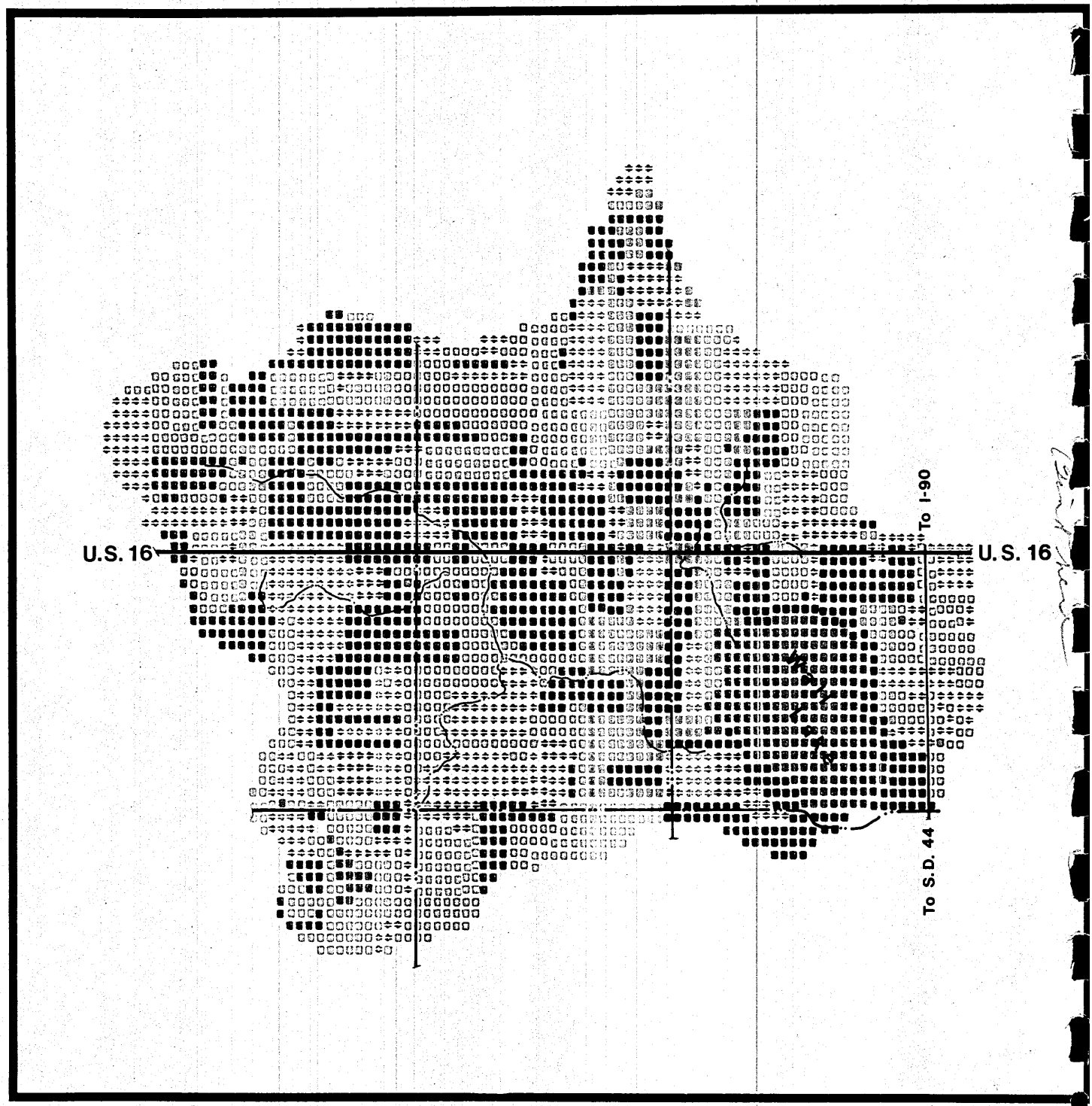


Figure 5

Land Cover - July 1979

CATEGORY	ACRES	HECTARES	PERCENT	ACCURACY
URBAN + BUILT-UP	97	39	2.5%	100%
ROW CROPS	1099	445	28.5%	100%
SMALL GRAINS	381	154	9.9%	79%
CULTIVATED GRASSES	545	221	14.1%	100%
SUMMER FALLOW	89	36	2.3%	100%
PASTURE	1147	463	29.7%	95%
FARMSTEADS	175	71	4.5%	100%
WATER	252	102	6.5%	100%
WETLANDS	78	32	2.0%	100%
TOTALS	3863	1563	100.0%	93%

****

WALL LAKE WATER QUALITY STUDY AREA

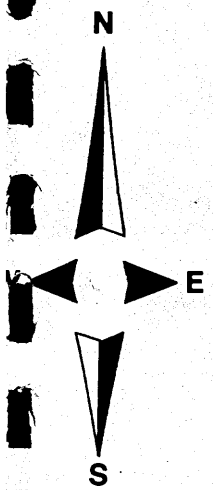
PRODUCED BY
SOUTH DAKOTA STATE PLANNING BUREAU

IN 1975, THE SOUTH DAKOTA STATE PLANNING BUREAU INITIATED A COMPREHENSIVE REMOTE SENSING MAPPING PROGRAM THOUGHOUT THE STATE. THIS WALL LAKE WATER QUALITY STUDY AREA MAP WAS PART OF THAT PROGRAM, AND WAS PRODUCED THROUGH THE INTERPRETATION OF LOW ALTITUDE COLOR INFRARED PHOTOGRAPHY OF THE STUDY AREA. THE MAP HAS UNDERGONE A VERIFICATION PROCESS USING A 5% RANDOM SAMPLE, IN ORDER TO ASSESS THE ACCURACY OF THE REPRESENTED LAND COVER CATEGORIES.

SOIL EROSION CAN BE A MAJOR PROBLEM ON CULTIVATED LANDS, PARTICULARLY ON STEEP SLOPES AND DRAINAGE NETWORKS. CROP ROTATION, TILLAGE SYSTEMS, MANAGEMENT OF RESIDUES, AND OTHER CONSERVATION PRACTICES HAVE A SIGNIFICANT EFFECT IN REDUCING THE AMOUNT OF EROSION IN AREAS USED AS CROPLAND.

THE PREPARATION OF THIS MAP WAS FINANCED THROUGH A SECTION 208 WASTE TREATMENT MANAGEMENT GRANT FROM THE U.S. ENVIRONMENTAL PROTECTION AGENCY. FOR MORE INFORMATION CONTACT:

PLANNING INFORMATION SECTION
SOUTH DAKOTA STATE PLANNING BUREAU
CAPITOL BUILDING
PIERRE, SD 57501
605-773-3661



SCALE

MILES
0 1 2

0 1 2
KILOMETERS

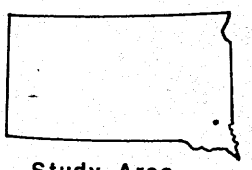

Study Area Location

Figure 5 (continued)

The average daily temperature minimum is 15°F during January. A temperature of 0°F or lower occurs on average 30 days per winter, while a summer temperature of 90°F or higher occurs an average of 25 to 30 days per year. Yearly temperatures average about 46°F with monthly averages varying from a low of 13.6°F in January to 70°F in July.

2. Geology

The Wall Lake watershed in southwestern Minnehaha County lies at the extreme southern edge of the Coteau des Prairie (Prairie Hills) section of the Central Lowland Province. Minnehaha County was invaded by the Nebraskan, the Kansan, the Illinoian, and finally the Wisconsin glaciers, which deposited drift of variable thickness on Precambrian quartzites and Cretaceous chalks and shales. Only the drift from Illinoian and Wisconsin glaciers is exposed in Minnehaha County. These Pleistocene glacial deposits cover about 90% of the county and range in thickness from a few feet to about 200 feet. The glacial materials were deposited as end or ground moraines, kames, outwash plains or terraces (soil survey of Minnehaha County, South Dakota, 1964).

The Wall Lake watershed of 3,072 acres is composed of nearly flat to gently rolling topography with numerous pot holes and wetland areas. The watershed drainage is rudimentary with many poorly drained or undrained small depressions the largest of which is Wall Lake.

3. Major Soils

The majority of watershed soils are well-drained silty clay loams formed in windblown loess overlying glacial till. Most of the soils fall in the Kranzburg or Buse series, although small pockets of Hidewood, Parnell, and LaPrairie soils are found in the low areas. Most of the series in this area are well-drained due to underlying sand and gravel deposits. The SCS has assigned the following general soils classifications for the Wall Lake watershed:

Buse Series - These soils are excessively drained, medium textured soils that formed in glacial till on rolling and steep uplands. It is calcareous in most places, and its organic-matter content is low. The underlying parent material is firm glacial till. Pebbles and stones are usually found on the surface and in the soil profile. These soils are often associated with the Kranzburg Series.

Hidewood Series - These soils are deep, moderately fine textured and poorly drained. They are found in swales, depressions, and at the heads of drainageways where they formed in sediments washed from adjacent uplands. They are usually calcareous in places and have a good organic-matter content. The amount of cultivation on these soils is dependent on the degree of wetness.

Kranzburg Series - Soils in this series are deep, well-drained, silty soils which formed in loess overlying glacial till. They occur on level to slightly sloping uplands. The surface layer is slightly acid while the subsoil ranges from neutral to slightly alkaline. This series is often found in various combinations with the Buse Series.

LaPrairie Series - These soils are deep, moderately well drained, and medium textured. They are formed in recently deposited alluvium in swales and slight depressions. The pH ranges from slightly acid at the surface to slightly alkaline in the lower subsoil. The underlying material is sandy and is quite alkaline. These soils are frequently flooded by runoff and are high in fertility.

Parnell Series - Parnell soils are deep, of a finer texture and poorly drained. They were formed in sediments from surrounding uplands. The surface layer is quite high in organic content. These soils are more poorly drained than either the Hidewood or LaPrairie and water tends to stand in these spots.

4. Hydrology of Wall Lake

The South Dakota Geological Survey conducted a hydrological study in the Wall Lake watershed during July, 1979, to identify the extent of the groundwater connection to the lake. To accomplish this, 25 test holes were drilled in the watershed (Figure 6). Three test holes, numbers 22, 8, and 7 were located in small glacial outwash deposits of sand and gravel (Figure 6). Test hole 22 located along the west inlet to Wall Lake, had a depth to water of 1.8 meters (5.94 feet) with sand and gravel encountered to a depth of 6.7 meters (22 feet). Layers of silty sand were encountered from 7 to 13.7 meters (23 to 45 feet). The sand and gravels decreased in thickness over relatively short distances north and south of Site 22. Test holes 122 meters (400 feet) north and 183 meters (600 feet) south of test hole 22 had no sands or gravels.

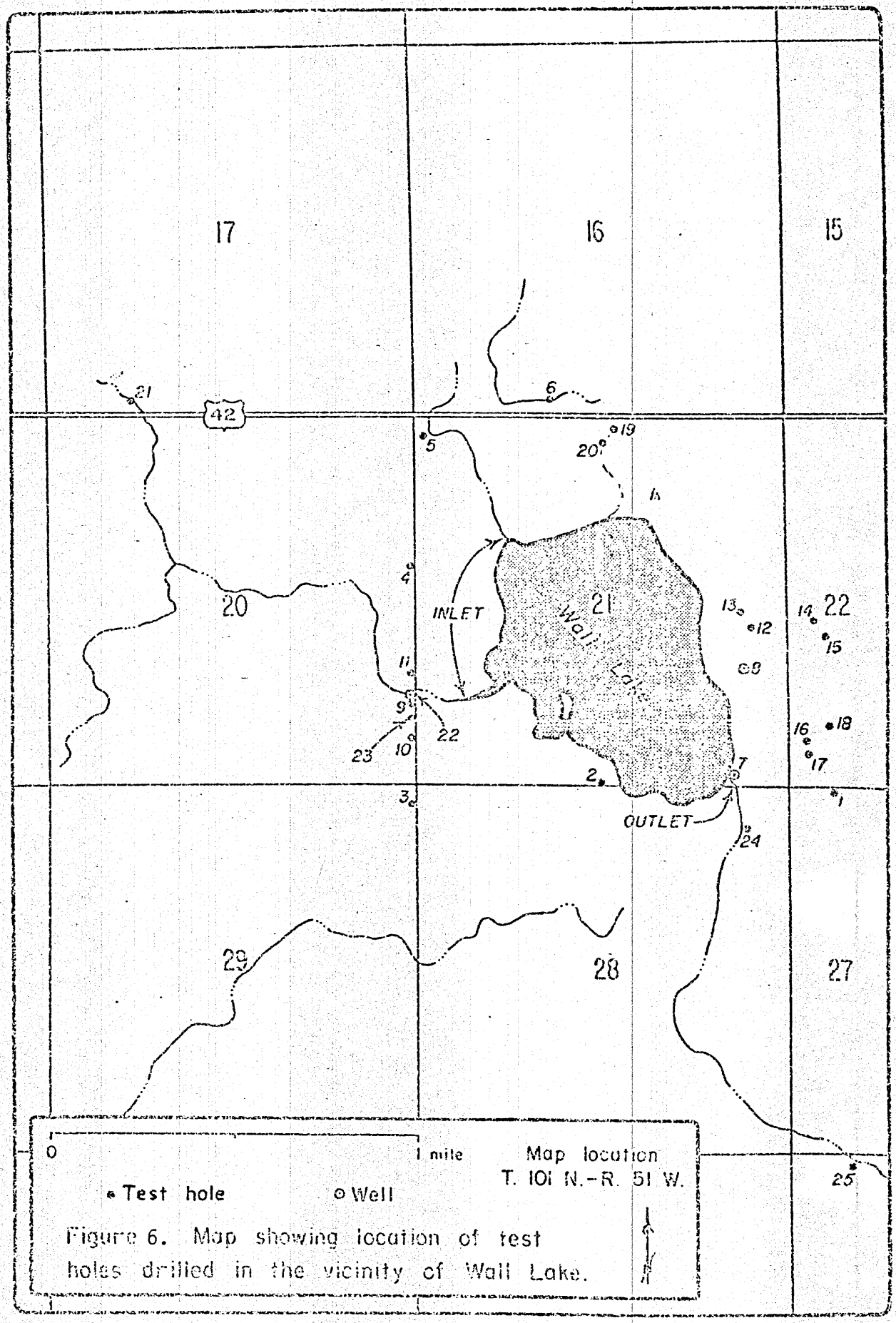


Figure 6. Map showing location of test holes drilled in the vicinity of Wall Lake.

Test holes 7 and 8 encountered sands and gravels from depths of 0.3048 meters (1 foot) to 2.7 meters (9 feet) and 1.8 meters (6 feet) to 5.2 meters (17 feet), respectively. No other test holes penetrated a sand or gravel outwash aquifer capable of providing a groundwater connection to the lake.

To determine net groundwater flow to Wall Lake, the Geological Survey made a water budget and calculated that from July 26 to August 2, 1979, the lake level dropped 15.24 centimeters (6 inches). For this period, the Sioux Falls weather station data indicated that lake evaporation was 8.33 centimeters (3.28 inches) and precipitation was 0.305 centimeters (0.12 inches). The Geological Survey did not measure surface water inflow-outflow to extrapolate the groundwater contribution. However, the Geological Survey calculated that during this period there was a drop in lake elevation due to the net groundwater exchange of -7.21 centimeters (-2.84 inches) using the following equation:

$$h = P + Gn - E$$

where:

h is the change in lake level

P is the precipitation

Gn is the net groundwater movement (into or out of the lake)

E is the lake evaporation

By substituting the known values into the equation, one obtains:

$$-15.24 = 0.3048 + GN - 8.33$$

$$Gn = -7.21$$

(All values expressed in centimeters)

Over the entire lake this amounts to a net change of - 61.2 acre-feet. Precipitation from July 26 to August 2, 1979, was 4.06 centimeters (1.6 inches) and the lake level rose 10.16 centimeters (4 inches), even though evaporation totaled 3.76 centimeters (1.48 inches).

The groundwater exchange rate indicates that, given the rise in lake levels during the July 26 to August 2, 1979, period, that:

1. The lake responds quickly to precipitation in the watershed; and

2. Surface water contributions to Wall Lake were more significant than groundwater contributions for the period studied.

II. Wall Lake Water Quality Study Area Selection and Study Coordination

The Southeastern Council of Governments (SECOG) nominated Wall Lake as a Water Quality Study Area (WQSA), February 14, 1979, Appendix E.

Wall Lake's selection as a WQSA was based on two factors:

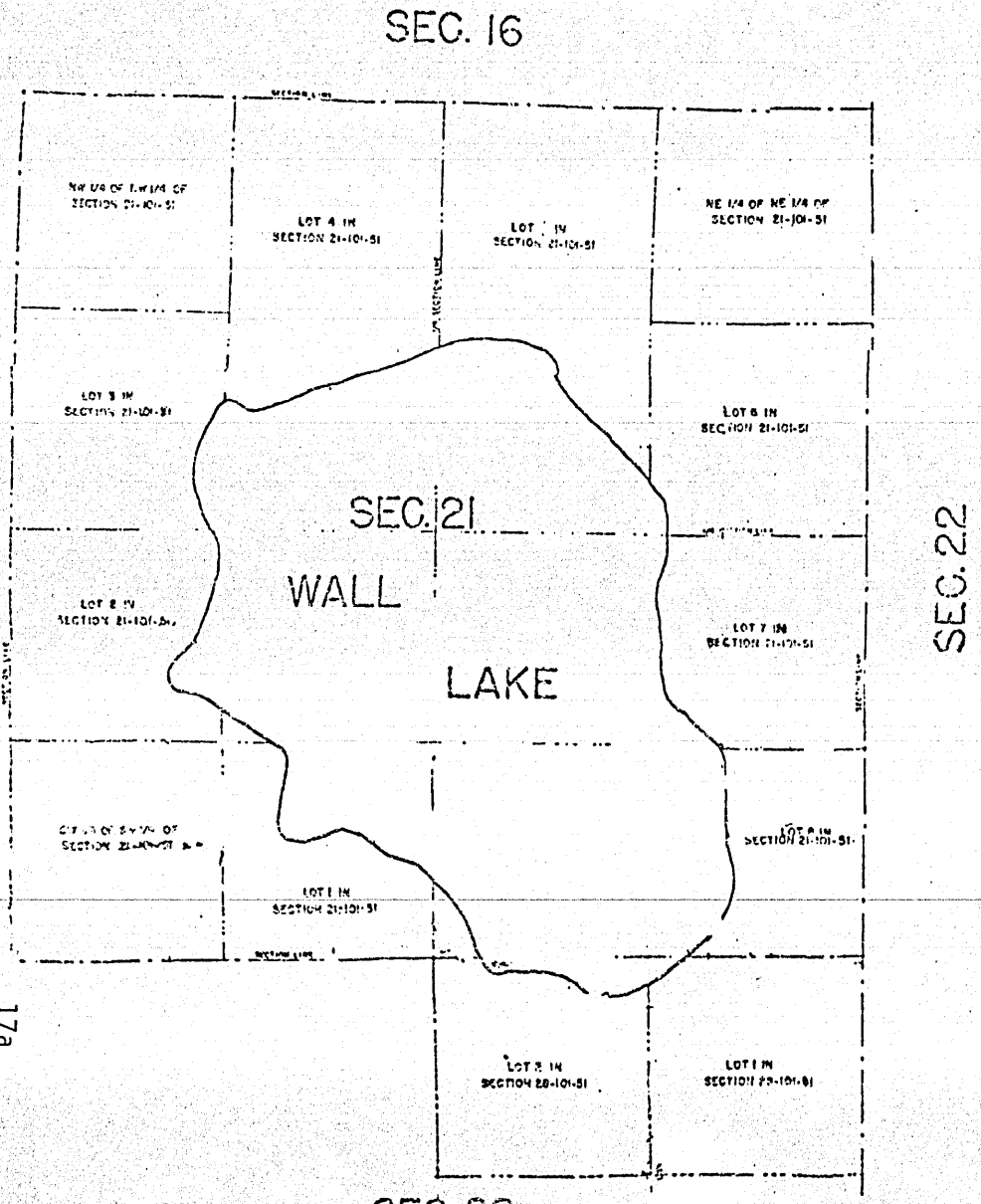
1. Wall Lake had 42 out of a possible 78 points on the Lake Significance Ranking List. Lake Significance Points are given to lakes based upon depth, surface area, fisheries classification, public accessibility, domestic water supply usage, publicly owned acreages adjoining the lake shore, and public facilities. The point total is designed as one of the criteria to rank lakes for expenditures of State Lake Restoration Grant Funds.

2. Wall Lake ranked thirteenth out of the 31 South Dakota lakes and reservoirs sampled in 1974 as part of the National Eutrophication Survey conducted by the U.S. Environmental Protection Agency. According to this ranking, 12 lakes had better water quality than Wall Lake based on a combination of 6 lake parameters.

After the selection of Wall Lake as a WQSA, the DWNR in June, 1980, contracted with the Minnehaha Conservation District to hire a project coordinator. The project coordinator collected study area data and worked toward establishment of a restoration plan for Wall Lake. The project coordinator worked with DWNR, the Minnehaha Conservation District, the East Dakota Conservancy Subdistrict, and other political entities as well as soliciting public involvement in the study. The Wall Lake Association, a group of area property owners, served as the main source of public comment on the project. Public information on the study project was provided through articles published in the Hartford "Herald", the Sioux Falls "Argus Leader", the Minnehaha Conservation District newsletter, and KELO television. The project coordinator summarized the study progress in the final report for the Wall Lake Restoration Project (Appendix C).

DWNR also selected Wall Lake for a COE dredging feasibility study, February 28, 1979. A summation of the dredging proposal is presented later in this report.

In July, 1974, Wall Lake area voters approved incorporation of the area shown in Figure 7, into the Wall Lake Sanitary District. The sanitary district serves as the governing body able to levy taxes to affect sewer corrections, domestic water improvements, and correct other sanitation problems. Therefore, the sanitary district is responsible for correcting the individual waste treatment (septic tank) systems which may be adversely affecting Wall Lake water quality (ARSD 74:03:02:02).



DESCRIPTION OF PROPERTY CONTAINED WITHIN BOUNDARIES OF PROPOSED WALL LAKE SANITARY DISTRICT

GOVERNMENT LOTS 1 TO 8, BOTH INCLUSIVE; THE NW 1/4 OF NW 1/4, THE NE 1/4 OF NE 1/4, AND THE SW 1/4 OF SW 1/4, ALL IN SECTION 21, T101N, R51W;

GOVERNMENT LOTS 1 AND 2 IN SECTION 28, T101N, R51W;

MINNEHAHA COUNTY, SOUTH DAKOTA INCLUDING ALL PLATTED TRACTS, LOTS, STREETS, DRIVES AND ALLEYS CONTAINED THEREIN.

SURVEYORS CERTIFICATE

I, D.C. KALDA, REGISTERED LAND SURVEYOR OF THE STATE OF SOUTH DAKOTA DO HEREBY CERTIFY THAT I HAVE ON AND BEFORE DECEMBER 29, 1972 PREPARED THE ABOVE MAP OF THE AREA INTENDED TO BE EMBRACED WITHIN THE LIMITS OF THE WALL LAKE SANITARY DISTRICT, AND THAT THE SAME IS A TRUE AND CORRECT REPRESENTATION OF THE INTENDED BOUNDARIES AND AREA OF SAID DISTRICT.

DATED THIS 29TH DAY OF DECEMBER, 19 .

D.C. Kalda
REGISTERED LAND SURVEYOR

WALL LAKE SANITARY DISTRICT

MINNEHAHA COUNTY, SOUTH DAKOTA

SCHMITZ, KALDA & ASSOCIATES

FILED
JAN 31 1973

Figure 7

For the forseeable future, EPA construction grant funding is not available due to the sanitary district's low priority ranking on the "South Dakota Construction Grant State Priority List". The lack of funding appears to have diminished citizen involvement with the sanitary district. However, some funding may be available for lake rehabilitation and related projects through other sources such as Farmers Home Administration loans, Housing and Urban Development Block Grants (administered by DWNR), and State Water Facility Plan (loans administered by DWNR). However, the sanitary district, Wall Lake Association, and other political entities need to actively pursue this project to develop the necessary public involvement.

III. Soil Loss and Sediment Yield Summary

The SCS conducted a soil erosion and sediment yield study using the Universal Soil Loss Equation (USLE) to estimate sheet and rill erosion (Appendix D). The SCS used the direct volume method which consists of multiplying the area of erosion by an estimated rate and the volume weight of the eroding soil in order to estimate gully, streambank, and lake shore erosion.

The SCS derived sediment yield, which is the amount of soil removed from a drainage basin, by estimating gross erosion and then multiplying by an estimated sediment delivery ratio.

The SCS, through the "Technical Guide for South Dakota" (available at local SCS offices), recommended soil conservation practices which could be applied to the Wall Lake watershed as best management practices (BMP's). No quantification of reductions in sediment yield due to application of BMP's was attempted by SCS for two reasons:

1. The technical data base was inadequate.

2. The potential combinations of BMP's were too great.

In Table 2, the SCS identified area land uses and estimated acres needing treatment in the Wall Lake Watershed. Figures are given for the following uses: cropland, grassland (both tame and native), woodland, farmsteads, urban, and non-sediment contributing areas. Of the 1,243 hectares (3,072 acres) in the watershed, 1,066.7 hectares (2,635.8 acres) or 86% of the watershed landuse is cropland or grassland. The SCS reports that 76% of the 607.8 hectares (1,502 acres) of cropland and 73% of the 459 hectares (1,134 acres) of grassland is in need of treatment. The non-sediment producing areas of the watershed are those areas with marsh, sloughs, or water (including Wall Lake).

Table 3 lists figures for soil erosion and sediment yield from each of the Wall Lake subwatershed areas. Cropland and grassland contributes 12,965 tons of sheet and rill erosion per year, with a sediment yield of 1,049 tons to the lake. Soil erosion in the entire watershed totals 13,121 tons per year with a sediment yield of 1,205 tons per year to the lake. The west tributary to Wall Lake (area 2 in Figure 8), has 74% of the cropland and 47% of the grassland in the watershed. Total soil erosion from Area 2 accounts for 71% of the entire watershed erosion, and 60% of watershed sediment yield.

Best Management Practices cost estimates for the entire watershed by SCS are found in Table 4. Conservation practices considered include but are not limited to: conservation tillage, grassed waterways, terraces, pasture and hayland planting, contour strip cropping, and waste management systems. Total cost estimated for all BMP's in the watershed is $137,949 or $44.91 per acre. However, as found in Table 4, $80,000 of the $137,949 cost is for waste

TABLE 2

LAND USE AND ESTIMATED ACRES NEEDING TREATMENT
WALL LAKE WATERSHED AREA

WQSA or SUBWATERSHEDS	LAND USE (Acres) and TREATMENT (Acres and Percent)											
	CROPLAND		GRASSLAND		WOODLAND		FARMSTEAD AND URBAN		NON SEDIMENT CONTRIBUTING[1]		TOTAL	
	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%
Tributary #2	1,122	100	657	100	-	-	63	100	38	100	1,880	100
Adequately Treated	269	24	177	27	-	-	61	97	38	100	545	29
Needs Treatment	853	76	480	73	-	-	2	3	-	-	1,335	71
Tributary #3	96	100	217	100	-	-	1	100	22	100	336	100
Adequately Treated	23	24	58	27	-	-	-	-	22	100	103	31
Needs Treatment	73	76	159	73	-	-	1	100	-	-	233	69
Tributary #4	100	100	100	100	-	-	1	100	4	100	205	100
Adequately Treated	23	24	27	27	-	-	-	-	4	100	54	27
Needs Treatment	77	76	73	73	-	-	1	100	-	-	151	73
Tributary #5 (+ lake)	184	100	160	100	-	-	67	100	240	100	651	100
Adequately Treated	44	24	43	27	-	-	61	90	220[2]	100	388[2]	60
Needs Treatment	140	76	117	73	-	-	6	10	-	-	263	40
TOTAL FOR WATERSHED	1,502	100	1,134	39	-	-	132	100	304	100	3,072	100
Adequately Treated	359	24	305	27	-	-	122	92	304	100	1,090	35
Needs Treatment	1,143	76	829	73	-	-	10	8	-	-	1,982	65

1/ Generally, water, marsh and sloughs. 2/ Includes Wall Lake contains approx. 220 acres.

TABLE 3

SOIL EROSION AND SEDIMENT YIELD
WALL LAKE WATERSHED AREA

WQSA or Subwatershed		Cropland	Grassland	Sub Total	Channels	Lakeshore	Construction [1]	Sub Total	Total	Acre Feet Per Yr. [2]	Percent [3]
Tributary 2	Erosion Tons/Yr.	9,305	129	9,434	-	40		40	9,473		
	Sed. Yield [4] Tons/Yr.			679	-	40	-	40	719	.55	.035
Tributary 3	Erosion Tons/Yr.	1,011	76	1,087	-	-	-	-	1,087		
	Sed. Yield [4] Tons/Yr.			82	-	-	-	-	82	.06	.004
Tributary 4	Erosion Tons/Yr.	1,232	35	1,267	-	-	-	-	1,267		
	Sed. Yield [4] Tons/Yr.			151	-	-	-	-	151	.12	.007
Tributary 5	Erosion Tons/Yr.	1,145	32	1,177		116		116	1,293		
	Sed. Yield [4] Tons/Yr.			137		116	-	116	253	19	.012
Total	Erosion Tons/Yr.	12,693	272	12,965		156	-	156	13,121		
	Sed. Yield [4] Tons/Yr.			1.049		156		156	1,205	.92	.058

1/ Not estimated, but has high potential. Planned developments should include a sediment control plan for before, during, and after construction.

2/ Tons converted to acre feet. Sediment in lake volume computed at 60 pounds per cubic foot due to sediment being submerged.

3/ Annual sediment yield expressed as a percent of total lake volume. Lake volume of Wall Lake is 1,575 acre feet.

4/ Sediment deposited in Wall Lake.

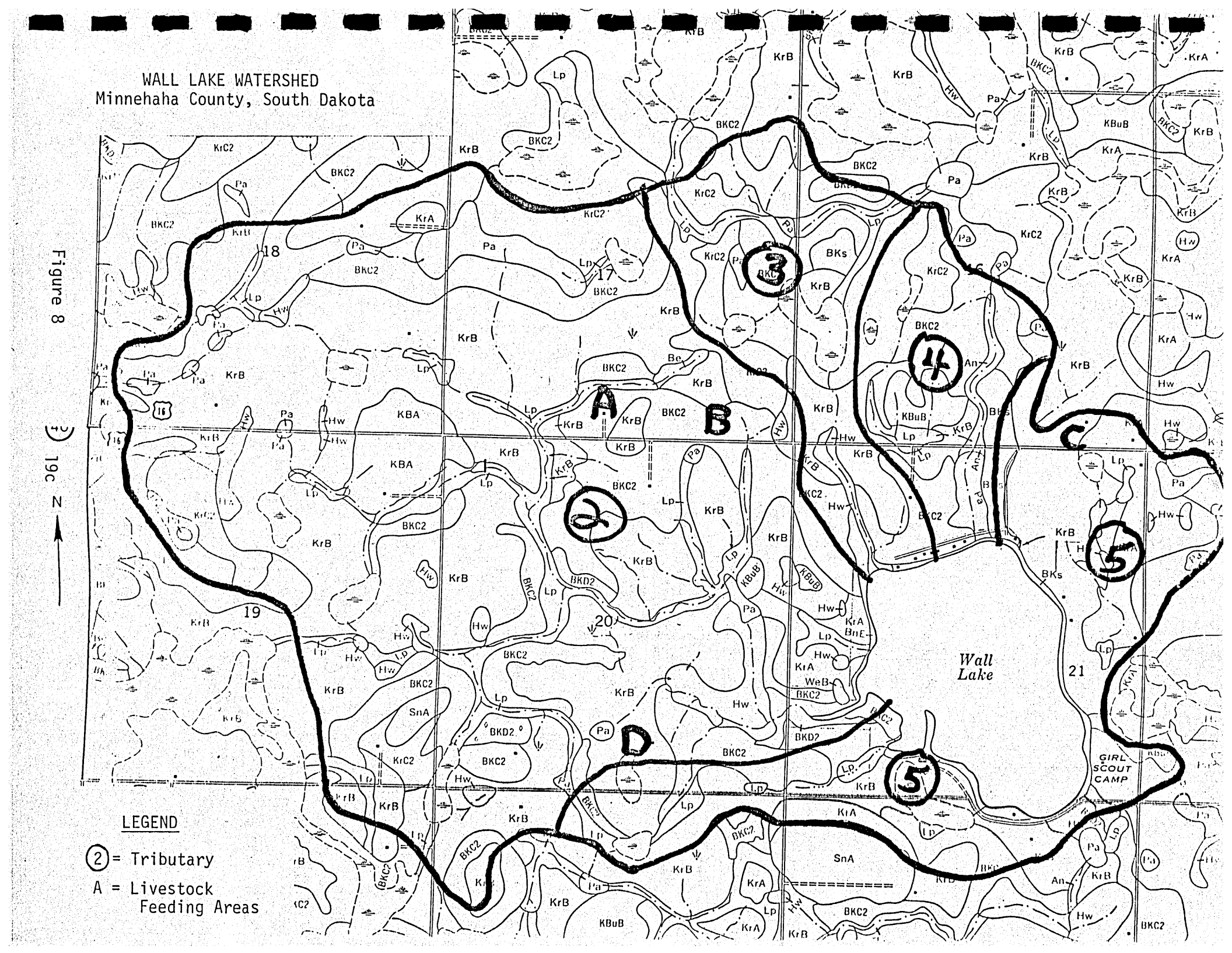

WALL LAKE WATERSHED
Minnehaha County, South Dakota
Wall Lake
GIRL SCOUT CAMP
LEGEND
(2) = Tributary
A = Livestock Feeding Areas
N

Figure 8

TABLE 4

BEST MANAGEMENT PRACTICES (Conservation Practices and Measures) 1/ 2/ 3/
WALL LAKE WATERSHED AREA

Conservation Practices	Unit	Unit Cost 4/	Tributary 2		Tributary 3		Tributary 4		Tributary 5		Total Watershed	
			Amount Needed	Cost	Amount Needed	Cost	Amount Needed	Cost	Amount Needed	Cost	Amount Needed	Cost
		(Dollars)		(Dollars)		(Dollars)		(Dollars)		(Dollars)		(Dollars)
Cropland-1502 Acres												
Conservation Cropping System	acre	-	853	-	73	-	77	-	140	-	1,143	-
Conservation Tillage System	acre	5	853	4,265	73	365	77	385	140	700	1,143	5,715
Grass & Legumes in Rotation	acre	18	280	5,040	24	432	25	450	46	828	375	6,750
Grass Waterways	acre	500	7	3,500	1	500	1	500	1	500	10	5,000
Waste Utilization	acre	3	300	900	-	-	-	-	100	300	400	1,200
Minimize Fall Tillage	acre	-	300	-	32	-	35	-	60	-	427	-
Pasture & Hayland Planting	acre	20	110	2,200	10	200	10	200	20	400	150	3,000
Minimize Pesticide Use	acre	-	450	-	36	-	40	-	74	-	600	-
Contour Stripcropping	acre	6	122	672	10	60	10	60	18	108	150	900
Terraces	mile	2,112	2	4,224	-	-	-	-	1	2,112	3	6,336
Grassland - 1134 Acres												
Proper Grazing Use	acre	-	240	-	80	-	38	-	52	-	410	-
Pasture and Hayland Planting	acre	20	110	2,200	10	200	10	200	20	400	150	3,000
Deferred Grazing	acre	-	240	-	80	-	38	-	52	-	410	-
Planned Grazing Systems	acre	-	240	-	80	-	38	-	52	-	410	-
Livestock Water Stations	No	1,000	2	2,000	1	1,000	-	-	1	1,000	4	4,000
Critical Area Planting	acre	1,000	-	-	-	-	-	-	2	2,000	2	2,000
Pasture & Hayland Management	acre	-	240	-	79	-	35	-	65	-	419	-
Waste Management Systems	No	20,000	3	60,000	-	-	-	-	1	20,000	4	80,000
Wildlife Upland Habitat Mgmt.	acre	4	6	24	2	8	2	8	2	8	12	48
Farmsteads, Urban & Other, 436 acres												
Sediment Control Measures 5/	acre	2,000	2	4,000	1	2,000	1	2,000	6	12,000	10	20,000
TOTALS - Total acres - 3,072 acres	-	-	-	89,025	-	4,765	-	3,803	-	40,356	-	137,949 or $44.91 per acre

1/ Needed to get "Land Adequately Treated".
2/ Refer to Soil Conservation Service Technical Guide for South Dakota 1981.
3/ On site investigation and planning are necessary to determine kinds, locations, sizes, extent & costs of practices (BMP's).
4/ Refer to Soil Conservation Service Cost-Return Handbook for South Dakota 1981.
5/ Examples of measures are: cover and green manure crop, filter strips, lined and grassed waterways, diversions, mulching, sediment basins, streambank protection, and critical area planting.

treatment systems for four livestock feedlots identified in the watershed as problem areas. Due to recent economics associated with cattle feeding operations, only one of the four feedlots is currently in operation. If the current status of the feedlots remained unchanged, the total cost estimate of watershed BMP's is reduced by nearly half to $72,949.

IV. Wall Lake: Water Quality Summary

Wall Lake is located in Minnehaha County, South Dakota, at a latitude of 43 Deg., 30 Min., 0 Sec., and a longitude of 96 Deg., 57 Min., 30 Sec., in Township 101N, Range 51W, Section 21. This lake is a natural lake situated at the southern end of the Prairie Coteau (a glacial lake region) and has the following morphometric characteristics:

Area	207.6A (84.0 ha)
Shoreline Length	13,200 ft. (4023 m)
Maximum Depth	12 ft. (3.7 m)
Mean Depth	8.6 ft. (2.6 m)
Volume	1,785.1 acre-feet ($2.202 \times 10^{6} m^{3}$)
Watershed/Lake Surface Area Ratio	13
Origin of Lake Basin	Natural
Thermal Stratification	No

Wall Lake is fed by three intermittent streams from the north, northwest and west sides of the lake. At the southeast end, the lake discharges intermittently to a tributary of Skunk Creek.

The beneficial uses assigned to Wall Lake are: 1) warmwater semipermanent fish life propagation; 2) immersion recreation; 3) limited contact recreation; and

4) wildlife propagation and stock watering. For purposes of this report the following water quality standards are applicable to Wall lake:

- Un-ionized ammonia nitrogen shall not exceed 0.04 mg/l (as N) with a variation allowed under subdivision 74:03:02:32(2).
- Dissolved oxygen shall be greater than 5.0 mg/l with a variation allowed under subdivision 74:03:02:32(1).
- pH shall be greater than 6.5 units but less than 8.3 units with a variation allowed under subdivision 74:03:02:32(1).
- Suspended solids shall not exceed 90 mg/l with a variation allowed under subdivision 74:03:02:32(3).
- Fecal coliform organisms shall not exceed a concentration of 200 per 100 milliliters as a geometric mean based on a minimum of not less than five samples obtained during separate twenty four-hour periods for any thirty-day period; nor shall they exceed this value in more than twenty percent of the samples examined in the above described thirty-day period, nor shall they exceed 400 per 100 milliliters in any one sample from May 1 to September 30.
- Total dissolved solids shall not exceed 2,500 mg/l with a variation allowed under subdivision 74:03:02:32(2).
- Nitrates shall not exceed 50 mg/l (as N) with a variation allowed under subdivision 74:03:02:32(2).

For the purpose of this report, violations can only be reported for fecal coliforms when they exceed 400 per 100 ml during the period May 1 to September 30 and for dissolved oxygen and pH. For the other parameters, not enough consecutive samples

were collected to determine whether a true violation occurred or not. Therefore, parameter values that exceed a water quality standard can only be considered as excessive. This point must be kept in mind when one reviews the "violation tables" retrieved from the STORET system.

Table IV-1 describes the sampling locations for Wall Lake and its inlets and its outlets. Samples were collected from Site 46WA01 in 1979 and 1983; from Sites 46WA02, 46WA03, and 46WA04 in 1979, 1982, and 1983; and from Sites 46WA05 and 46WA06 in 1979, 1980, 1982, and 1983. In 1981, the inlets and outlets were dry and all samples were collected in-lake (Figure 9).

In the following presentation, the water quality of the lake and its inlets and outlet will be discussed in terms of the individual parameters. In addition, the nutrient (i.e., phosphorus or nitrogen) tending toward limitation will be identified, the trophic state index discussed, and recommendations presented. All tables and figures discussed in this chapter are found in Appendix F.

Water Quality

Dissolved Oxygen (DO)

As stated earlier, the dissolved oxygen (DO) standard is 5.0 mg/l since Wall Lake has the assigned beneficial use of a marginal warmwater fishery. In-lake DO concentrations were never observed below 5.0 mg/l (Tables IV-6 through IV-11). DO concentrations in the tributaries were frequently low. At sites 46WA01 and 46WA03, one low concentration was observed in 1979 (3.3 mg/l and 4.8 mg/l, respectively); at Site 46WA02, seven low concentrations were observed during the study; and at Site 46WA04, nine low concentrations were observed over the study period (Table IV-12, IV-13 and IV-15). (Note, the criteria used in the violations was

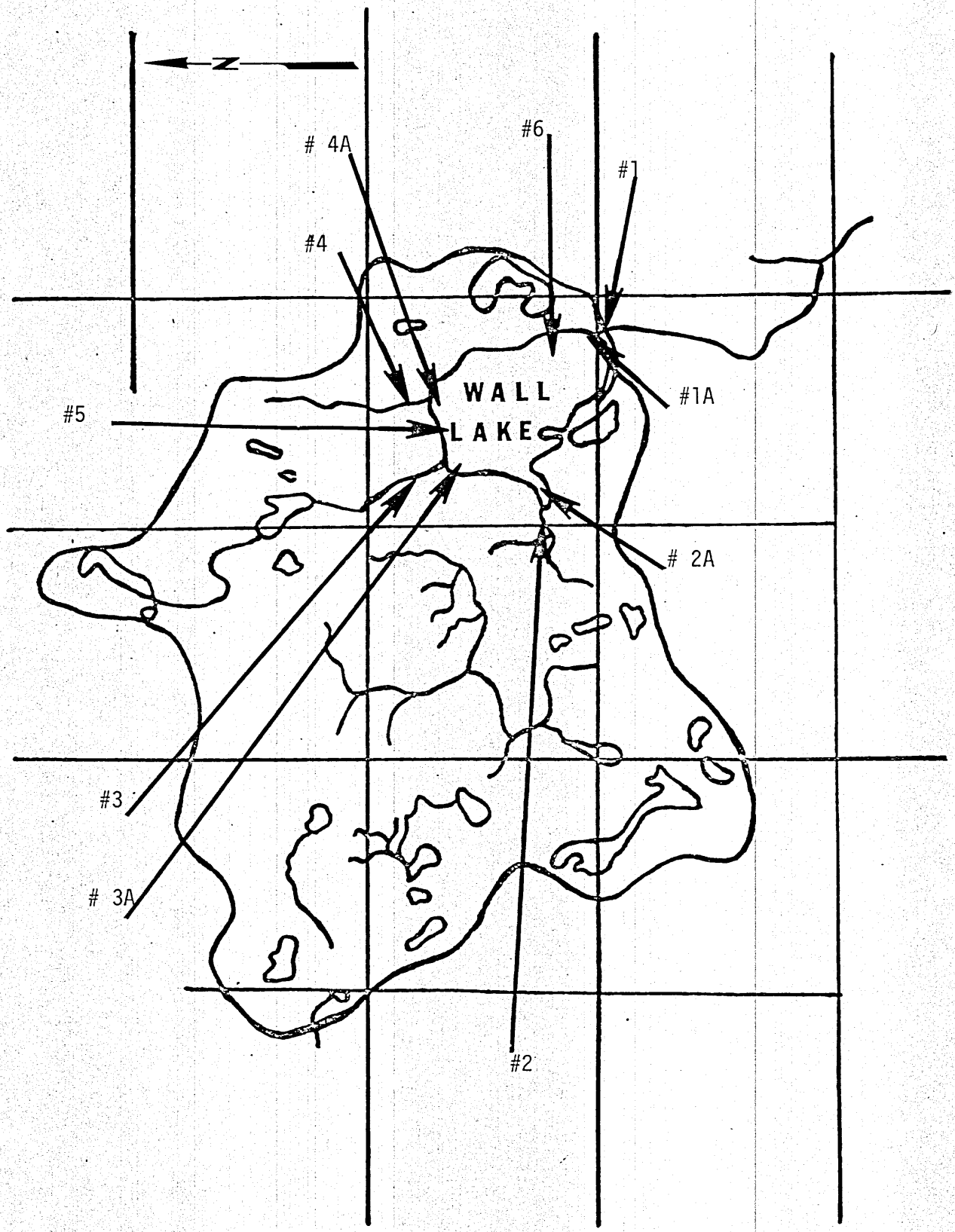


FIGURE 9
WALL LAKE SAMPLING SITES

Site	Description
Site 46WA01 (Site 1)	This site is located at a latitude of 43 Deg., 31 Min., 44 Sec., and a longitude of 96 Deg., 57 Min., 10 Sec. Site 46WA01 is on the outlet just northeast of Wall Lake's southeast beach. T101N, R51W, Section 21. SE1/4, SE1/4, SW1/4, SE1/4.
Site 46WA02 (Site 2)	Located at a latitude of 43 Deg., 31 Min., 57 Sec., and a longitude of 96 Deg., 58 Min., 11 Sec., in T101N, R51W, Section 21, SW1/4, NW1/4, SW1/4, SW1/4, this site is on the west inlet.
Site 46WA03 (Site 3)	Located at a latitude of 43 Deg., 32 Min., 20 Sec., and longitude of 96 Deg., 57 Min., 55 Sec., in T101N, R51W, Section 21, NW1/4, SW1/4, NE1/4, SE1/4, the site is on the northwest inlet.
Site 46WA04 (Site 4)	This site, which is on the northeast inlet, is located at a latitude of 43 Deg., 32 Min., 23 Sec., and a longitude of 96 Deg., 57 Min., 32 Sec., in T101N, R51W, Section 21. NE1/4, SW1/4, NW1/4, NW1/4.
Site 46WA05 (Site 5)	Located at a latitude of 43 Deg., 32 Min., 19 Sec., and at a longitude of 96 Deg., 57 Min., 40 Sec., in T101N, R51W, Section 21, NW1/4, SE1/4, NE1/4, SW1/4, the site is in-lake off the north beach.
Site 46WA06 (Site 6)	Located at a latitude of 43 Deg., 31 Min., 59 Sec., and at a longitude of 96 Deg., 57 Min., 15 Sec., in T101N, R51W, Section 21, SE1/4, NE1/4, SW1/4, SW1/4, the site is in-lake off the souteast beach.
Site 46WA1A (Site 1A)	This site, which is near the outlet, is located at a latitude of 43 Deg., 31 Min., 45 Sec., and at a longitude of 96 Deg., 57 Min., 13 Sec., in T101N, R51W, Section 21, SE1/4, SE12/4, SW1/4, SE1/4.
Site 46WA2A (Site 2A)	This site is in the west inlet bay (in-lake) and is sited at a latitude of 96 Deg., 57 Min., 55 Sec., and at a longitude of 97 Deg., 31 Min., 58 Sec., in T101N, R51W, Section 21, SW1/4, NW1/4, SE1/4, SE1/4.
Site 46WA3A (Site 3A)	Located at a latitude of 43 Deg., 32 Min., 18 Sec., and at a longitude of 96 Deg., 57 Min., 53 Sec., in T101N, R51W, Section 21, NW1/4, SE1/4, NW1/4, SW1/4. This site is near the northwest inlet (in-lake).
Site 46WA4A (Site 4A)	This site is in-lake near the northeast inlet at a latitude of 43 Deg., 32 Min., 21 Sec., and at a longitude of 96 Deg., 57 Min., 32 Sec., in T101N, R51W, Section 21, NE1/4, SW1/4, NW1/4, NW1/4.

Figure 9 (cont.) Description of Wall Lake sampling sites.

4.0 mg/l of DO instead of 5.0 mg/l. That is the reason for more excessive levels being reported here as opposed to those in the Tables.)

Figures IV-1 through IV-6 illustrate the DO data for Wall Lake and its tributaries. At the inflow and outflow sites (Figure IV-1 through IV-4), the DO appeared to increase during spring runoff and then decrease over the summer. In 1979, this same trend was observed at the in-lake sites. However, in 1983 the highest DO concentrations were observed in November and then they gradually decreased, with a minor increase at Site 46WA06 in late April or early May, until the end of the sampling period (Figures IV-5 and IV-6).

Alkalinity (Total)

Alkalinity can be defined as the sum total of components in the water that tend to elevate the pH of water above a value of 4.5 (EPA, 1976) or expressed differently, it represents the buffering capacity of a lake. Buffering in a lake is important for the maintenance of aquatic life since most lethal effects occur when the pH is less than 4.5 or greater than 9.5 (Wetzel, 1975).

Wall Lake is a well buffered lake with mean concentrations of 225 mg $CaCO_3$/l at Site 46WA05 and 232 mg $CaCO_3$/l at Site 46WA06 (Range 193 mg CaCO3/l to 248 mg $CaCO_3$/l).

Solids (Total, Dissolved and Suspended)

There is not a water quality standard in South Dakota for total solids. However, this fraction can be used as an indicator of high concentrations either in the dissolved solids or suspended solids fractions. The mean concentrations of total solids in the outlet and the inlets ranged from 1,197 mg/l at Site 46WA02 to 198 mg/l

at Site 46WA03. In-lake the mean concentrations ranged from 1068 mg/l at Site 46WA05 to 2594 mg/l at Site 46WA2A.

Dissolved solids (dissolved residue) is a term associated with fresh water systems and consists of inorganic salts, small amounts of organic matter and dissolved materials (EPA, 1976). The principal inorganic anions dissolved in water are carbonates, chlorides, sulfates, and nitrates and the principal cations are sodium, potassium, calcium, and magnesium. Dissolved solids were excessive at inlet Site 46WA04 in 1979 and at in-lake Site 46WA2A in 1981. At Site 46WA04, nine observations exceeded the standard of 2500 mg/l in 1979 (Figure 10). Only one value was excessive at Site 46WA2A in 1981. (Note, in Tables IV-12 through IV-21 there were no "violations" of dissolved solids observed and yet excessive levels are discussed. The computer only searched for those observations that were taken from samples dried at 180°C. The "violations" occurred for these samples dried at 105°C.) The mean concentrations of dissolved solids range from 171 mg/l to 1,928 mg/l at the inlets and outlets and from 984 mg/l to 2,576 mg/l at the in-lake sites. The high concentration observed at the in-lake site (i.e., 2,576 mg/l) represents the mean of two samples collected during a dry year (1981). Based on Figures IV-7 through IV-12, there appears to be a general trend of dissolved solids increasing from April until late July or early August. However, this trend is tenuous and based on limited observations.

Suspended solids can have a detrimental effect on a lake's fishery. In 1965, the European Inland Fisheries Advisory Committee identified four means by which suspended solids can adversely affect fish and fish food populations (EPA, 1976). Fish swimming in water with high suspended solids can be killed directly, their growth rate reduced, or their resistance to disease reduced. In addition, suspended solids

can prevent the successful development of fish eggs and larvae, modify natural movements and migrations of fish, and reduce the abundance of food available to fish.

Excessive suspended solids were observed at Sites 46WA02, 46WA03, 46WA04, 46WA2A, 46WA3A and 46WA4A (Tables IV-13 through IV-15, Tables IV-19 through IV-21). One observation at each site was observed to be greater than the standard of 90 mg/l. Mean in-lake concentrations ranged from 8 mg/l to 1,880 mg/l. The 1,880 mg/l mean concentration is extremely high even though it represents the mean of two data points in 1981. The reason for the high concentration is unknown.

In general, the results for dissolved solids and suspended solids are below the water quality standards for Wall Lake. Therefore, based on those parameters the lake is meeting its assigned beneficial uses. Although excessive levels in the inlets are discussed there are no water quality standards assigned to these intermittent streams. However, by using the standards for the lake one can determine that there are times when excessive levels of dissolved and suspended solids do enter the lake and can possibly stress the fish population which is rated as semipermanent. Sources responsible for the excursions above the standards should be identified and corrected.

Biochemical Oxygen Demand (BOD)

Water samples were analyzed for BOD in 1979 and the mean concenirations ranged from 3.6 mg/l to 8.7 mg/l. The range of values was from 1.0 mg/l to 21.0 mg/l. The 21.0 mg/l BOD concentration was observed on March 22, 1979, at Site 46WA02. Another relatively high value was observed on March 20, 1979, at Site 46WA04 (16.0 mg/l). Other than these two relatively high values, the BOD concentrations were relatively low and were not considered to be indicative of a major problem. Based on 95% confidence intervals there were no differences in BOD concentrations between sites.

pH

In-lake mean pH values ranged from 7.4 at Site 46WA2A in 1981 to 8.7 at Site 46WA05 in 1980. Inlets and the outlet mean concentrations ranged from 7.5 to 8.4. Figure IV-19 through Figure IV-24 illustrate the data collected from Wall Lake and its tributaries.

At Site 46WA05 the pH limits were exceeded 13 times and at Site 46WA06 the pH limits were exceeded 12 times over the period of study. Although there are no specific standards applicable to the intermittent streams flowing into Wall Lake, the criterion used in-lake was applied to the streams to determine if pH was a potential problem. Only two deviations from the standards were observed (i.e., 6.2 and 9.6 at Site 46WA02). In general, pH does not seem to be a problem in the tributaries. The outlet (Site 46HA01) reflected the in-lake conditions where 13 excessive levels of pH were observed.

Phosphorus

Over the course of the study, four fractions of phosphorus were measured: total phosphorus, total orthophosphate, dissolved orthophosphate, and dissolved organic phosphorus. Total phosphorus was determined by digesting the sample and analyzing it colorimetrically. Total orthophosphate was determined by direct colorimetry. This parameter measures dissolved orthophosphate, colloidal phosphate and inorganic phosphate. Until 1983, total orthophosphate also consisted of some hydrolyzable phosphate because the water to be analyzed was taken from a sample preserved with 2 mls. of sulfuric acid. Dissolved othophosphate was determined by filtering a sample through a .45 micron filter and analyzing the filtrate colorimetrically. Dissolved orthophosphate is that fraction assumed to be available for algal uptake. Again, the water to be analyzed was taken from preserved samples and therefore the

dissolved orthophosphate also reflects hydrolyzable phosphorus. The last fraction measured was dissolved organic phosphorus. This fraction was filtered through a .45 micron filter, digested, and then analyzed colorimetrically. This fraction does not represent an actual organic phosphorus value because it consists of dissolved orthophosphate and hydrolyzable phosphorus fractions which were not subtracted from the final result. The majority of the data consists of total orthophospate and tota phosphorus. Therefore, the discussion will only consider these two parameters.

In-lake mean annual concentrations of total phosphorus ranged from .142 mg/l at Site 46WA06 in 1982 to .644 mg/l at Site 46WA05 in 1980. The observations ranged from .142 mg/l to .770 mg/l. The mean annual concentrations of total phosphorus in the tributaries to Wall Lake ranged from .323 mg/l to .931 mg/l at Site 46WA04 in 1979 and 1982, respectively. The range of observations was from .231 mg/l to 2.44 mg/l.

A Tukey-Kramer test for multiple comparison among pairs of means based on unequal sample sizes showed that tributary Sites 46WA02 and 46WA04 had higher concentrations of total phosphorus than Site 46WA03 ($P<.05$) in 1979. No significant differences were observed between sites in 1983. Site 46WA02's water quality reflects the drainage from the largest watershed and Site 46WA04's may reflect the impact from an identified feedlot.

A linear regression between annual precipitation and mean total phosphorus was conducted. Although the r^2 value was only .21, there is an indication that total phosphorus concentrations in the lake decrease as precipitation increases. This implies that total in-lake phosphorus concentrations were diluted during periods of high precipitation. This possibility deserves further investigation through hydrologic and phosphorus budget determinations.

In-lake annual mean concentrations of total orthophosphate ranged from .140 mg/l at Site 46WA06 in 1982 to .565 mg/l at Site 46WA06 in 1979. The in-lake observations ranged from .094 mg/l to .638 mg/l. Figures IV-24 through IV-29 illustrate the total orthophosphate data. Notice that the total orthophosphate values increased in 1979 dramatically between May and July (Figure IV-25 and Figure IV-27). This increase is assumed to be related to precipitation which increases in May, June, and July. The range between January and April was .41 to 2.78 in./month and between May and July it was 3.10 to 4.36 in./month (National Oceanic and Atmospheric Administration, Climatological Data - South Dakota). Precipitation data was not available for Wall Lake so the data from three stations in the vicinity of Wall Lake were averaged and used to estimate precipitation in the Wall Lake Watershed. The same relationship discussed above appears to hold true at Site 46WA02 in 1983 (Figure IV-25). The total orthophosphate value in July increased dramatically over the concentration observed in May. Precipitation in June was 7.2 inches as opposed to only 2.49 in July. In general, it appears that summer thunderstorms increased the phosphorus concentrations in some tributaries but not in others. The relationship between rainfall and phosphorus needs to be investigated in detail and land use patterns identified to determine if land use elucidates why some tributaries increased in concentration and others did not.

Reckhow, et.al., (1980) characterized a lake with a phosphorus concentration exceeding .05 mg/l as hypereutrophic. Such a lake is characterized as being a typical "old aged" lake in advanced succession, with some fisheries, high levels of sedimentation, and algae or macrophytes diminishing the open water surface area. Based on total phosphorus concentrations, Wall Lake would be considered hypereutrophic and the mean concentrations of phosphorus were higher than most of the lakes studied under the auspices of the "208" program.

Fecal Coliforms

Wall Lake has been assigned the beneficial use of immersion recreation. Only one excessive level (>200 per 100 ml) of fecal coliforms was observed in-lake (Site 46WA2A in 1981; 2,200 per 100 ml). In-lake mean concentrations ranged from 1,131.5 per 100 ml at Site 46WA2A in 1981 to 3 per 100 ml at Site 46WA05 and Site 46WA06 in 1980. Generally, fecal coliforms are not a problem in the lake.

In the tributary sites, 13 excessive levels were observed over the course of the study at Site 46WA02 (Table IV-13), 8 excessive levels at Site 46WA03 (Table IV-14), and 8 excessive levels at Site 46WA04 (Table IV-15). Tributary Site 46WA02 had the highest mean concentrations in 1979 and 1983 (mean concentrations were 3,196 per 100 ml and 2,231 per 100 ml, respectively). This site was followed by tributary Site 46WA03 which, in turn, was followed by Site 46WA04. The observations ranged from 23,000 per 100 ml to 3 per 100 ml.

Figures IV-30 through IV-35 illustrate the observations from the various sampling sites. In Figures IV-31 through IV-33 there appears to be a similar trend to that observed with total orthophosphate. In 1979, fecal coliform levels in the tributaries increased when monthly precipitation values increased. Also, note at Site 46WA02 (Table IV-31) fecal coliform levels increased in March when monthly precipitation increased from .16 inches in February to 3.33 inches in March. Again, fecal coliform levels increased in June, 1983, when precipitation increased from 2.06 inches in May to 7.68 inches in June. Superficially, it appears that the tributary concentrations increased with increased precipitation. Why fecal coliforms at Site 46WA02 increased with precipitation in 1982 and not the other sites is unknown. Also, why the outlet site (Site 46WA01) demonstrated increased fecal coliform levels similar to the tributary sites but the lake did not is unknown.

Intuitively, it appears that sample Site 46WA01 was receiving fecal coliforms from a source other than the lake (e.g., cattle in the stream).

Nitrogen

Analyses were conducted for four fractions of nitrogen: total Kjeldahl nitrogen, ammonia, nitrate, and nitrite. In addition, inorganic and organic nitrogen determinations were made by either summing ammonia, nitrate, and nitrite values (inorganic nitrogen) or by subtracting ammonia comcentrations from total Kjeldahl nitrogen (organic nitrogen).

Total Kjeldahl data for the water quality monitoring sites are presented in Figures IV-36 through IV-41. There are no obvious trends in the figures except for Site 46WA03 (Figure IV-38) where total Kjeldahl nitrogen increased between late May/early June until late July. The reason for this increase is unknown.

In-lake total Kjeldahl nitrogen mean concentrations ranged from 1.064 mg/l at Site 46WA05 in 1982 to 5.710 mg/l at Site 46WA2A in 1981. The data ranged from .680 mg/l to 7.570 mg/l. Inflow mean concentrations ranged from 1.190 mg/l at Site 46WA03 in 1983 to 8.34 mg/l at Site 46WA02 in 1982. (Note, the 8.34 mg/l value represents only one data point.) The data observations ranged from .780 mg/l to 8.34 mg/l.

Mean ammonia as nitrogen concentrations in-lake ranged from .045 mg/l at Site 46WA06 in 1982 to 1.695 mg/l at Site 46WA2A in 1981. The observations ranged from .020 mg/l to 2.80 mg/l. Figures IV-46 through IV-47 illustrate the in-lake data. In 1979 it appears, except for one point at Site 46WA06, that ammonia concentrations tended to decrease over the summer followed by a gradual increase in the fall and early winter.

Mean ammonia as nitrogen concentrations in the tributaries ranged from .110 mg/l at Site 46WA02 in 1979 to 1.61 mg/l at Site 46WA02 in 1982, and in the outlet they ranged from .097 mg/l to .329 mg/l. Figures IV-42 through IV-45 show the ammonia levels observed in the tributaries and the outlet. There are not any discernable trends in the data.

The un-ionized ammonia fraction of total ammonia is of concern because excessive levels can be toxic to fish. Only one excessive level of un-ionized ammonia was observed in-lake (Site 46WA06, August, 1979, .305 mg/l) and only two were observed in the outlet and tributary Site 46WA02.

Nitrate concentrations range from 0 to 10 mg/l in unpolluted fresh waters (Wetzel, 1975) and it is a nutrient source readily assimilated by the phytoplankton. In-lake mean concentrations of nitrate ranged from 2.5 mg/l to 0.1 mg/l, and the tributaries and outlet mean concentrations ranged from 1.5 mg/l to 0.1 mg/l. Figures IV-48 through IV-53 show the observations for the various sampling sites. In general, the 1979 data show high levels of nitrates in late March and early April which decrease rapidly to summer lows and either increase in June as at Site 46WA03 or in early November as at Site 46WA05. All nitrate values were in a range considered normal for unpolluted waters.

Nitrite concentrations are generally low in natural waters (0 to .01 mg/l; Wetzel, 1975). Generally, the in-lake concentrations were .01 mg/l or less. However, the tributaries had mean concentrations ranging from .01 to .06. Therefore, there is a tendency for higher nitrate concentrations to occur in the tributaries than would normally be expected (see Figures IV-54 through IV-59).

The mean concentrations of inorganic nitrogen are presented in Tables IV-22 through IV-25. They ranged, in-lake, from .155 mg/l to .557 mg/l and in the tributaries and

outlet from .306 mg/l to 2.985 mg/l. Based on Table 11-4 (Wetzel, 1975), Wall Lake would be classified anywhere from an ultra-oligotrophic lake to a meso-eutrophic. Whatever classification is used the mean inorganic nitrogen concentrations suggest better lake conditions than the mean total phosphorus concentrations. Figures IV-60 through IV-66 present the observed data for inorganic nitrogen, and there appears to be a trend of high inorganic nitrogen, during the period considered to be spring runoff, followed by a decrease into the early summer and then an increase. With exceptions, Figures IV-67 through IV-72 demonstrate the same general trend in the lake.

Mean organic nitrogen concentrations ranged from 1.969 mg/l to 1.012 mg/l in the lake and ranged from .930 mg/l to 6.730 mg/l (1 data point) in the tributaries (Tables IV-22 through IV-25). Based on these values, Wall Lake would be classified as eutrophic to hypereutrophic. As with many other South Dakota lakes, organic nitrogen appears to dominate the nitrogen fraction. Figures IV-73 through IV-85 do not demonstrate discernable trends.

Limiting Nutrient

A methodology used by the Environmental Protection Agency (EPA, 1980) to determine whether phosphorus nitrogen will tend to be limiting in a lake is to calculate the weight ratio between total nitrogen and total phosphorus. If this ratio is about 15:1, then these two nutrients are considered to be optimum for maintenance of a diverse population of algae. If the ratio is greater than 15:1, the system is considered to be phosphorus limited and if it is less than 15:1, the system is considered to be nitrogen limited. The further the ratio is from 15:1, the more comfortable the analyst is with his conclusion.

Using the data from Sites 46WA05, 46WA06, 46WA1A, 46WA2A, 46WA3A, and 46WA4A the ratio between total nitrogen and total phosphorus were calculated. The ratios range from 2.84 at Site 46WA05 in 1980 to 13.43 at Site 46WA2A in 1981. Therefore, Wall Lake would be considered a lake with a tendency toward nitrogen limitation.

Trophic State Index

Carlson (1977) developed a methodology to calculate Trophic State Indices (TSIs) based on total phosphorus, Secchi disc, and chlorophyll *a* concentrations. The basic assumption is that for every 10 unit increase (e.g., 0 to 10) the biomass of the algae doubles.

Based on the TSI values calculated from phosphorus concentrations collected during the study, the mean in-lake trophic state index was 91.55 and the standard deviation was 7.44. The 95% confidence interval was 91.55 to 89.71, suggesting that Wall Lake is an extremely productive lake in terms of chlorophyll *a* (i.e., between 427 and 1,183 mg/m^3 of chlorophyll *a*). However, this is based on limited evidence (two samples collected in June and July, 1979) which only had a mean chlorophyll *a* concentration of 52.6 mg/m^3. Therefore, the lake may not be as productive as predicted.

Nutrient Loads

Flow data were available for Sites 46WA02, 46WA03, and 46WA01 in 1979. Therefore, nutrient loads are available only for these three sites for 1979. The total phosphorus load to Wall Lake was 9.09 $g/m^2/yr.$ and the total nitrogen load was 45.24 $g/m^2/yr.$ Subtracting the phosphorus and nitrogen loads leaving the lake, the net nutrient load to the lake would be 4.63 $g/m^2/yr.$ of phosphorus and 21.25 $g/m^2/yr.$ of nitrogen. These levels both exceed Vollenweider's provisional dangerous loads (Table 12-10; Wetzel, 1975).

The majority of the nutrients were contributed from the watershed on which Site 46WA02 was located. Eighty-eight percent (88%) of the phosphorus came from this watershed and 85% of the nitrogen.

Summary of the Water Quality in Wall Lake

1. Several low dissolved oxygen concentrations were observed in the tributaries, especially at Sites 46WA02 and 46WA04.

2. Wall Lake is a well buffered lake with alkalinities normally >200 mg $CaCO_3$/l.

3. Dissolved solids were excessive at tributary Site 46WA04 in 1979 (nine observations exceeded 2,500 mg/l).

4. In general, suspended solids were below the standard of 90 mg/l.

5. Mean pH values ranged from 7.5 to 8.7 in-lake. Excessively high pH values were observed 13 times at Site 46WA05 amd 12 times at Site 46WA06.

6. In-lake mean annual total phosphorus concentrations ranged from .142 mg/l to .644 mg/l and the mean annual concentrations in the tributaries ranged from .323 mg/l to .931 mg/l. Precipitation explains 21% of the variation associated with in-lake total phosphorus concentrations. It appears that as rainfall increases, total phosphorus concentrations in-lake decrease. Based on the total phosphorus concentrations, Wall Lake would be considered hypereutrophic.

7. In general, fecal coliforms are not a problem in-lake. Excessive levels were observed at tributary Sites 46WA02, 46WA03, and 46WA04. Site 46WA02 appeared to have the highest concentrations of fecal coliform followed by Site 46WA03 which was followed by 46WA04. Tributary fecal coliform levels appeared to be increased with increases in precipitation in the spring and summer months.

8. Only one excessive level of un-ionized ammonia was observed in-lake and only tw in the inlets and outlet samples.

9. The nitrate as nitrogen concentrations were at levels considered normal for unpolluted lakes.

10. Nitrite as nitrogen concentrations tended to be higher than those expected in natural waters.

11. Based on inorganic nitrogen levels, Wall Lake would be classified anywhere from ultra-oligotrophic to meso-eutrophic.

12. Based on the organic nitrogen levels, Wall Lake would be classified as eutrophic to hypereutrophic.

13. Nitrogen is the nutrient that will tend to be limited in Wall Lake.

14. The mean in-lake Trophic State Index (TSI) was 91.55 (standard deviation was 7.44). This level indicates that Wall Lake would be extremely productive. However, based on limited TSIs for chlorophyll *a* (two samples with a mean TSI of 58.5), the lake does not support this high level of production, suggesting limiting factor other than phosphorus.

15. Phosphorus and nitrogen loads into Wall Lake in 1979 were well above the level that would be considered dangerous.

Conclusions and Recommendations

Wall Lake is a shallow, very eutrophic lake that tends toward nitrogen limitation. Loads to the lake from Sites 46WA02 and 46WA03 are dangerously high. In particular, Site 46WA02 contributed 88% of the phosphorus and 85% of the nitrogen to the lake. A

significant reduction in the nutrient load from this watershed would be beneficial to the lake.

Recommendations that are applicable to Wall Lake are as follows:

1. Identify sources of non-point source pollution by land use surveys, identification of agricultural practices, and by soil surveys.

2. Identify sources contributing to fecal coliform levels.

3. Identify Best Management Practices (BMPs) that would be applicable in the watershed to control non-point pollution.

Site	Description
Site 46WA01	This site is located at a latitude of 43 Deg., 31 Min., 44 Sec., and a longitude of 96 Deg., 57 Min., 10 Sec. Site 46WA01 is on the outlet just northeast of Wall Lake's southeast beach. T101N, R51W, Section 21.
Site 46WA02	Located at a latitude of 43 Deg., 31 Min., 57 Sec., and a longitude of 96 Deg., 58 Min., 11 Sec., in T101N, R51W, Section 21, this site is on the west inlet.
Site 46WA03	Located at a latitude of 43 Deg., 32 Min., 20 Sec., and longitude of 96 Deg., 57 Min., 54 Sec., in T101N, R51W, Section 21, the site is on the northwest inlet.
Site 46WA04	This site, which is on the northeast inlet, is located at a latitude of 43 Deg., 32 Min., 23 Sec., and a longitude of 96 Deg., 57 Min., 32 Sec., in T101N, R51W, Section 21.
Site 46WA05	Located at a latitude of 43 Deg., 32 Min., 19 Sec., and at a longitude of 96 Deg., 57 Min., 40 Sec., in T101N, R51W, Section 21, the site is in-lake off the north beach.
Site 46WA06	Located at a latitude of 43 Deg., 31 Min., 59 Sec., and at a longitude of 96 Deg., 57 Min., 15 Sec., in T101N, R51W, Section 21, the site is in-lake off the souteast beach.
Site 46WA14A	This site, which is near the outlet, is located at a latitude of 43 Deg., 31 Min., 17 Sec., and at a longitude of 96 Deg., 57 Min., 13 Sec., in T101N, R51W, Section 21, SE1/4.
Site 46WA2A	This site is in the west inlet bay (in-lake) and is sited at a latitude of 43 Deg., 31 Min., 58 Sec., and at a longitude of 97 Deg., 31 Min., 58 Sec., in T101N, R51W, Section 21, SW1/4.
Site 46WA3A	Located at a latitude of 43 Deg., 32 Min., 18 Sec., and at a longitude of 96 Deg., 57 Min., 55 Sec., in T101N, R51W, Section 21, NW1/4. This site is near the northwest inlet (in-lake).
Site 46WA4A	This site is in-lake near the northeast inlet at a latitude of 43 Deg., 32 Min., 21 Sec., and at a longitude of 96 Deg., 57 Min., 32 Sec., in T101N, R51W, Section 21, NE1/4.

V. Watershed Problems and Recommendations

A. Nutrient and Sediment Loading from Cropland/Grassland/Feedlot Runoff Problem:

Nutrient loading from the Wall Lake watershed during periods of runoff has helped create hypereutrophic conditions in Wall Lake. Data collected from inlet sites #2 and #3 indicate that the lake has been receiving extremely high loads of total phosphorus and nitrogen. Net nutrient loads in 1979, the only year for which flow data are available, amounted to 4.63 $g/m^2/yr$ for phosphorus and 21.25 $g/m^2/yr$ for nitrogen. These values are far in excess of permissible levels of loading which, for shallow bodies of water such as Wall Lake, are estimated to be less than 0.13 $g/m^2/yr$ P and 2.0 $g/m^2/yr$ N (Wetzel, 1975). The nutrient loads entering Wall Lake are more than sufficient to keep the lake in a hypereutrophic state. Specific sources of these high phosphorus and nitrogen loads have not been located although they may originate in runoff from eroding soils, fertilized croplands, livestock operations in the immediate watershed, and/or failing septic tank systems around the lake periphery.

The Soil Conservation Service (SCS) assessed the sediment input to Wall Lake from the surrounding watershed (Appendix D). The SCS determined there are few sediment problems of any consequence in the watershed contributing to Wall Lake due to potholes and sloughs trapping most of the sediment before it reaches the lake. Annual sediment yield amounts to 1,049 tons or about .05% of the lake volume.

The majority of nutrients and sediment were contributed by area 2, the largest drainage area within the watershed (Figure 8). Eighty-eight percent (88%) of the phosphorus came from this subwatershed

and 85% of the nitrogen. Sediment provided by area 2 to the lake amounted to 719 tons/year or 60% of the total watershed sediment yield. No feedlots are currently operating in this subwatershed which drains into Wall Lake from the west through a major intermittent tributary monitored by Site 2.

One livestock operation in the watershed is still active and impacting Wall Lake. This feedlot, monitored by Site 4, is located about 1/2 mile north of the lake within area 5 (Figure 8).

Recommendations:

Plans have been developed to construct a waste management system at the remaining active feedlot impacting Wall Lake. Construction of a drainage system and holding pond is expected to be complete by spring 1985 which should reduce or eliminate one source of nutrient and fecal coliform contamination to the lake (Lufco, Inc., written communication, 1984, Appendix G).

Sediment input from Wall Lake's tributaries is not a major problem at this time; but soluble nutrients entering the lake during periods of runoff appear to be severe. The Soil Conservation Service estimated 65% of the watershed land is in need of treatment to minimize erosion. Critical erosion areas (e.g. area 2) should be prioritized and BMP's outlined in the SCS report (Appendix D) should be implemented as needed. Current fertilizer application rates and timing should be analyzed and fertilizer management practices implemented where necessary.

If feasible, buffer zones about 30 feet wide should be established on land adjacent to Wall Lake tributaries that presently is overgrazed, eroding or lacks adequate vegetative cover. These zones should be seeded for a

diversified vegetative cover, restricted as to use, and kept free of fertilizers.

B. Individual Septic Tank/Drainfield Systems

Problem:

In 1979 DWNR contracted with EPA to supply an aerial infrared photograph of Wall Lake to locate potential septic system problems. On May 9, 1980, infrared imagery by EPA identified eight (8) homes, out of a total of 70 residences on the perimeter of Wall Lake, that had surface failures of their on-site waste disposal systems.

Some septic tank surface failures may not have been detected. Dense tree cover obstructed aerial photography of a number of residential lots in the more developed areas of Wall Lake.

Virtually all Wall Lake housing is situated on soils poorly rated for sub-surface waste disposal. Lakeshore soils consist primarily of Buse-Kranzburg loams which have very severe limitations for septic tank absorption fields as a result of very slow permeability due to high clay content and low pore space. These soil characteristics greatly increase the probability of septic tank surface failure.

A door to door sanitary survey of 52 lakeside residences, conducted by DWNR in 1978-79, revealed few obvious system failures but indicated that over half of the septic systems were located less than 100 feet from the lakeshore contrary to current guidelines governing placement of sub-surface waste disposal systems near lakes and reservoirs (ARSD 74:03:01:11). The close proximity of many of the drainfields to the shoreline raises the

likelihood of septic tank leachate being transmitted to Wall Lake through the groundwater as well as increasing the probability of surfaced effluent reaching the lake through surface runoff.

A field investigation conducted by the East Dakota Conservancy Sub-District in 1983 disclosed septic tank problems (in seven of eleven Wall Lake residences surveyed) of a type that can be associated with soils of poor permeability (ponding, plugged lines, and septic tank effluent backups into basements and toilets). Although some of these malfunctions have been remedied by upgrading the tank systems involved, the total magnitude of the problem around Wall Lake remains difficult to determine, partially as a result of technical difficulties in monitoring and pinpointing individual sources of septic tank leachate.

East Dakota contacts with homeowners indicated that the practice of pumping wastewater directly into Wall Lake may still be prevalent. East Dakota employees observed several homes that had hoses leading to the lake. Several residents told East Dakota employees that at various times in spring and summer it was not uncommon to see a dozen or more hoses running to and from the lake.

Recommendations:

1. The Wall Lake Sanitary District should initiate procedures necessary for correcting the presently identified septic tank surface failures and waste disposal violations, and for a system of monitoring to detect future system malfunctions and violations as they occur. The district should serve as the sponsoring agency in efforts to secure

funds for upgrading malfunctioning systems and for planning and construction of facilities deemed necessary.

2. The Wall Lake Sanitary District should promote homeowner education through public meetings, explaining operation/maintenance and promotion of efficient systems through seminars and brochures.

3. The District should promote voluntary compliance in renovation of malfunctiong systems.

4. Regulatory agencies should enforce current regulations concerning installation and maintenance of individual wastewater systems and review of applicable zoning regulations.

VI. In-lake problems and recommendations

A. Eutrophication

Problem:

Wall Lake is hypereutrophic based on a method known as the trophic state index (TSI). The TSI rates three parameters: total phosphorus values, Secchi disk depth visibility readings, and chlorophyll *a* concentration (a measure of algal production). These parameters are utilized as indicators of the trophic status of a lake for use in comparison to other lakes. The trophic index ranking scale is from 1 to 100 for each parameter. A low value indicates nutrient poor (oligotrophic) conditions while a high value is indicative of nutrient rich (eutrophic) conditions. Mean Wall Lake TSI values for total phosphorus, chlorophyll *a*, and Secchi disk visibility were 96.7, 58.4, and 49.2, respectively.

Extremely high phosphorus levels and elevated total nitrogen concentration at in-lake sites were more than sufficient to maintain dense blue green algal blooms in Wall Lake during summer and fall. Decay of large algal masses in late autumn and winter may be capable of producing the severe oxygen depletion and subsequent increases in ammonia levels observed during ice cover in Wall Lake. Both of these conditions are detrimental to fish and other aquatic organisms.

Recommendations:

Major emphasis should be placed on reducing nutrient loads from the watershed by using BMPs on cropland and grassland. Efforts need to be made toward upgrading malfuncting septic tank systems around the perimeter of Wall Lake. In-lake treatment may at first show an improvement in water quality; however, continued excessive nutrient loadings from the watershed and failing septic tanks will eventually return the lake to a degraded state.

Chemical phosphorus precipitation should be considered as a possible in-lake treatment if proven cost effective by appropriate feasibility studies. This method involves the application of a chemical such as aluminum sulfate (alum) to the lake surface to tie up the soluble phosphorus which forms a precipitate, settles out, and creates a partial bottom seal. This treatment may have to be repeated every 1 to 3 years depending on conditions.

B. Lake Sediment

Problem:

In addition to the nutrients from sources in the watershed, the bottom sediments may be a significant source of excess nutrients contributing to Wall Lake's problems. Two studies have been conducted to address this issue; one by the Corps of Engineers and another by Augustana Research Institute of Augustana College, Sioux Falls, South Dakota.

The U.S. Army Corps of Engineers in the Wall Lake dredging feasibility study (Appendix A), estimated that 7.8% of the bottom sediments are composed of organic or humic material. The COE further estimated that 56.8 tons of phosphorus and 11.3 tons of nitrogen would be removed by implementing their recommended dredging alternative. Following dredging, the COE estimated that at the present rate of sedimentation more than 300 years would elapse before Wall Lake returned to present trophic conditions.

After additional sediment core sampling, the COE concluded that about 50 acres (29%) out of a total 172 acres of lake bed could be dredged 2 feet instead of the full 4 feet originally planned, without appreciably reducing the quantity of nutrients removed. This reduction in dredging is possible due to core samples that show nutrient concentrations in certain areas of lake bottom decrease at depths of 2 feet below the sediment surface (Addendum to the Wall Lake Dredging Feasibility Study, Wall Lake, South Dakota, Corps of Engineers, Omaha District, Appendix A). Water quality improvements after dredging would result from the decreased effect of wind-induced water turbulence over the now deeper-lying, more compacted bottom sediments. The stirring and suspension of bottom sediments by water

moving over a lake bed surface is a major factor involved in the release of nutrients into the water column of shallow lakes (Ibid.).

DWNR submitted the COE dredging proposal to the U.S. EPA in January, 1981, as a 314 Clean Lakes Project. The U.S. EPA (Ron Eddy, written communication, December 19, 1981, Appendix H) concluded that insufficient data existed to justify funding for a dredging proposal. The water quality assessments used for the January, 1981, Clean Lakes dredging proposal were inadequate to determine if dredging would solve the in-lake water quality problems. Specifically, questions remained about the cycle of nutrient availability in the bottom sediments. For example, under anoxic conditions, nutrient release is accelerated. However, the lake is shallow and at least during ice free periods it is not anoxic due to wind stirring. Another question posed by EPA was whether dredging alone will improve the water quality due to significant nutrient inputs from watershed tributaries and individual septic tank systems around the perimeter of Wall Lake.

In response to the EPA comments on the Wall Lake dredging proposal, DWNR initiated a study to determine the extent of nutrient release from the lake bottom sediments and gathered more information on nutrient loadings to the lake from the watershed. Results of the sediment nutrient release study conducted by Augustana Research Institute (Dorband, 1983) did not indicate that the bottom sediments contributed appreciably to nutrient loading in Wall Lake. The sediments appeared to act as a nutrient sink rather than a source of nutrients to the water column for most of the study period. This was particularly evident with regard to the movement of phosphorus. Nitrogen in the form of ammonia and nitrate was only occasionally released into the overlying water. In general, movement (flux) of nutrients between

the sediments and overlying water appeared to be slow and mainly in the direction of the sediments. The study suggested that little is to be gained in terms of nutrient load reduction by dredging the bottom sediments in Wall Lake.

Recommendations:

It is apparent that high nutrient concentrations are present in Wall Lake sediments (COE Addendum) and it is evident that their contribution to the nutrient load of the overlying water column has so far not been adequately assessed. The contribution of bottom sediments to the lake nutrient budget remains an unresolved issue. The Corps of Engineers concluded that 56.8 tons of phosphorus and 11.3 tons of nitrogen would be removed during the dredging process thereby decreasing nutrient availability; Augustana Research Institute, on the other hand, found the bottom sediments to be a "nutrient sink" limiting the availability of these nutrients to the overlying water column. Additional study, including use attainability analysis, will be necessary to determine whether dredging will assist in achieving the full range of designated beneficial uses for Wall Lake.

Even if the issue of nutrient removal is not considered, deepening Wall Lake by dredging may still be beneficial in terms of extending the useful lifespan of the lake and improving its overall recreational potential. Beneficial uses that would be enhanced include fishing, swimming, and boating recreation. The frequency and severity of winter fish kills may be reduced as a result of the increased oxygen carrying capacity of the deepened lake.

C. Shoreline erosion

Problem:

Sediment input to Wall Lake from shoreline erosion represents a minimal lake-wide impact. SCS estimates lakeshore erosion provides 156 tons of sediment per year or 13% of total yearly sediment yield to Wall Lake (Appendix D). This represents less than .01% of the lake water capacity in acre-feet. The major impact of shoreline erosion is localized and results in the gradual loss of lakeshore property, the degradation of sections of beach, elevated turbidity of near-shore water and siltation of bottom substrates. Beneficial uses affected are immersion recreation and shallow water habitat for fish and other aquatic life. Principal areas of erosion in Wall Lake are three relatively short sections of shoreline (40 to 100 feet) on the western, northeastern, and southeastern shores of the lake. The shoreline in most developed areas has been adequately stabilized by local owners of lakeside lots.

Recommendations:

Lake shoreline stabilization normally involves shaping existing eroding banks to a flatter, stable slope by cut and/or fill, placing stone riprap on the new slope and establishing grass on the exposed areas above the riprap. A stabilization project for the eroding southeast shoreline had been approved on September 20, 1984 (P.M. Kappen, Minnehaha Conservation District Manager, personal communication). Construction is expected to commence in the spring of 1985. The shoreline property is owned by the County and leased by the Girl Scouts. Construction costs will be shared jointly by Minnehaha County and the East Dakota Conservancy Sub-District.

VII. Implementation

A waste management system is being constructed on the premises of the remaining active feedlot impacting Wall Lake, and a section of eroding shoreline on southeast Wall Lake is scheduled to be stabilized in the spring of 1985. Other watershed improvement programs and restoration plans for Wall Lake have not been carried out to completion due to lack of landowner response according to the project coordinator (Appendix C).

VIII. Summary and Conclusions

The poor water quality of Wall Lake reflects the high nutrient contributions from both agricultural and domestic sources. Snowmelt and stormwater runoff from Wall Lake's watershed are the principal sources of phosphorus and nitrogen to the lake. Secondary sources of nutrients may be from failing septic tank systems around the lake periphery. In the past, feedlots may also have contributed nutrients and fecal coliforms to the lake.

Unless nutrient loads from these sources are greatly reduced, Wall Lake will continue to experience fish kills and remain a poor habitat for desirable game fish species.

Remedial measures to reduce nutrient and sediment input should be directed toward watershed stabilization such as conservation tillage, and fertilizer management. Septic tank leachate into Wall Lake may be reduced or eliminated by upgrading faulty on-site waste disposal systems or the construction of centralized waste collection systems.

Following implementation of the above measures, further reductions in nutrient load may be realized by chemical phosphorus flocculation and dredging two to four feet of Wall Lake bottom sediment.

IX. Literature Cited

Carlson, R.E. 1977. A Trophic State Index for Lakes. Limnology and Oceanography. 22:361-369.

Dorband, W.R., 1983. Sediment nutrient flux in Wall Lake, South Dakota. Augustana Research Institute, Sioux Falls, South Dakota. 80 pp.

Koth, R.M., 1981. South Dakota Lakes Survey, South Dakota Department of Water and Natural Resources, Office of Water Quality, Joe Foss Building, Pierre, South Dakota 57501. 688 pp.

Reckhow, K.H., M.N. Beaulac, and J.T. Simpson. 1980. Modeling Phosphorus Loading and Lake Response Under Uncertainty; A Manual and Compilation of Export Coefficients. United States Environmental Protection Agency. EPA 440/5-80-011.

Soil Survey of Minnehaha County, South Dakota, 1964. U.S. Department of Agriculture, Soil Conservation Service in cooperation with the South Dakota Agricultural Experimental Station, Series 1958, No. 30. 102 pp.

U.S. Environmental Protection Agency. 1976. Quality Criteria for Water. U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency. 1980. Clean Lakes Program Guidance Manuel. U.S. Environmental Protection Agency, EPA-440/5-81-003.

Wetzel, R.G., 1975. Limnology. W.B. Saunders Company, Philadelphia. 743 pp.

B30603AR.wq

Appendix A

Wall Lake Dredging Feasibility Study Report and Addendum

WALL LAKE, SOUTH DAKOTA

WALL LAKE DREDGING

FEASIBILITY STUDY

U.S. ARMY CORPS OF ENGINEERS, OMAHA DISTRICT

MARCH 1980

WALL LAKE, SOUTH DAKOTA

DREDGING FEASIBILITY STUDY

TABLE OF CONTENTS

Item	Page
Summary	1
The Study and Report	1
Authority	2
Study Objectives	2
Study Area	3
Problem Identification	4
Comparison of Alternatives	6
Wall Lake	
Plan Description	8
Disposal Sites	9
Cost	10
Dredging Timetable	10
Water Budget	11
Discussion of Expected Improvements	11
Water Quality Analysis	13
Copper	13
Pesticide Analysis	15
Nitrogen and Phosphorus (Sediments)	16
Nitrogen and Phosphorus (Overburden Water)	17
Elutriate Tests	17
Plan Implementation	19
Conclusions	19

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

No.	Item	Page
I	Comparative Watershed Data for Madison and Wall Lakes	4
II	Pertinent Data	8
III	Cost Estimate	10
IV	Copper Concentrations	14
V	Pesticide and Herbicide Analysis Results	15
VI	Sediment - Nutrient and Organic Concentrations	16
VII	Overburden Water - Nitrogen and Phosphorus Concentrations	17
VIII	Parameter and Elutriate Concentration Averages and Ranges	18

LIST OF PLATES

No.	Title
I	Wall Lake Location Map
II	Wall Lake Bottom Topography and Proposed Dredging Area
III	Potential Dredged Material Disposal Sites
IV	Sediment and Overburden Water Sampling Locations

SUMMARY

Five alternatives were considered for the purpose of improving Wall Lake water quality with alternative "a" being the selected plan. This alternative was selected on the basis of least cost and greatest lake improvement potential. The selected plan involves dredging 172 acres of Wall Lake to a depth 4 feet greater than the existing depth. This quantity of dredging would result in the removal of 1.11×10^6 cubic yards of sediment and would require approximately 145 acres of disposal area.

It is estimated that 56.8 tons of phosphorus and 11.3 tons of nitrogen would be removed during the dredging process. It has also been estimated, because of small annual sediment depletions, that more than 300 years would be required for Wall Lake to return to its present state. In addition, the dredging program, once completed, would result in a decreased potential for winterkill, a decreased nutrient availability and associated decreases in algal bloom severity, decreases in turbidity associated with wind generated turbulence, improved fishery management potential, an esthetically more pleasing lake, and potential agricultural benefits.

THE STUDY AND REPORT

This report presents the findings of the survey study conducted at Wall Lake, South Dakota.

AUTHORITY

The Wall Lake dredging feasibility study was conducted under the authority of Section 22 of the Water Resources Development Act of 1974. Section 22, which is entitled "Planning Assistance to States", provides for the following:

"a. The Secretary of the Army, acting through the Chief of Engineers, is authorized to cooperate with any State in the preparation of comprehensive plans for the development, utilization and conservation of the water and related resources of drainage basins located within the boundaries of such State and to submit to Congress reports and recommendations with respect to appropriate Federal participation in carrying out such plans."

"b. There is authorized to be appropriated not to exceed $2,000,000 annually to carry out the provisions of this section except that not more than $200,000 shall be expended in any one year in any one State."

STUDY OBJECTIVES

The objectives of this study were to evaluate the costs and expected improvements which would accrue from various dredging alternatives. Dredging was previously selected as the method of choice for Wall Lake improvements because previous studies on sediment trap effectiveness conducted on similar lakes in the same geographic area indicated that these methods would produce, at best, only minimal results.

STUDY AREA

Wall Lake, shown on Plate I, is located approximately 10 miles west of Sioux Falls, South Dakota. This lake was formed during the late Wisconsin glaciation period and carbon-14 dating has indicated an age of approximately 13,000 years. At a pool elevation of 1559.5 feet M.S.L., this lake has a surface area of approximately 225 acres, an average depth of 9 feet, and a contributing drainage area of approximately 4.09 square miles. A contour map of the lake bottom, Plate II, indicates that the lake bottom is extremely flat, thus, the maximum depth and average depth are nearly equal.

Terrain in the upland drainage is undulating to nearly flat and is comprised of well drained silty soils formed in alluvium over sand and gravel. This area has an average annual precipitation of 23 inches, monthly averages range from 0.52 inches in January to 4.05 inches in June. Temperatures average about 46^0 F yearly with monthly values varying from an average low of 13.6^0 F in January to an averaage high of 70.8^0 F in August. Freezeup in the Wall Lake area normally begins in the latter part of November and ice-out begins in the late March or early April period. Water inflow data for Wall Lake are nearly nonexistent; however, the feeder streams are intermittent and the period of greatest flow normally occurrs during spring runoff.

PROBLEM IDENTIFICATION

The major problems at Wall Lake are the shallow depth and high nutrient levels, both of which contribute to the eutrophic or hypereutrophic condition. As a result of existing trophic conditions, algal blooms are frequent and severe during the summer months and winterkills are common during periods of ice and snow cover.

The shallow depths are essentially attributable to sedimentation. However, it is not known if the source is derived from land runoff, shoreline erosion contributions, wind blown dust and debris, or a combination of all three. Since sedimentation data are not available for Wall Lake, comparisons have been drawn from studies conducted on nearby Lake Madison. Table I presents comparative watershed data upon which sedimentation extrapolations to Wall Lake were made.

TABLE I

Comparative Watershed Data for Madison Lake and Wall Lake

Lake	Contributing Watershed Size (sq. miles)	Average % Slope of Immediate Watershed (percent)	Percent of Watershed Under Cultivation (percent)
Madison	30.6	2	70
Wall	4.09	3	70

It was estimated that the average annual depletion rate was 0.067 acre-feet per square mile of drainage area for Lake Madison. This figure, when multiplied by the contributing watershed size, resulted in an annual depletion of 2.1 acre-feet per year. Based on the similarity of the Wall Lake terrain, the average annual depletion rate for Wall Lake would be 0.27 acre-feet; this is probably liberal because Wall Lake does not have a well defined inflow channel.

High nutrient levels in Wall Lake are a function of the rich agricultural soils in the drainage basin. In addition, the shallow lake depths result in frequent stirring of the bottom sediments by strong winds which can impart sediment nutrients to the water column and, thus, provide additional nutrients for algal growth. Data are not present, however, to quantify the various nutrient inputs to Wall Lake.

Winter fish kills are also a function of Wall Lake's shallow depth. The small lake volume coupled with high organic productivity results in the rapid depletion of oxygen during periods of ice and snow cover, thus, fisheries management would be difficult.

COMPARISON OF ALTERNATIVES

Alternatives considered during the study include, (a) purchase of a horizontal auger cutterhead dredge by the Wall Lake Improvement Association and using it to deepen the lake by 4 feet, (b) using a conventional hydraulic cutterhead dredge to deepen the lake by 4 feet, (c) using a conventional hydraulic cutterhead dredge to deepen selected areas of the lake, (d) draining the lake and using conventional earthmoving equipment to remove the material, and (e) reduction of lake nutrient levels through nutrient inactivation by addition of chemicals. Each of these alternatives is discussed briefly in subsequent paragraphs.

Restorative techniques not considered include sediment entrapment, dilution, water level manipulation, aeration, and covering the bottom sediment. Sediment input to Wall Lake is low, thus, the effectiveness of sediment entrapment structures in retaining sediment-associated nutrients would produce, at best, only minimal results. This was clearly demonstrated by sediment trap effectiveness studies conducted on nearby Lake Madison. Dilution and water level manipulation were eliminated due to the lack of available water to make these techniques feasible. Aeration was eliminated since this technique would have little beneficial effect on a shallow, nonstratified, nutrient rich lake system. Covering the bottom sediments was not considered because of large areas of extremely shallow depths and the expense involved in covering the majority of the lake bottom. Because of the heavy recreational usage, maintenance of the bottom cover could be extremely difficult.

a. Alternative "a" is the selected plan and it will be discussed more fully in the section entitled "Plan Description."

b. Alternative "b" is identical to alternative "a" except for the difference in dredging equipment to be utilized. While this alternative would yield the same results, it was eliminated on the basis of cost. In addition, a greater volume of water would be removed from Wall Lake during the dredging process and this would result in reduced pool elevations.

c. Alternative "c", the dredging of only selected areas, was eliminated because it would yield a lesser volume increase in Wall Lake this would result in decreased benefits. In addition, wind generated sediment resuspensions would result in the refilling of the selectively dredged areas while the undredged area would continue to supply the overburden water with nutrients. This alternative would also result in a smaller total loss of sediment associated nutrients.

d. Draining Wall Lake and using terrestrial earth moving equipment, as proposed in alternative "d", was rejected because of the difficulty and time required to completely drain the lake. In addition, the cost of moving a cubic yard of material with terrestrial equipment is greater than moving a cubic yard of material via dredging.

e. Alternative "e" was eliminated because nutrient inactivation methods or algacides treat the symptom as opposed to the disease. Because of the shallowness and associated wind generated turbulence, alternatives of this sort would require frequent monitoring and treatment. In addition, the repeated use of flocculants and/or algacides over a period of years may result in detrimental environmental effects.

WALL LAKE

Plan Description

The pertinent data and cost estimates for the selected alternative are presented in Tables II and III, respectively. The plan involves dredging the lake to increase its depth by 4 feet inside 172 acres of lake bed surface defined approximately by the 1,550-foot lake bottom contour line as shown in Plate II. The 1,550-foot contour line limitation is necessary to avoid shoreline instability. Areas of possible shoreline erosion or instability resulting from the dredging activity should be protected with riprap. The proposed dredging would increase the lake volume by about 688 acre-feet, or 41 percent. Dredging would be accomplished by a special type of cutterhead dredge equipped with an 8-foot horizontal spiral auger, and the dredged material would be piped to diked terrestrial disposal areas. The total volume required for disposal would be about 145 acres. Although the time required for dredging could vary somewhat, it is expected that the lake improvement project could be completed in 21 months at a cost of $792,000.

TABLE II

Pertinent Dredging Data

Volume of Excavation, Cubic Yards	1.11×10^6 cu. yd.
Area of Excavation, acres	172 acres
Construction Period, Months	21 months
	7 ice-free month/year
Dredging Plant:	
Dredge, hydraulic horizontal auger cutterhead	9' x 13 5/8"
Pipeline diameter	8 in.
Flow, GPM	2000 @ 1160 RPM against 180' head
Production	to 120 cu. yds/hr
Dredged Material Disposal Areas:	
Area, acres - 220 @ 4 ft. depth or 145 @ 6 ft. depth	
Levee height, feet (average) 10 ft.	
Average detention time, days - 7 days	

DISPOSAL SITES

The dredged material disposal areas are shown on Plate III. The dredged material would be deposited in several different sites with total volumes of about 868 acre-feet and the areas would be about 145 acres. Most of the areas would have to be diked along at least half of their perimeter. The exact sites cannot be determined at this time because of inadequate topographical information and the fact that the actual sites have not been selected by local officials. A typical dike section would have a 10-foot average height, a 6-foot top width, and 1 on 3 side slopes. Actual dimensions would vary depending on stability requirements. Selected sites could possibly be compartmentalized into primary and secondary settling basins to facilitate disposal area management.

Because of the large quantities to be dredged, disposal would have to alternate between the various sites to allow adequate time for settlement and possibly redistribution by earthmoving equipment.

During the first 2 years, the dredged material would be deposited in containment areas situated so that the decanted water could be returned to the lake. In the final year of dredging, the decanted water would be brought up to acceptable quality and released into the outflow channel below the lake.

COST

Cost figures for the proposed dredging of Wall Lake are shown in Table 3. Estimates are based on the assumption that:

(1) the Wall Lake Improvement Association will purchase a dredge capable of at least 30 percent production efficiency;

(2) the Wall Lake Improvement Association will hire the necessary operators to run the dredge and the contractors to build and maintain the

containment areas; and

(3) the Wall Lake Improvement Association will engage a qualified engineer to devise a detailed plan and supervise its execution.

TABLE III

COSTS

Items	Cost
Purchase of Dredge, Accessories and Booster Pump	$150,000
Fuel and Maintenance for Dredge	127,000
Build Containment Area Dikes (w/20 yd scraper - 13125 ft.)	55,000
Build Road Crossing Culverts, Wiers, and Drainage Channels	25,000
Salaries	242,000[1/]
Contingencies	90,000
SUBTOTAL	689,000
Engineering and Design	55,000
Supervision and Administration	48,000
TOTAL PROJECT COST	$792,000

1/ Salary Breakdown
$16.00 per hour, 24 hours per day, 7 days per week
2-3 man crew per shift.

DREDGING TIMETABLE

Dredging could commence as soon as weather and ice conditions would permit the completion of containment area construction in the spring of 1980. Assuming a production rate of 1,800 cubic yards per day, the monthly dredge rate would be 54,000 cubic yards. At this rate, the total volume

of 1.11 million cubic yards could be dredged in about 21 months or three 7-month dredging seasons. Dredging rates can sometimes be highly variable because of the many factors involved, such as weather and wind conditions, maintenance problems, and operator experience.

WATER BUDGET

Investigations conducted by the South Dakota Geological Survey indicated that the ground water connection with Wall Lake is minimal. This being the case, lake levels during the dredging process would be decreased and the resultant levels would be dependent upon return flows and precipitation.

The initial volume of water in Wall Lake at the beginning of dredging would be approximately 1,686 acre-feet. At the end of the initial month of dredging, this value would be reduced by 111 acre-feet. As dredging continues through the next 6 months, the volume of clarified water available for return to the lake would be similar to the volume removed from the lake minus evaporation losses and water still contained in the dredge disposal areas. Assuming normal precipitation, the lake level would be reduced by less than 1 foot. Further water level decreases would result if the water removed during dredging is utilized for irrigation. It is proposed that the decanted water from the dredging operation would be returned to Wall Lake during the first 2 years of dredging.

Water levels in Wall Lake would be further decreased during the third year of dredging since water removed via dredging would be released to the Wall Lake outflow channel.

DISCUSSION OF EXPECTED IMPROVEMENTS

Several improvements to Wall Lake can be expected to occur as a result

of this proposed dredging plan. These improvements are discussed in the following paragraphs. It should be noted, however, that precise quantification of the improvements is not possible since algal blooms, fish kills, and other Wall Lake aspects may vary with existing environmental conditions.

Dredging 172 acres of Wall Lake to a depth 4 feet greater than the existing depth will have the effect of reducing wind induced bottom sediment resuspension. The increased depth would decrease the magnitude of wind generated wave energies available to resuspend bottom sediments. In addition, assuming sediment homogeneity, the bottom sediments remaining after dredging would have been compacted, because of the overlying sediment weight; this would have been compacted, because of the oeverlying seditment weight; this would increase the magnitude of energy necessary to cause sediment resuspension. This effect would result in a decreased nutrient supply available for algal growth. Since annual sediment depletions are small, approximately 2.1 acre-feet per year, it is estimated that more than 300 years would be required for Wall Lake to return to its existing state.

Sediment associated nutrients would also be removed from the Wall Lake ecosystem. It is estimated, assuming approximately equal nutrient distribution throughout the dredged sediments, that approximately 11.3 tons of nitrogen and 56.8 tons of phosphorus would be removed from the Wall Lake ecosystem via the proposed dredging action.

The possibility of winterkills would also be reduced with the proposed dredging. Assuming a dissolved oxygen concentration throughout the water column of 9 mg/l immediately before freezeup, Wall Lake would contain approximately 24.7 tons of oxygen. As a result of the increased lake volume because of dredging, Wall Lake would contain approximately 33.1 tons of dissolved oxygen. Obviously, the larger volume of oxygen could ease or prevent fish kills depending upon the severity of snow cover conditions. The

increased overwinter oxygen conditions would facilitate fisheries management efforts.

In addition to the expected improvement previously discussed, some agricultural benefits could also result from this project. Decanted water at the dredge material disposal sites could be utilized as irrigation water during the dredging period. Since this water would contain large quantities of ammonia nitrogen and lesser quantities of phosphorus, it is assumed that this water would be beneficial for agricultural purposes. The sediments dredged from Wall Lake would also contain large quantities of nitrogen, phosphorus, and other nutrients. These sediments may be utilized as agricultural soils. However, the presence of copper would necessitate testing before this soil can be utilized for agricultural purposes.

WATER QUALITY ANALYSIS

An analysis of water quality data pertinent to the Wall Lake dredging project is presented in the following paragraphs and sampling locations are shown in Plate IV. Historic limnological data are contained in the Environmental Protection Agency National Eutrophication Survey Working Paper No. 627 and the State Lakes Preservation Committee's "Plan for the Classification-Preservation-Restoration of Lakes in Northeastern South Dakota."

COPPER

Since it was indicated that copper sulphate had been used as an algacide in Wall Lake for a period of 20 to 30 years, tests were conducted to determine copper accumulation in mud and the problem potential if the dredged material be utilized for agricultural purposes. Table 4 below indicates copper concentrations present in mud, overburden water, and water after elutriation.

TABLE IV

Copper concentrations in mud, overburden water, and elutriated water.

Sampling Site	Copper Concentration		
	Mud	Overburden Water	Elutriated Water
	mg/kg dry wt.	mg/l	mg/l
A	22.2	-	-
B	29.3	-	-
C	25.7	0.01	0.06
D	37.2	-	-
E	14.4	0.00	0.00
F	5.7	0.00	0.00

The above data indicate that the copper appears to be adhered to the sediment particles and would not be released to the water column in appreciable quantities during dredging operations. While the range of copper indicated in Table IV is well within the range of copper concentration found in agricultural soils, tests should be conducted to insure the suitability of bottom sediment before it is used as or incorporated into agricultural lands. Environmental Protection Agency (EPA) publications indicate that the minimum concentration of copper which begins to exhibit toxicity to some agricultural plants is 100 ug/l. As indicated in Table IV, the Wall Lake mud copper concentrations are many times this minimum value. The EPA publication, Quality Criteria for Water, 1976, further states that adverse copper effects can be easily overcome by the addition of materials such as lime, phosphate fertilizers, or iron salts to the soil. Although not quantified in this instance, large quantities of iron would be released during Wall Lake dredging operations. Since released iron is rapidly oxidized and precipitated, it tends to inactivate both other metals and orthophosphates. However, since copper is present in extremely large quantities, tests should be conducted to determine the effect of copper concentrations upon agricultural crops before it is used for agricultural purposes.

PESTICIDE ANALYSIS

Pesticides and herbicides should present little or no problem in terms of dredging or dredge material disposal, as indicated in Table V.

TABLE V

Pesticide and Herbicide Analysis Results*[1/]

Pesticide or Herbicide	Test Value in Mud	Test Value in Water
Organo-Chlorides		
Lindane	Less than 0.02 mg/l	Less than 0.02 mg/l
Heptachlor	Less than 0.02 mg/l	Less than 0.02 mg/l
Aldrin	Less than 0.02 mg/l	Less than 0.02 mg/l
DDE	Less than 0.02 mg/l	Less than 0.02 mg/l
Dieldrin	Less than 0.02 mg/l	Less than 0.02 mg/l
Endrin	Less than 0.02 mg/l	Less than 0.02 mg/l
DDD	Less than 0.02 mg/l	Less than 0.02 mg/l
DDT	Less than 0.02 mg/l	Less than 0.02 mg/l
Organo-Phosphates		
Diazinon	Less than 0.02 mg/l	Less than 0.02 mg/l
Methyl Parathion	Less than 0.02 mg/l	Less than 0.02 mg/l
Malathion	Less than 0.02 mg/l	Less than 0.02 mg/l
Parathion	Less than 0.02 mg/l	Less than 0.02 mg/l
Ethion	Less than 0.02 mg/l	Less than 0.02 mg/l
Atrazine	0.19 mg/l	Less than 0.02 mg/l
Sencor	Less than 0.02 mg/l	Less than 0.02 mg/l
Treflan	Less than 0.02 mg/l	Less than 0.02 mg/l
Toxaphene	Less than 0.02 mg/l	Less than 0.02 mg/l
Chlordane	Less than 0.02 mg/l	Less than 0.02 mg/l

1/ * The 0.02 value represents the lower detection limit.

As indicated, all pesticides and herbicide values, with the exception of Atrazine, are below the lower detection limits. The Atrazine value of 0.19 mg/l was obtained from a mud sample at sampling site A. However, elutriation tests indicated that Atrazine was not released to the water column upon stirring the bottom muds and allowing them to resettle. It appears that the Atrazine is adhered to the soil particles.

If these bottom muds were used as or incorporated into agricultural land, or if the settling pond water were used for irrigation purposes, no detrimental effects would be expected to occur as a result of residual pesticides or herbicides.

NITROGEN AND PHOSPHORUS (SEDIMENTS)

Sediment data indicate that nitrogen and phosphorus concentrations are high and exhibit large variations between sampling points. These data are presented in Table VI.

TABLE VI

Sediment-Nutrient and Organic Concentrations

Sampling Site	Ammonia Nitrogen mg/l	Nitrate Nitrogen mg/l	Total Phosphorus mg/l	Loss on Ignition percent
A	8.10	0.21	111	3.2
B	1.06	16.88	123	12.9
C	15.97	1.10	113	12.8
D	25.11	0.48	137	12.3
E	3.33	0.34	301	5.1
F	0.29	0.03	207	0.7

These data indicate that Wall Lake muds could be incorporated into or used as agricultural soils on a nutrient basis. Factors such as copper concentrations could limit agricultural usefulness however.

Loss on ignition data indicates that the bottom muds are composed of an average of 7.8 percent organic or humic material. This level of organic material could improve water retention capabilities if it were used as or incorporated into agricultural soils.

NITROGEN AND PHOSPHORUS (OVERBURDEN WATER)

A comparision between overburden water data taken for purposes of the Wall Lake dredging study and historic data compiled by the Environmental Protection Agencies' National Eutrophication Survey generally indicates agreement between nitrogen concentration levels while historic phosphorus data indicated lower average concentrations. This difference in phosphorus is most likely a reflection of limited sampling, both spatially and temporally, as opposed to any real differences on trends in phosphorus concentrations.

TABLE VII

Overburden Water Nitrogen and Phosphorus Concentrations

Sampling Site	Ammonia Nitrogen mg/l	Nitrate Nitrogen mg/l	Total Phosphorus mg/l
C	0.27	0.00	0.57
E	0.15	0.00	0.59
F	0.20	0.00	0.02
1/ Historic EPA Averages		Inorganic Nitrogen 0.16	0.19

1/ Inorganic nitrogen is a combination of ammonia, nitrate, and nitrite nitrogen with the nitrite component normally representing a very small portion of the total.

The above data clearly indicate that excess nutrients are a highly significant part of Wall Lake's existing problem.

ELUTRIATE TESTS

Table 8 indicates sampling averages and ranges for sediment, overburden water, and elutriate tests. As indicated by the elutriate test, nitrogen could be expected to show large increases during the dredging

process while the sediments appear to have an affinity for phosphorus which will result in a phosphorus decrease within the water column. Iron and manganese could also be expected to show large releases from the bottom muds to the water column; this is characteristic for most bottom sediments. These parameters were not measured, however, since they normally have relatively small effects on aquatic biota. In addition, iron precipitates readily when exposed to oxidizing conditions, such as those that occur in aerobic water columns. The precipitation of iron results in the formation of coprecipitates with other metals and orthophosphorus.

TABLE VIII

Parameter and Elutriate
Concentration Averages and Ranges

Sample Average	Ammonia Nitrogen mg/l	Nitrate Nitrogen mg/l	Total Phosphorus mg/l
Sediment	8.98	3.17	165.33
Range	0.29-23.11	0.05-16.88	111-301
Overburden Water	0.21	0.00	0.59
Range	0.15-0.27	0.00-0.00	0.57-0.62
Elutriate	3.22	0.02	0.12
Range	0.86-5.30	0.00-0.04	0.03-0.26

This iron precipitation and associated coprecipitation would have a tendency to negate the detrimental effects resulting from high copper concentrations.

These tests also indicate that both the sediments and the excess water that would result from dredging activities have the potential to be utilized for agricultural purposes.

Sediment core samples at least 4 feet in length remain to be taken

at Wall Lake. Because of the difficulty involved in obtaining good core samples of this length from a boat, these samples will be taken through the ice and sent to the Corps of Engineers for analysis. The results of these analyses will be forwarded to the appropriate agencies as an addendum to this report.

PLAN IMPLEMENTATION

The study was conducted under the assumption that the dredging would be accomplished using funds from the Environmental Protection Agency's Clean Lakes Program. The Environmental Protection Agency has the authority to fund lake restoration projects under Section 314 and 104(h) of Public Law 92-500 (Clean Lakes Program). The Federal share of funding under the Clean Lakes Program is limited to 50 percent of the total project cost. The remaining 50 percent of the project cost must be paid by non-Federal interests. It is anticipated that the dredging project at Wall Lake would be done with Clean Lakes Program Funds.

CONCLUSIONS

Alternative "a" (as discussed in the report) is the plan selected on the basis of least cost and greatest lake improvement potential. The selected plan would result in numerous lake improvements (including potential agricultural benefits).

While the Corps of Engineers has no Congressional authority to initiate or execute projects of this type, this program could be eligible for funding under programs of other Federal agencies.

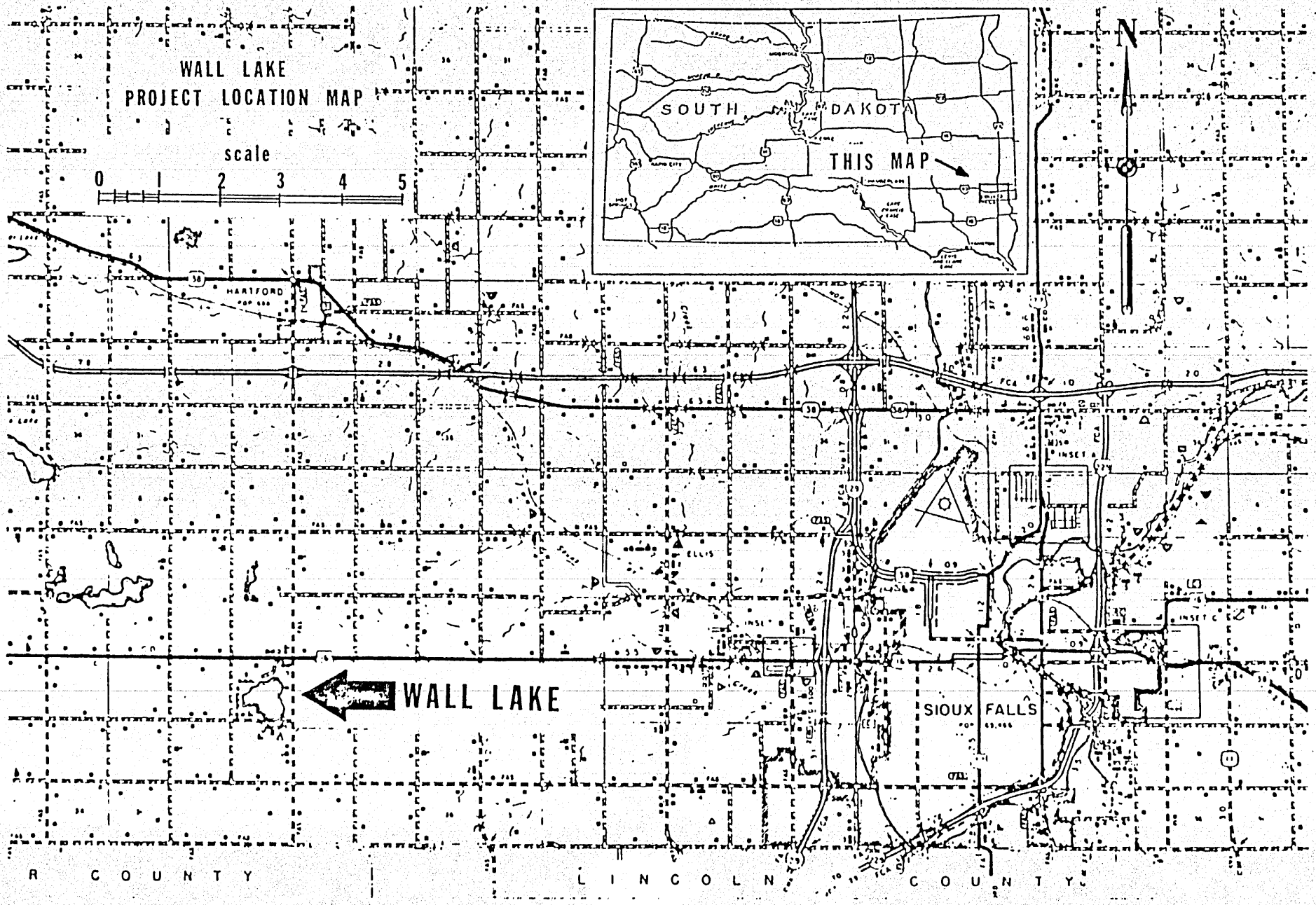


Plate I – Wall Lake Location Map

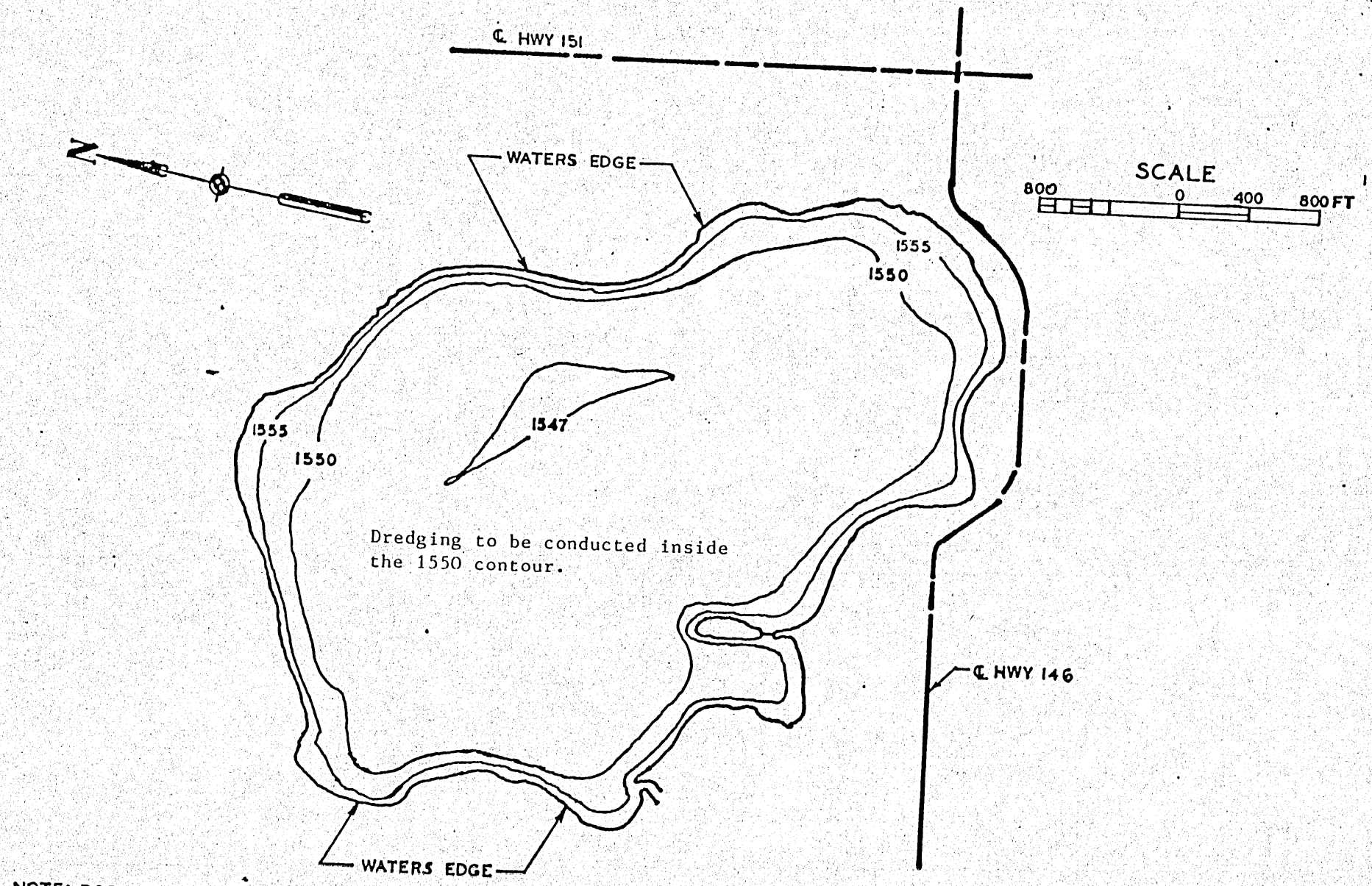
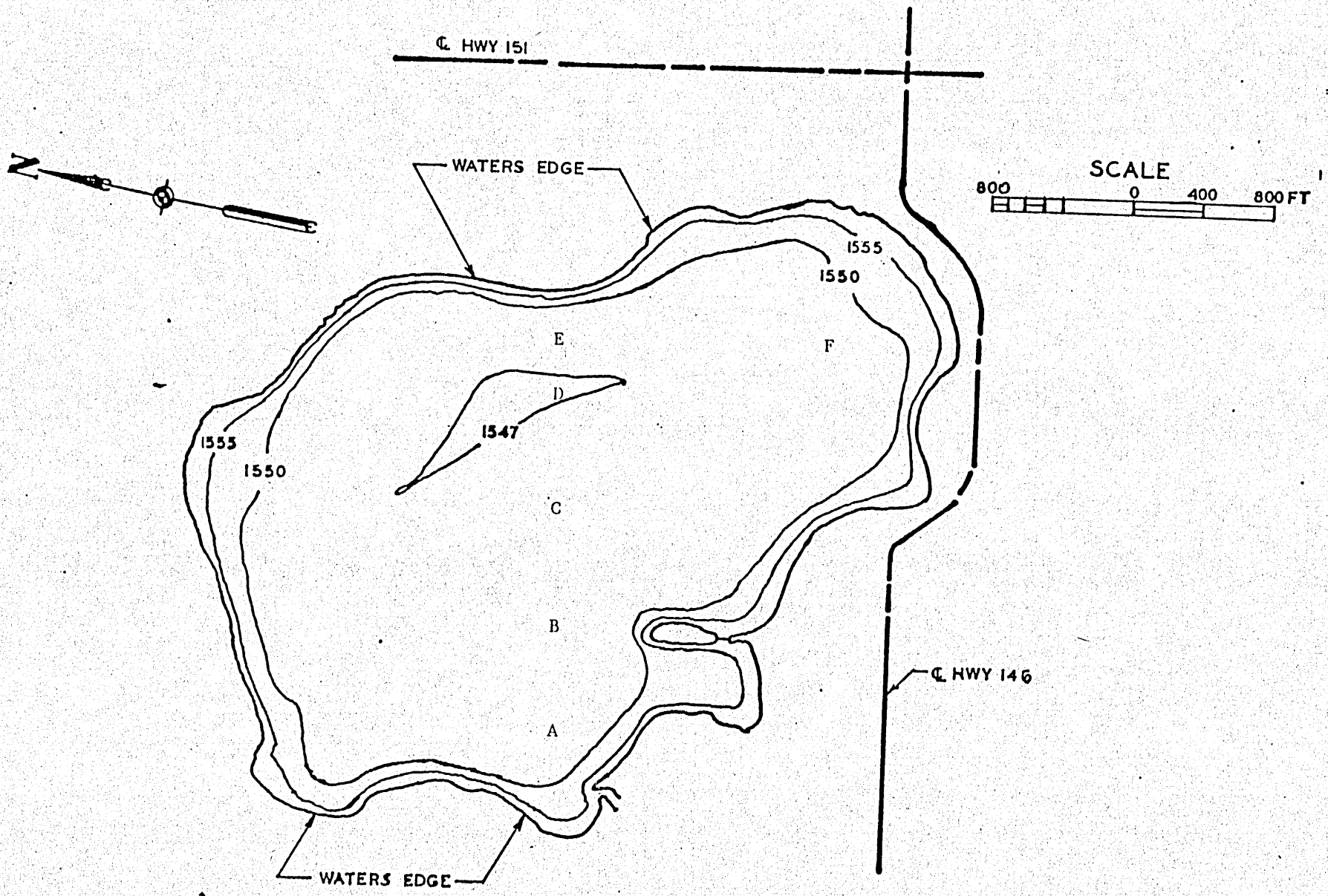


Plate II – Wall Lake bottom topography
and proposed dredging area.

Wall Lake
School No 61
21
17
5
1600
1610
1620
1570
1580
1590



NOTE: POOL ELEVATION ON 19 JUNE 1979 = 1559.5 MSL

Plate IV – Sediment and overburden water sampling locations

ADDENDUM
TO THE
WALL LAKE DREDGING
FEASIBILITY STUDY
WALL LAKE, SOUTH DAKOTA

CORPS OF ENGINEERS, OMAHA DISTRICT

INTRODUCTION

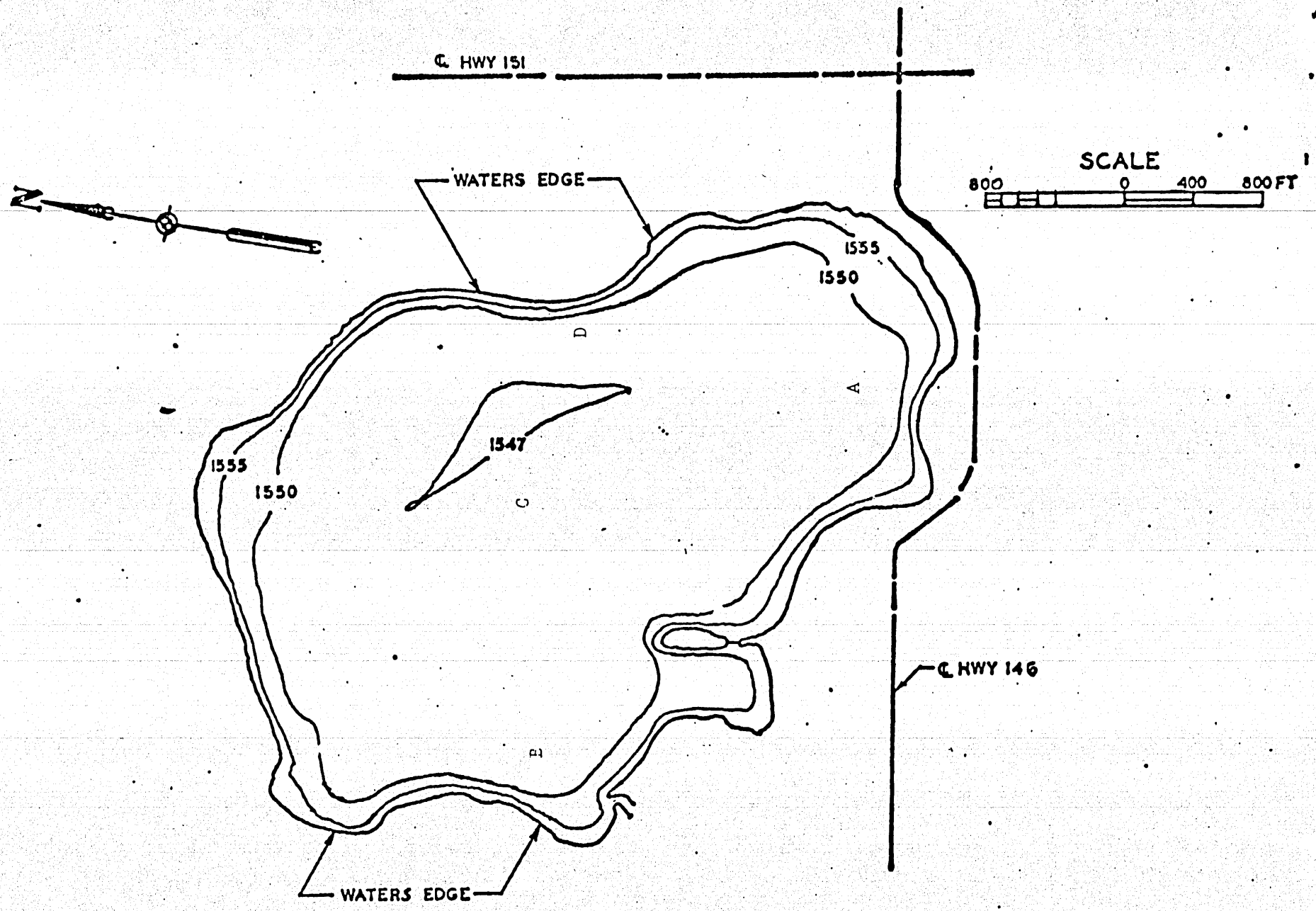
As stated in the section entitled "Elutriate Tests" (page 19), this report is provided as an addendum to the "Wall Lake Dredging Feasibility Study, Wall Lake, South Dakota".

METHODS

Because of the difficulty involved in obtaining four foot core samples from a boat, it was decided to obtain such samples through the ice which provided a more stable working platform. However, the nature of the lake bottom sediments and the coring device utilized, single four foot cores could not be obtained. As a result of these limitations, it was decided to acquire a first core of the maximum obtainable length with the second, and in one instance, third cores obtained by attempting to insert the core sampler in the hole created by first core. Thus the first core sample would act as a guide for successively deeper cores. These attempts were only partially successful since the second and third core samplings would, inevitably, capture some sediments near the mud-water interface before penetrating the hole created by the first core sample. After the core samples were obtained, they were wrapped in plastic and shipped to the Missouri River Division for analysis. All sampling sites are indicated on Plate I.

RESULTS

Chemical analysis of all core samples is shown in Table I and the results of these analyses for each of the sampling sites (Plate I) are discussed in the following paragraphs.



NOTE: POOL ELEVATION ON 19 JUNE 1970 = 1559.5 MSL

PLATE I
WALL LAKE CORE SAMPLING LOCATIONS

Site A. Sampling at this site, located near the Wall Lake outflow (Plate I) consisted of a single 24 inch core. The hardness of the sediments at this sampling site precluded the taking of deeper cores. Visual inspection of this sample indicated a high, but unquantified, percentage of sand which appeared to increase with depth. The density of this sample is indicated by the percent solids in Table I which clearly shows that site A exhibited the highest percent solids values. High sand quantites are also indicated by the fact that this site had the lowest chemical values of all sampled areas with nitrate nitrogen being the sole exception. Since nitrate nitrogen has a higher oxidative state than either ammonia or kjeldahl nitrogen, these values very likely represent an oxidative state conversion from ammonia to nitrate. Since the quantity of nitrate is extremely small when compared to either ammonia or kjeldahl nitrogen, total nitrogen values are still considerably lower than those obtained at all other sampling sites.

As indicated in Table I, all chemical parameters show definite decreases with depth clearly indicating lowered nutrient content and thus decreased nutrient availability should the upper sediments be dredged. In addition, because of relatively low nutrient content, it may be possible to achieve the desired benefits by dredging this area to a depth of two feet as opposed to the originally planned four feet.

Site B. Sampling at this site, located near the Wall Lake inflow (Plate I), consisted of three successive core samples totaling a depth of 56 inches. As noted in Table I and discussed in the Methods section of this report, successive sampling utilizing the previous core holes as a guide was only partially successful resulting in some unquantified mixing of mud-water interface sediments with deeper sediments. In general, however, deeper sediment samples showed a

TABLE I
Chemical Analysis of Core Samples[1/]

Sample	Percent Solids	Total Kjeldahl Nitrogen mg/l as N	Ammonia Nitrogen mg/l as N	Nitrate Nitrogen mg/l as N	Total Phosphorous mg/l as P	Copper mg/l as CU
A-1, 0-6 in.	62.3	2700	53	0.59	1200	9
6-12	75.1	1000	34	0.24	1040	5
12-18	80.6	400	21	0.16	860	3
18-24	77.4	100	28	0.13	840	6
B-1, 0-5 in.	43.6	4700	77	0.14	890	31
5-10	46.7	5400	85	0.08	1330	16
10-15	52.1	3800	76	0.19	1120	20
15-20	49.8	4100	75	0.12	750	20
*B-2, 20-26 in.	55.6	2600	71	0.14	1160	19
26-32	48.9	4100	91	0.25	1110	20
32-38	46.6	4600	78	0.14	890	19
**B-3, 38-44 in.	47.3	4600	87	0.14	1070	20
44-50	55.6	2500	69	0.14	1010	18
50-56	55.7	2900	76	0.08	1120	16
C-1, 0-6 in.	44.9	5400	91	0.42	1010	21
6-12	45.4	4900	94	0.30	1040	21
12-18	48.4	5200	126	0.06	940	20
18-24	46.5	5000	135	0.08	1110	19
24-30	44.2	4700	130	0.03	1120	18
30-36	50.9	3300	129	0.02	960	21
*C-2, 36-42 in.	44.8	5800	136	0.14	1070	19
42-48	43.9	5400	141	0.08	990	18
48-54	50.9	4300	133	0.08	1090	20
54-60	48.1	4500	153	0.06	1200	21
D-1, 0-6 in.	50.4	5800	82	0.22	1090	15
6-12	51.1	4900	108	0.11	1110	19
12-18	53.2	4100	80	0.11	1100	18
18-24	53.3	4000	62	0.11	1000	13
24-30	69.5	1700	36	0.11	1030	11
30-36	69.0	2200	40	0.11	1020	11

1/ All concentrations are expressed as dry sample weight. Ammonia and Nitrate were determined on water extracted from the sample and reported on a dry weight Basis.

Hydrochloric acid digestion was used to determine Copper concentrations.

* Second successive core sample.

** Third successive core sample.

greater degree of compaction and thus less interstitial water than did surface sediment samples. Total kjeldahl nitrogen samples showed definite decreases with depth ranging from an average concentration of 4500 mg/l in the top 20 inches, 3767 mg/l in the middle eighteen inches and 3333 mg/l in the lower 18 inch core sample. Copper concentrations also showed slight decreases with depth. Total phosphorous concentrations, while exhibiting some variations, appeared to be relatively evenly distributed throughout the sampled core depths. To what extent these distributions may have been affected by inflowing waters or wind induced turbulence acting upon the sediments cannot be determined.

As indicated in the Table I notations, ammonia and nitrate nitrogen concentrations were determined on water extracted from the sample. These parameters showed relatively even distribution throughout the sample. However, due to the increased compaction with depth and the resultant decrease in interstitial water quantity, ammonia and nitrate nitrogen would decrease with depth because of decreased water quantities even though they exhibit no decrease on a per unit basis. In addition, since kjeldahl nitrogen shows decreases with depth, less nitrogen is available for oxidative conversion to ammonia and nitrate forms.

These data appear to indicate that total nitrogen would be significantly reduced by dredging the upper four feet of sediment while copper concentrations would be slightly reduced. It would appear that phosphorous concentrations would remain at or near the original concentrations. Thus phosphorous reduction would be dependent upon reduced internal cycling resulting from decreased wind induced sediment resuspension due to greater water depths and greater sediment compaction.

Site C. Sampling at site C, located in the central area of Wall Lake consisted of two successive core samples totaling a depth of 60 inches. As noted in Table I and discussed in the Methods section of this report, successive sampling utilizing the previous core holes as a guide was only partially successful

resulting in some unquantified mixing of mud-water interface sediments with deeper sediments. Visual inspection of this site C core samples indicated a softer consistency of lower sand content that did core samples from other sites. Analysis results indicate that percent solids are similar throughout the depth of core sampling as are copper concentrations. All other parameters show slight increases with depth with the exception of nitrate nitrogen which decreased.

The site C data indicate that the central lake area consists of similarly compacted sediments with relatively similar or slightly increasing nutrient concentration throughout the depth of core sampling. Thus dredging to the proposed 4 foot depth would result in decreased internal nutrient cycling due to decreased wind induced sediment resuspension because of increased water depth.

Site D. Sampling at this site, located near the east edge of Wall Lake (Plate I) consisted of a single 36 inch core sample. Visual inspection of the core sample obtained at this site indicated that small gravel was present in the lower 30 to 36 inches of sample. Whether or not this is indicative of original lake bed proximity could not be determined with the existing samples.

This sampling site clearly showed the expected increase in percent solids and the expected decrease in nutrients with increasing sediment depth (Table I). Total phosphorous was the only parameter which showed relatively even distribution throughout the sample depth. As discussed under the Site A and B sections of this report, dredging of this area would result in the desired benefit of improved water quality and lake aesthetics.

CONCLUSIONS

As discussed in the Results section of this report, dredging Wall Lake would result in decreased nutrient availability and improved water quality in addition to benefits previously discussed in the "Wall Lake Dredging Feasibility

Study, Wall Lake, South Dakota." Data shown in this report indicates that sample areas A and D could be dredged to a depth of two feet as opposed to the originally planned depth of four feet without substantial loss of benefits. Arbitrarily assuming that the A and D sample sites are representative of a combined area of 50 acres, dredging these areas to a depth of two feet instead of the originally planned four feet would result in 161,000 fewer cubic yards of dredge material. This would represent a 14.5% reduction thereby reducing the required dredge disposal area to approximately 124 acres.

ENVIRONMENTAL EVALUATION

GENERAL CONDITIONS

Wall Lake is a shallow, fresh-water lake formed in glacial till about 13,000 years ago; it occupies 220 acres. Increases in its load of nutrients, organic matter, and sediment have been accelerated by agricultural and residential development.

Nearby land is predominantly cropland, the area being typical of rural eastern South Dakota. Some year-round residents live along the lakeshore. Numerous visitors use the lake for recreation, especially in summer.

Wall Lake supports a good bullhead fishery and the surroundings offer some habitat resources to wildlife. This habitat, however, is scarce and wildlife is not abundant.

Data on lake drainage, soils, and the climate are found in the Corps of Engineers Wall Lake Dredging Feasibility Study.

The lake and suggested dredge material disposal sites are located about 10 miles west of Sioux Falls in Minnehaha County, South Dakota, T. 101 N., R. 51 W., sections 15-19, 20-22, and 28-29. A single small outlet channel drains from the south end of the lake, through parts of this township, as well as through T. 100 N., R. 51 W.

SIGNIFICANT RESOURCES

The resources outlined in 40 CFR Part 35, Environmental Protection Agency (EPA) regulations for grant application, must be considered in the State's environmental evaluation. These resources are discussed in the following paragraphs. The effects of both the no-action alternative and the proposed dredging alternative are evaluated for each resource. Other measures that could be taken toward lake restoration are discussed at the end of this report.

A. Existing Residential Areas. The lake is bordered on about 50 percent of its perimeter by residential units. There are about 50 homes; most are in year-round use. There is also a Girl Scout camp adjacent to the lake.

B. Established Land Use Practices.

1. Agriculture. Seventy percent of the watershed is planted to row crops and there is some associated hayland and pasture. Three livestock feedlots are located within one-half mile of the lake.

2. Residential Development. Thirty percent of the shoreline is undeveloped, but is susceptible to development if economic conditions become suitably favorable to landowners. The area has recently been zoned "rural residential", facilitating such development.

3. Recreation. The Wall Lake area has a beach and boat dock facility, and is a recreation resource for the more than 90,000 residents of the Sioux Falls area. It is heavily used for many recreational activities, such as fishing, waterskiing, boating, swimming, sunbathing and picnicking. At times it has become congested to the point of being hazardous to users. Severe algal blooms do not seem to cause significant declines in overall recreational use.

C. Waste Treatment Management Plans. Current residences use septic tank/drain field systems. These contribute to high nutrient concentrations in the lake. Future residences would probably use similar systems. The sponsor of the proposed project will have to discuss whether current and future systems would conform with the areawide waste treatment management plans, administered by Minnehaha County.

D. Agricultural Land. The area's deep silty or loamy soils contribute to good crop productivity. The runoff from fields and feedlots contributes to high concentrations of nutrient materials in the lake, especially during spring thaw. If Wall Lake is dredged, farmlands would be used as dredge material detention

sites. Dredge supernatants and the dewatered sediments could be disposed of by spreading on the fields.

E. Scenic Land. There are several types of wetlands near the lake. They are the last of the many wetlands that once occupied the area. Also, several tree stands, not associated with active farmlands, are scattered in the area. A thin strip of woody growth remains along the undeveloped lakeshore segments.

F. Archeological/Historical Resources. Early American Indians may have been attracted to visit or camp near Wall Lake, which offers the best fishery within a 55-mile radius. The South Dakota State Historic Preservation Officer would have to give clearance to the proposed project. A survey would have to be conducted to locate and identify any cultural resources.

G. Energy Demands. There is currently a minor energy demand involved in the use of fuel for the State fishery stocking program. An undetermined demand for fuel results from the recreational activities of lake users. The effect of either alternative on fuel demand, for travel to the lake and recreational activities, is dependent on many variables. This effect is therefore undetermined, and in any case is considered insignificant. Other effects on fuel demand are considered below.

H. Noise/Air Quality. Because Wall Lake is in a rural location, the air quality is good and noise levels are low. Exceptions include the occasional smell of decaying algae and the noise of motorboats in summer.

I. In-Lake Chemical Treatment/Water Quality. The lake is subject to annual algal blooms. Extensive use of copper sulphate as an algacide in recent years has resulted in an accumulation of copper in lakebed sediments. The sponsor should address the effects of possible continued use of copper sulphate or other algacides. The project sponsor should also specify whether flocculants or coagulants would be added to dredge supernatant before its release onto fields or into the lake.

J. Flood Plains. The proposed project is not in a flood plain.

K. Dredging Lakeshore or Lakebed. The lake, occupying 220 acres, is uniformly shallow with very little emergent, floating or submerged vegetation. The lakebed is composed primarily of organic material, silts and clays. Perch spawning habitat occurs near the main inlet and good bullhead spawning habitat is abundant in the lake. The lake supports a sport fishery of predominantly bullheads.

If the lake was to be dredged, provisions would have to be made for detention of dredge materials, disposal of supernatants, and disposal of dewatered dredge sediments. Resources that would be affected by these activities include the farmland, the lake, and the outlet drainageway; and these would have to be addressed in the sponsor's environmental evaluation.

1. Chemical Qualities of Dredge Material. Analyses of the upper 18 inches of sediment, overburden water, and elutriate are shown in Tables 4-8 of the feasibility study. Lake sediments contain high concentrations of nitrogen and phosporous. The nutrients stimulate high algal productivity. Large die-offs and decay of algae, which can occur under winter ice and snow cover, use up oxygen and aggravate winter fishkills. The lake's shallow depth facilitates wind action on the sediments. This mixing makes the nutrients available for use by algae. Deepening the lake would be intended to reduce the degree of this mixing. Elutriate samples show that lake waters disturbed by dredging would have high concentrations of ammonia nitrogen and phosphorous. The water would also be very turbid. The projected ammonia levels could be lethal to fish but dredge design would tend to confine these effects of dredging to a small area.

2. Farmland. The dredge material would be held in detention basins on nearby farmland. One question yet to be answered is whether the 1.11 million cubic yards of sediment and approximately 3.0 million cubic yards of supernatant would be finally applied to agricultural fields.

3. The Lake. Dredging activity and dredge supernatant returns would degrade lake water quality. Lake water quality is described in the feasibility study and its addendum and in Section 1. above. A metal shroud which surrounds the specified type of dredge auger would help contain disturbance to a small area, but some dispersion of elutriate water beyond the dredging site would occur. The degree of this dispersion is unknown at the present time, and would partly depend on wind disturbance.

4. Outlet Drainageway. A single outlet, typically dry or intermittent, runs 12 miles from the south end of the lake through pastures to Skunk Creek. Two miles beyond that confluence, Skunk Creek enters the Big Sioux River. There are lowlands contiguous with the outlet drainageway, but it is reported that there are no wetlands in the drainageway.

If not used for irrigation, supernatant waters obtained during the last year of dredging would be released into the lake outlet, carrying associated nutrients and some sediment. The flow, if released evenly over the final 7-month work period, would average in the range of 1.10 c.f.s. to 2.20 c.f.s.

L. Wildlife and Habitat. Eight species of State protected animals, including the Federally protected bald eagle, occur in the region. There are also five plant species unofficially classified as endangered in the State; these include the white ladyslipper and prairie fringed orchid, both in the Smithsonian's Endangered and Threatened Plants of the United States. Several sources have indicated, however, that none of these species inhabit Wall Lake or its immediate surroundings.

The lake, although degraded, is a significant resource as a fresh-water lake. It supports algae, invertebrates, and a perennial population of bullheads, and it offers breeding habitat for introduced yellow perch. A State stocking program maintains populations of perch, northern pike, and walleye. Pike and walleye breeding habitats are not present in the lake.

Local mammals include the white-tailed deer, red fox, badger, raccoon, skunk, rabbits, tree squirrels, ground squirrels, mink, weasel, and muskrat. Some common birds are mourning doves, pheasants, partridges, and waterfowl such as mallards and snow geese.

The few wetlands remaining in the area serve as breeding habitat for birds and offer food and shelter to both resident and visiting wildlife. The nearby tree stands serve as islands of habitat for species not adapted to the surrounding cultivated fields, including migratory birds. The lakeshore vegetation provides cover for any wildlife visiting the lake and is a breeding, shelter, and food source for resident wildlife.

The lake outlet drainageway is largely dry. It passes through pastures over much of its length, and its value to wildlife is currently nominal. Skunk Creek is also an intermittent stream and is of moderate value to aquatic life.

ENVIRONMENTAL EFFECTS

A. Effects on Existing Residential Areas. Both the proposed project and the alternative of no action would appear to cause no significant displacement of or disturbance to residents and would not deface residential property.

B. Effects on Established Land Use Practices

1. Agriculture.

a. Effects of No Action. No action would have no effect on agricultural land use.

b. Effects of Dredging. Four aspects of the proposed dredging could have effects on the nearby farm operations. These effects are discussed in detail in the following sections.

(1) Dredge Material Detention. Constructing detention basins would temporarily remove from five to ten parcels of land, ranging from about 10 to 40 acres each, from cultivation. A total of from 145 to 220 acres would be occupied in the course of the project depending on final detention basin designs. After dewatering the dredge material in each basin, the sediments would be removed for disposal, the dikes would be obliterated, and the land would again be available for cultivation.

The State and farm operators would have to reach agreement on the location and size of detention basins.

Excavation to secure dike material would disrupt land contour and soil structure, and would remove topsoil and subsoil. After sediment dewatering and removal, the sites could be recontoured, and the soils could be replaced with dike material and dredge sediments.

Dredge sediments would be high in nutrients and organic matter, and could help restore crop productivity at the detention basin site. The sediments also contain high copper concentrations. Current indications are that these concentrations of copper would not damage soil fertility where the dredge materials are placed. Further copper studies should be done by the State.

(2) Irrigation with Dredge Supernatants. It is possible that arrangements would be made to use some dredge supernatants to irrigate nearby farmland. The effects of irrigating farmland with dredge material supernatant would depend on supernatant quality and irrigation techniques. Supernatant would approximate the quality given for elutriate samples in Table 8 of the feasibility study. This supernatant could enrich any receiving fields and might be considered a benefit by any farm operators using it.

Runoff of irrigation water into the lake, during the first 2 years of the project, would help maintain water levels necessary for dredge operations. During the third year, supernatants are specified to be released only outside the Wall Lake watershed.

(3) Dispensing of Dredge Sediments on Farmland. Another possible component of the project would be the disposal of dewatered sediments on nearby farmlands. There are several possible effects of final dispensing of dredged sediments onto farmland. The sediments contain high nitrogen and phosphorus concentrations which would enrich the substrate. This could be a benefit to landowners. Sediment texture would be very fine, but this would not cause significant degradation of receiving soil texture.

As previously mentioned, copper is not expected to be a problem. But further confirmation of this should be attained before activity begins.

(4) Encouragement of Residential Development. Dredging of Wall Lake could encourage residential development which would eventually remove some lakeside farmland from production. This is treated further in the following section.

2. Residential Development.

Effects of Dredging. Dredging could indirectly encourage future housing development on the lakeshore. If dredging significantly reduces the frequency and severity of algal blooms and fishkills, there would be more incentive to live on the lake.

Increased demand for and development of housing would cause destruction of much of the remaining lakeside vegetation. This would also be a loss of lakeside wildlife habitat and housing would also cause conversion of land, presently being cultivated, into lawns; this would cause a reduction in soil erosion and runoff.

3. Recreation

a. Effects of No Action. No action would allow continued water quality degradation. Pollution, algal blooms, odor, and fishkills would discourage potential swimmers and sunbathers. Algal blooms have not been shown to substantially reduce boating activities.

b. Effects of Dredging. With dredging, stirring of sediments and the nutrients contained therein would degrade water quality at least in the immediate dredging area. Water contact sports and fishing would be somewhat discouraged. After dredging, water quality would improve, fisheries would be restocked, and recreational use would increase. The degree of improvement is uncertain. Dredging is intended to provide for less eutrophic conditions and better recreational opportunities, over a longer period than would be possible without dredging.

C. Effects on Waste Treatment.

1. Effects of No Action. No action would have no effect on waste treatment management plans.

2. Effects of Dredging. To the extent that dredging would encourage residential development, it would also increase the need for planning to conform with areawide waste treatment management plans. Otherwise, dredging would have no effect on such plans.

D. Effects on Agricultural Land. These are discussed in Section B.1. above.

E. Effects on Scenic Land.

1. Effects of No Action. No action would have no impact on the nearby wetlands, tree stands, or shoreline vegetation.

2. Effects of Dredging. Dredging would have no impact on the nearby wetlands or tree stands.

The effect on shoreline vegetation by dredging would be the probable displacement of the shoreline growth, as previously described, due to residential development.

F. Effects on Historical/Archeological Resources. These resources are yet to be identified.

G. Effects on Energy Demands.

1. Effects of No Action. No action would have no impact on fuel consumption patterns.

2. Effects of Dredging. Dredging would consume approximately 7 to 8 gallons of fuel per hour for the dredge motor, or a total of about 88,200 gallons.

Also, construction of detention basins and dredge material deposition would temporarily require a variable, but considerable, amount of fuel. Use of a 20-yard scraper and a blade dozer would require about 0.15 gallons of fuel for each cubic yard of material to be excavated and moved. If the total estimated dike volume were excavated and diked, about 6,500 gallons of fuel would be consumed.

A larger volume of fuel would also be consumed in sediment redistribution after dewatering. Moving the total volume of sediment, either with trucks and front-end loaders or with a scraper, would require about 130,000 gallons of fuel. The method of sediment redistribution is yet to be determined by project sponsors and landowners.

Detention sites would have to be determined by project sponsors in cooperation with landowners. Contour of the sites would determine the amount of material to be excavated and diked in basin construction.

H. Effects on Noise/Air Quality.

1. Effects of No Action. No action would not affect noise or air quality.

2. Effects of Dredging. Dredging would involve continuous running of a dredge motor, at varied locations around the lake, for three 7-month periods. There would be some noise and exhaust, but both would be at a level tolerable to residents.

I. Effects on In-Lake Chemical Treatment/Water Quality.

1. Effects of No Action. No action would allow continued nutrient and sediment buildup and would lead to maintenance or degradation of current water quality. The project sponsor would also have to determine whether algacide would continue to be applied. If so, the effects of the use of copper sulphate or any algacide involved would have to be addressed.

2. Effects of Dredging. Dredging would disrupt the aquatic community temporarily in the following ways. Nitrogen, phosphorous, copper, and other substances would be stirred by the dredging. Increased turbidity would temporarily reduce the potential for algal growth and would contribute to the loose floc covering undredged areas of lakebed. The increased availability of nutrients due to dredging would temporarily promote high algal productivity after turbidity declined. Also, un-ionized ammonia could reach levels lethal to fish. As mentioned, dredge design would tend to confine the effects to a small area.

Lake degradation would also result from return of supernatants to the lake. Dredging would also reduce the volume of water and, thus, the volume of dissolved oxygen available to fish. This latter effect would not allow full fish populations to survive the winter. The duration of each of these effects after dredging will depend on wind, precipitation, and other factors. It is expected that after one to two seasons, water levels would return to near normal.

Dredging could entail use of coagulants to reduce turbidity in dredge supernatants before their release into the lake or outlet channel. These coagulants are not expected to have any significant impact on water quality.

State water quality standards would be violated by the combination of dredging and supernatant returns. Both the Environmental Protection Agency and the State of South Dakota would have to waive water quality requirements and, as mentioned, certify the proposed project before its initiation.

After completion of dredging, water quality would improve. The degree of improvement is uncertain. It could, in fact, reach presettlement quality, resulting in a lower likelihood of severe algal blooms and fishkills. All dredge material should be held in detention basins for a sufficient time to allow some nutrients and most of the particulate matter to settle out of the water. Some nutrients and turbidity remaining in supernatants after detention would be released, with the supernatant, outside of the Wall Lake watershed. As mentioned, further data and plan clarification would facilitate the best estimate of expected improvement.

With improved water quality after dredging, there should be reduced need for algacide applications. However, such applications could still occur with lower frequency. Again, the sponsor would have to address any such applications.

J. Dredging Lakeshore or Lakebed.

1. Effects of Dredging on the Lake. One hundred seventy-two acres of lakebed would be dredged 4 feet deep; this would destroy the benthic community of that area. A new benthic community, though initially less productive than the present community, would be established within 1 to 2 years after dredging.

The near-shore communities would not be dredged. However, depending on the rate and volume of water removal from the lake, some of these communities would be exposed above the new water line. These exposed communities would be destroyed, but would be restored soon after dredging.

As mentioned previously, ammonia concentrations and other factors due to dredging could prove lethal to fish, and could cause considerable reductions in fish populations. The State Department of Game, Fish and Parks would restock the lake after dredging.

2. Effects of Dredging on the Outlet Drainageway. The effects of supernatant release into downstream drainages would be moderate or nominal. The release volume

would not normally reach Skunk Creek or the Big Sioux River. During spring thaw or rains, when the release might be carried to these streams, dilution should render the supernatants harmless. The release of supernatants would not have a volume sufficient to cause significant erosion problems or damage to the pastures through which it would flow.

K. Effects on Wildlife and Habitat.

1. Effects of No Action. No action would have no impacts on any protected species, or on the existing tree stands, the wetlands, or on the lakeside vegetation.

2. Effects of Dredging. Dredging would have no impacts on any protected species or existing tree stands. The sponsor has recognized the wetlands for their habitat values. For this environmental analysis to be valid, dredging and dredge material handling should be conducted so as to avoid any interference with wetland communities.

OTHER ASPECTS OF PROJECT DESIGN AND EFFECTIVENESS

The 4-foot depth increase was chosen because it was seen as the deepest alteration possible with available funding. This approach was based on the expectations that the deeper the lake is after dredging, the less significant is the action of wind; the more compacted and less easily stirred are the sediments; and the larger are the winter oxygen volumes available to fish.

On the basis of core sample data reported in this addendum, dredging uniformly to a 4-foot increase may be unnecessary. An alternative to dredging 4 feet would seem to be indicated by the pronounced decrease in nutrient concentrations at depths below 2 feet, specifically at Sites A and D. At these sites and perhaps elsewhere significant nutrient removal could be effected by dredging only about 2 feet.

This approach would have results similar to 4-foot dredging as regards nutrient removal in certain sites. Environmentally, project impacts would be reduced as most impacts on the lake and on farmlands would be slightly reduced.

Also, Sample C from the center of the lake indicates that lakebeds exposed there after dredging 4 feet would still have high nutrient concentrations. Improvement there would thus depend on decreased effect of the wind.

Other considerations merit attention in planning lake restoration by dredging or any other means. For one, although the loose nutrient rich sediments would have been removed by dredging, a new stratum of loose floc would tend to accumulate over the exposed sediments. This floc would be derived from several short-term and long-term sources. The extent or rate of this floc buildup is undetermined.

Also, the prospects for improvement depend partly on measures not included in the current proposal. For example, the construction of feedlot containment structures may be required on adjacent farms. This would require landowner

cooperation and some expenditures by landowners and the Agricultural Stabilization and Conservation Service. The need for such structures, their support by landowners, their design, costs, and impacts are yet to be determined by the sponsor.

The EPA has published "Restoration of Publicly Owned Freshwater Lakes Authorized by Section 314 of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500)." This guide describes 8 categories of restorative techniques. One of these techniques, nutrient diversion, may be required by the EPA in the form of feedlot containment structures. This is discussed in the preceding paragraph. Another of the techniques, conservation farming, may also be required.

Supplementary information to 40 CFR part 35 states that EPA gives priority to water pollution controls or lake protection measures, over in-lake treatment measures. Those regulations also require project sponsors to describe any feasible alternatives to the proposed project.

ADDENDUM
TO THE
WALL LAKE DREDGING
FEASIBILITY STUDY
WALL LAKE, SOUTH DAKOTA

CORPS OF ENGINEERS, OMAHA DISTRICT

Ind 1

INTRODUCTION

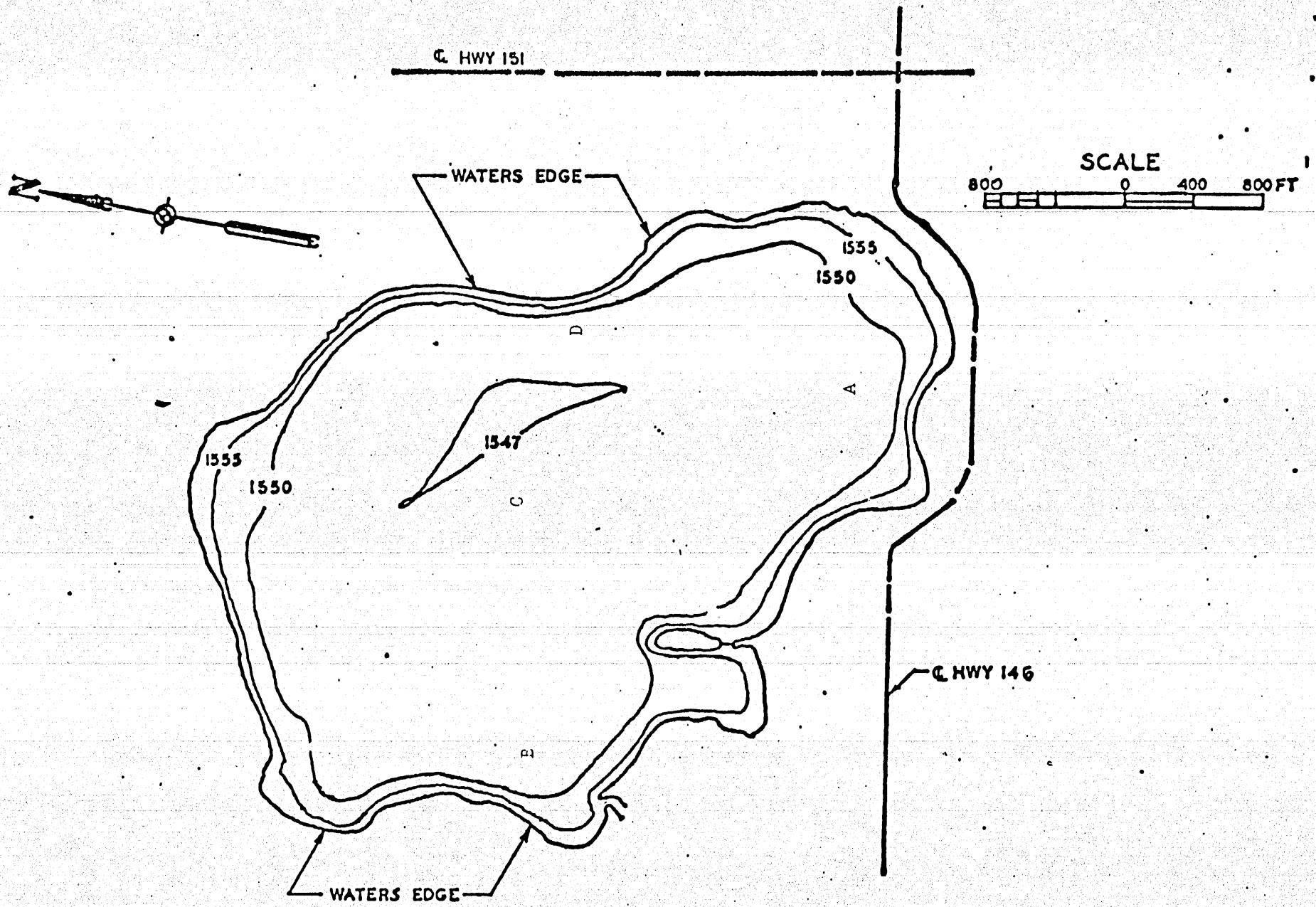
As stated in the section entitled "Elutriate Tests" (page 19), this report is provided as an addendum to the "Wall Lake Dredging Feasibility Study, Wall Lake, South Dakota".

METHODS

Because of the difficulty involved in obtaining four foot core samples from a boat, it was decided to obtain such samples through the ice which provided a more stable working platform. However, the nature of the lake bottom sediments and the coring device utilized, single four foot cores could not be obtained. As a result of these limitations, it was decided to acquire a first core of the maximum obtainable length with the second, and in one instance, third cores obtained by attempting to insert the core sampler in the hole created by first core. Thus the first core sample would act as a guide for successively deeper cores. These attempts were only partially successful since the second and third core samplings would, inevitably, capture some sediments near the mud-water interface before penetrating the hole created by the first core sample. After the core samples were obtained, they were wrapped in plastic and shipped to the Missouri River Division for analysis. All sampling sites are indicated on Plate I.

RESULTS

Chemical analysis of all core samples is shown in Table I and the results of these analyses for each of the sampling sites (Plate I) are discussed in the following paragraphs.



NOTE: POOL ELEVATION ON 19 JUNE 1970 = 1559.5 MSL

PLATE I
WALL LAKE CORE SAMPLING LOCATIONS

Site A. Sampling at this site, located near the Wall Lake outflow (Plate I) consisted of a single 24 inch core. The hardness of the sediments at this sampling site precluded the taking of deeper cores. Visual inspection of this sample indicated a high, but unquantified, percentage of sand which appeared to increase with depth. The density of this sample is indicated by the percent solids in Table I which clearly shows that site A exhibited the highest percent solids values. High sand quantites are also indicated by the fact that this site had the lowest chemical values of all sampled areas with nitrate nitrogen being the sole exception. Since nitrate nitrogen has a higher oxidative state than either ammonia or kjeldahl nitrogen, these values very likely represent an oxidative state conversion from ammonia to nitrate. Since the quantity of nitrate is extremely small when compared to either ammonia or kjeldahl nitrogen, total nitrogen values are still considerably lower than those obtained at all other sampling sites.

As indicated in Table I, all chemical parameters show definite decreases with depth clearly indicating lowered nutrient content and thus decreased nutrient availability should the upper sediments be dredged. In addition, because of relatively low nutrient content, it may be possible to achieve the desired benefits by dredging this area to a depth of two feet as opposed to the originally planned four feet.

Site B. Sampling at this site, located near the Wall Lake inflow (Plate I), consisted of three successive core samples totaling a depth of 56 inches. As noted in Table I and discussed in the Methods section of this report, successive sampling utilizing the previous core holes as a guide was only partially successful resulting in some unquantified mixing of mud-water interface sediments with deeper sediments. In general, however, deeper sediment samples showed a

TABLE I
Chemical Analysis of Core Samples[1/]

Sample	Percent Solids	Total Kjeldahl Nitrogen mg/l as N	Ammonia Nitrogen mg/l as N	Nitrate Nitrogen mg/l as N	Total Phosphorous mg/l as P	Copper mg/l as CU
A-1, 0-6 in.	62.3	2700	53	0.59	1200	9
6-12	75.1	1000	34	0.24	1040	5
12-18	80.6	400	21	0.16	860	3
18-24	77.4	100	28	0.13	840	6
B-1, 0-5 in.	43.6	4700	77	0.14	890	31
5-10	46.7	5400	85	0.08	1330	16
10-15	52.1	3800	76	0.19	1120	20
15-20	49.8	4100	75	0.12	750	20
*B-2, 20-26 in.	55.6	2600	71	0.14	1160	19
26-32	48.9	4100	91	0.25	1110	20
32-38	46.6	4600	78	0.14	890	19
**B-3, 38-44 in.	47.3	4600	87	0.14	1070	20
44-50	55.6	2500	69	0.14	1010	18
50-56	55.7	2900	76	0.08	1120	16
C-1, 0-6 in.	44.9	5400	91	0.42	1010	21
6-12	45.4	4900	94	0.30	1040	21
12-18	48.4	5200	126	0.06	940	20
18-24	46.5	5000	135	0.08	1110	19
24-30	44.2	4700	130	0.03	1120	18
30-36	50.9	3300	129	0.02	960	21
*C-2, 36-42 in.	44.8	5800	136	0.14	1070	19
42-48	43.9	5400	141	0.08	990	18
48-54	50.9	4300	133	0.08	1090	20
54-60	48.1	4500	153	0.06	1200	21
D-1, 0-6 in.	50.4	5800	82	0.22	1070	15
6-12	51.1	4900	108	0.11	1110	19
12-18	53.2	4100	80	0.11	1100	18
18-24	53.3	4000	62	0.11	1000	13
24-30	69.5	1700	36	0.11	1030	11
30-36	69.0	2200	40	0.11	1020	11

1/ All concentrations are expressed as dry sample weight. Ammonia and Nitrate were determined on water extracted from the sample and reported on a dry weight Basis.

Hydrochloric acid digestion was used to determine Copper concentrations.

* Second successive core sample.

** Third successive core sample.

greater degree of compaction and thus less interstitial water than did surface sediment samples. Total kjeldahl nitrogen samples showed definite decreases with depth ranging from an average concentration of 4500 mg/l in the top 20 inches, 3767 mg/l in the middle eighteen inches and 3333 mg/l in the lower 18 inch core sample. Copper concentrations also showed slight decreases with depth. Total phosphorous concentrations, while exhibiting some variations, appeared to be relatively evenly distributed throughout the sampled core depths. To what extent these distributions may have been affected by inflowing waters or wind induced turbulence acting upon the sediments cannot be determined.

As indicated in the Table I notations, ammonia and nitrate nitrogen concentrations were determined on water extracted from the sample. These parameters showed relatively even distribution throughout the sample. However, due to the increased compaction with depth and the resultant decrease in interstitial water quantity, ammonia and nitrate nitrogen would decrease with depth because of decreased water quantities even though they exhibit no decrease on a per unit basis. In addition, since kjeldahl nitrogen shows decreases with depth, less nitrogen is available for oxidative conversion to ammonia and nitrate forms.

These data appear to indicate that total nitrogen would be significantly reduced by dredging the upper four feet of sediment while copper concentrations would be slightly reduced. It would appear that phosphorous concentrations would remain at or near the original concentrations. Thus phosphorous reduction would be dependent upon reduced internal cycling resulting from decreased wind induced sediment resuspension due to greater water depths and greater sediment compaction.

Site C. Sampling at site C, located in the central area of Wall Lake consisted of two successive core samples totaling a depth of 60 inches. As noted in Table I and discussed in the Methods section of this report, successive sampling utilizing the previous core holes as a guide was only partially successful

resulting in some unquantified mixing of mud-water interface sediments with deeper sediments. Visual inspection of this site C core samples indicated a softer consistency of lower sand content that did core samples from other sites. Analysis results indicate that percent solids are similar throughout the depth of core sampling as are copper concentrations. All other parameters show slight increases with depth with the exception of nitrate nitrogen which decreased.

The site C data indicate that the central lake area consists of similarly compacted sediments with relatively similar or slightly increasing nutrient concentration throughout the depth of core sampling. Thus dredging to the proposed 4 foot depth would result in decreased internal nutrient cycling due to decreased wind induced sediment resuspension because of increased water depth.

Site D. Sampling at this site, located near the east edge of Wall Lake (Plate I) consisted of a single 36 inch core sample. Visual inspection of the core sample obtained at this site indicated that small gravel was present in the lower 30 to 36 inches of sample. Whether or not this is indicative of original lake bed proximity could not be determined with the existing samples.

This sampling site clearly showed the expected increase in percent solids and the expected decrease in nutrients with increasing sediment depth (Table I). Total phosphorous was the only parameter which showed relatively even distribution throughout the sample depth. As discussed under the Site A and B sections of this report, dredging of this area would result in the desired benefit of improved water quality and lake aesthetics.

CONCLUSIONS

As discussed in the Results section of this report, dredging Wall Lake would result in decreased nutrient availability and improved water quality in addition to benefits previously discussed in the "Wall Lake Dredging Feasibility

A. Existing Residential Areas. The lake is bordered on about 50 percent of its perimeter by residential units. There are about 50 homes; most are in year-round use. There is also a Girl Scout camp adjacent to the lake.

B. Established Land Use Practices.

1. Agriculture. Seventy percent of the watershed is planted to row crops and there is some associated hayland and pasture. Three livestock feedlots are located within one-half mile of the lake.

2. Residential Development. Thirty percent of the shoreline is undeveloped, but is susceptible to development if economic conditions become suitably favorable to landowners. The area has recently been zoned "rural residential", facilitating such development.

3. Recreation. The Wall Lake area has a beach and boat dock facility, and is a recreation resource for the more than 90,000 residents of the Sioux Falls area. It is heavily used for many recreational activities, such as fishing, waterskiing, boating, swimming, sunbathing and picnicking. At times it has become congested to the point of being hazardous to users. Severe algal blooms do not seem to cause significant declines in overall recreational use.

C. Waste Treatment Management Plans. Current residences use septic tank/drain field systems. These contribute to high nutrient concentrations in the lake. Future residences would probably use similar systems. The sponsor of the proposed project will have to discuss whether current and future systems would conform with the areawide waste treatment management plans, administered by Minnehaha County.

D. Agricultural Land. The area's deep silty or loamy soils contribute to good crop productivity. The runoff from fields and feedlots contributes to high concentrations of nutrient materials in the lake, especially during spring thaw. If Wall Lake is dredged, farmlands would be used as dredge material detention

sites. Dredge supernatants and the dewatered sediments could be disposed of by spreading on the fields.

E. Scenic Land. There are several types of wetlands near the lake. They are the last of the many wetlands that once occupied the area. Also, several tree stands, not associated with active farmlands, are scattered in the area. A thin strip of woody growth remains along the undeveloped lakeshore segments.

F. Archeological/Historical Resources. Early American Indians may have been attracted to visit or camp near Wall Lake, which offers the best fishery within a 55-mile radius. The South Dakota State Historic Preservation Officer would have to give clearance to the proposed project. A survey would have to be conducted to locate and identify any cultural resources.

G. Energy Demands. There is currently a minor energy demand involved in the use of fuel for the State fishery stocking program. An undetermined demand for fuel results from the recreational activities of lake users. The effect of either alternative on fuel demand, for travel to the lake and recreational activities, is dependent on many variables. This effect is therefore undetermined, and in any case is considered insignificant. Other effects on fuel demand are considered below.

H. Noise/Air Quality. Because Wall Lake is in a rural location, the air quality is good and noise levels are low. Exceptions include the occasional smell of decaying algae and the noise of motorboats in summer.

I. In-Lake Chemical Treatment/Water Quality. The lake is subject to annual algal blooms. Extensive use of copper sulphate as an algacide in recent years has resulted in an accumulation of copper in lakebed sediments. The sponsor should address the effects of possible continued use of copper sulphate or other algacides. The project sponsor should also specify whether flocculants or coagulants would be added to dredge supernatant before its release onto fields or into the lake.

J. Flood Plains. The proposed project is not in a flood plain.

K. Dredging Lakeshore or Lakebed. The lake, occupying 220 acres, is uniformly shallow with very little emergent, floating or submerged vegetation. The lakebed is composed primarily of organic material, silts and clays. Perch spawning habitat occurs near the main inlet and good bullhead spawning habitat is abundant in the lake. The lake supports a sport fishery of predominantly bullheads.

If the lake was to be dredged, provisions would have to be made for detention of dredge materials, disposal of supernatants, and disposal of dewatered dredge sediments. Resources that would be affected by these activities include the farmland, the lake, and the outlet drainageway; and these would have to be addressed in the sponsor's environmental evaluation.

1. Chemical Qualities of Dredge Material. Analyses of the upper 18 inches of sediment, overburden water, and elutriate are shown in Tables 4-8 of the feasibility study. Lake sediments contain high concentrations of nitrogen and phosporous. The nutrients stimulate high algal productivity. Large die-offs and decay of algae, which can occur under winter ice and snow cover, use up oxygen and aggravate winter fishkills. The lake's shallow depth facilitates wind action on the sediments. This mixing makes the nutrients available for use by algae. Deepening the lake would be intended to reduce the degree of this mixing. Elutriate samples show that lake waters disturbed by dredging would have high concentrations of ammonia nitrogen and phosphorous. The water would also be very turbid. The projected ammonia levels could be lethal to fish but dredge design would tend to confine these effects of dredging to a small area.

2. Farmland. The dredge material would be held in detention basins on nearby farmland. One question yet to be answered is whether the 1.11 million cubic yards of sediment and approximately 3.0 million cubic yards of supernatant would be finally applied to agricultural fields.

3. The Lake. Dredging activity and dredge supernatant returns would degrade lake water quality. Lake water quality is described in the feasibility study and its addendum and in Section 1. above. A metal shroud which surrounds the specified type of dredge auger would help contain disturbance to a small area, but some dispersion of elutriate water beyond the dredging site would occur. The degree of this dispersion is unknown at the present time, and would partly depend on wind disturbance.

4. Outlet Drainageway. A single outlet, typically dry or intermittent, runs 12 miles from the south end of the lake through pastures to Skunk Creek. Two miles beyond that confluence, Skunk Creek enters the Big Sioux River. There are lowlands contiguous with the outlet drainageway, but it is reported that there are no wetlands in the drainageway.

If not used for irrigation, supernatant waters obtained during the last year of dredging would be released into the lake outlet, carrying associated nutrients and some sediment. The flow, if released evenly over the final 7-month work period, would average in the range of 1.10 c.f.s. to 2.20 c.f.s.

L. Wildlife and Habitat. Eight species of State protected animals, including the Federally protected bald eagle, occur in the region. There are also five plant species unofficially classified as endangered in the State; these include the white ladyslipper and prairie fringed orchid, both in the Smithsonian's Endangered and Threatened Plants of the United States. Several sources have indicated, however, that none of these species inhabit Wall Lake or its immediate surroundings.

The lake, although degraded, is a significant resource as a fresh-water lake. It supports algae, invertebrates, and a perennial population of bullheads, and it offers breeding habitat for introduced yellow perch. A State stocking program maintains populations of perch, northern pike, and walleye. Pike and walleye breeding habitats are not present in the lake.

Local mammals include the white-tailed deer, red fox, badger, raccoon, skunk, rabbits, tree squirrels, ground squirrels, mink, weasel, and muskrat. Some common birds are mourning doves, pheasants, partridges, and waterfowl such as mallards and snow geese.

The few wetlands remaining in the area serve as breeding habitat for birds and offer food and shelter to both resident and visiting wildlife. The nearby tree stands serve as islands of habitat for species not adapted to the surrounding cultivated fields, including migratory birds. The lakeshore vegetation provides cover for any wildlife visiting the lake and is a breeding, shelter, and food source for resident wildlife.

The lake outlet drainageway is largely dry. It passes through pastures over much of its length, and its value to wildlife is currently nominal. Skunk Creek is also an intermittent stream and is of moderate value to aquatic life.

ENVIRONMENTAL EFFECTS

A. Effects on Existing Residential Areas. Both the proposed project and the alternative of no action would appear to cause no significant displacement of or disturbance to residents and would not deface residential property.

B. Effects on Established Land Use Practices

1. Agriculture.

a. Effects of No Action. No action would have no effect on agricultural land use.

b. Effects of Dredging. Four aspects of the proposed dredging could have effects on the nearby farm operations. These effects are discussed in detail in the following sections.

(1) Dredge Material Detention. Constructing detention basins would temporarily remove from five to ten parcels of land, ranging from about 10 to 40 acres each, from cultivation. A total of from 145 to 220 acres would be occupied in the course of the project depending on final detention basin designs. After dewatering the dredge material in each basin, the sediments would be removed for disposal, the dikes would be obliterated, and the land would again be available for cultivation.

The State and farm operators would have to reach agreement on the location and size of detention basins.

Excavation to secure dike material would disrupt land contour and soil structure, and would remove topsoil and subsoil. After sediment dewatering and removal, the sites could be recontoured, and the soils could be replaced with dike material and dredge sediments.

Dredge sediments would be high in nutrients and organic matter, and could help restore crop productivity at the detention basin site. The sediments also contain high copper concentrations. Current indications are that these concentrations of copper would not damage soil fertility where the dredge materials are placed. Further copper studies should be done by the State.

(2) Irrigation with Dredge Supernatants. It is possible that arrangements would be made to use some dredge supernatants to irrigate nearby farmland. The effects of irrigating farmland with dredge material supernatant would depend on supernatant quality and irrigation techniques. Supernatant would approximate the quality given for elutriate samples in Table 8 of the feasibility study. This supernatant could enrich any receiving fields and might be considered a benefit by any farm operators using it.

Runoff of irrigation water into the lake, during the first 2 years of the project, would help maintain water levels necessary for dredge operations. During the third year, supernatants are specified to be released only outside the Wall Lake watershed.

(3) Dispensing of Dredge Sediments on Farmland. Another possible component of the project would be the disposal of dewatered sediments on nearby farmlands. There are several possible effects of final dispensing of dredged sediments onto farmland. The sediments contain high nitrogen and phosphorus concentrations which would enrich the substrate. This could be a benefit to landowners. Sediment texture would be very fine, but this would not cause significant degradation of receiving soil texture.

As previously mentioned, copper is not expected to be a problem. But further confirmation of this should be attained before activity begins.

(4) Encouragement of Residential Development. Dredging of Wall Lake could encourage residential development which would eventually remove some lakeside farmland from production. This is treated further in the following section.

2. Residential Development.

Effects of Dredging. Dredging could indirectly encourage future housing development on the lakeshore. If dredging significantly reduces the frequency and severity of algal blooms and fishkills, there would be more incentive to live on the lake.

Increased demand for and development of housing would cause destruction of much of the remaining lakeside vegetation. This would also be a loss of lakeside wildlife habitat and housing would also cause conversion of land, presently being cultivated, into lawns; this would cause a reduction in soil erosion and runoff.

3. Recreation

a. Effects of No Action. No action would allow continued water quality degradation. Pollution, algal blooms, odor, and fishkills would discourage potential swimmers and sunbathers. Algal blooms have not been shown to substantially reduce boating activities.

b. Effects of Dredging. With dredging, stirring of sediments and the nutrients contained therein would degrade water quality at least in the immediate dredging area. Water contact sports and fishing would be somewhat discouraged. After dredging, water quality would improve, fisheries would be restocked, and recreational use would increase. The degree of improvement is uncertain. Dredging is intended to provide for less eutrophic conditions and better recreational opportunities, over a longer period than would be possible without dredging.

C. Effects on Waste Treatment.

1. Effects of No Action. No action would have no effect on waste treatment management plans.

2. Effects of Dredging. To the extent that dredging would encourage residential development, it would also increase the need for planning to conform with areawide waste treatment management plans. Otherwise, dredging would have no effect on such plans.

D. Effects on Agricultural Land. These are discussed in Section B.1. above.

E. Effects on Scenic Land.

1. Effects of No Action. No action would have no impact on the nearby wetlands, tree stands, or shoreline vegetation.

2. Effects of Dredging. Dredging would have no impact on the nearby wetlands or tree stands.

The effect on shoreline vegetation by dredging would be the probable displacement of the shoreline growth, as previously described, due to residential development.

F. Effects on Historical/Archeological Resources. These resources are yet to be identified.

G. Effects on Energy Demands.

1. Effects of No Action. No action would have no impact on fuel consumption patterns.

2. Effects of Dredging. Dredging would consume approximately 7 to 8 gallons of fuel per hour for the dredge motor, or a total of about 88,200 gallons.

Also, construction of detention basins and dredge material deposition would temporarily require a variable, but considerable, amount of fuel. Use of a 20-yard scraper and a blade dozer would require about 0.15 gallons of fuel for each cubic yard of material to be excavated and moved. If the total estimated dike volume were excavated and diked, about 6,500 gallons of fuel would be consumed.

A larger volume of fuel would also be consumed in sediment redistribution after dewatering. Moving the total volume of sediment, either with trucks and front-end loaders or with a scraper, would require about 130,000 gallons of fuel. The method of sediment redistribution is yet to be determined by project sponsors and landowners.

Detention sites would have to be determined by project sponsors in cooperation with landowners. Contour of the sites would determine the amount of material to be excavated and diked in basin construction.

H. Effects on Noise/Air Quality.

1. Effects of No Action. No action would not affect noise or air quality.

2. Effects of Dredging. Dredging would involve continuous running of a dredge motor, at varied locations around the lake, for three 7-month periods. There would be some noise and exhaust, but both would be at a level tolerable to residents.

I. Effects on In-Lake Chemical Treatment/Water Quality.

1. Effects of No Action. No action would allow continued nutrient and sediment buildup and would lead to maintenance or degradation of current water quality. The project sponsor would also have to determine whether algacide would continue to be applied. If so, the effects of the use of copper sulphate or any algacide involved would have to be addressed.

2. Effects of Dredging. Dredging would disrupt the aquatic community temporarily in the following ways. Nitrogen, phosphorous, copper, and other substances would be stirred by the dredging. Increased turbidity would temporarily reduce the potential for algal growth and would contribute to the loose floc covering undredged areas of lakebed. The increased availability of nutrients due to dredging would temporarily promote high algal productivity after turbidity declined. Also, un-ionized ammonia could reach levels lethal to fish. As mentioned, dredge design would tend to confine the effects to a small area.

Lake degradation would also result from return of supernatants to the lake. Dredging would also reduce the volume of water and, thus, the volume of dissolved oxygen available to fish. This latter effect would not allow full fish populations to survive the winter. The duration of each of these effects after dredging will depend on wind, precipitation, and other factors. It is expected that after one to two seasons, water levels would return to near normal.

Dredging could entail use of coagulants to reduce turbidity in dredge supernatants before their release into the lake or outlet channel. These coagulants are not expected to have any significant impact on water quality.

State water quality standards would be violated by the combination of dredging and supernatant returns. Both the Environmental Protection Agency and the State of South Dakota would have to waive water quality requirements and, as mentioned, certify the proposed project before its initiation.

After completion of dredging, water quality would improve. The degree of improvement is uncertain. It could, in fact, reach presettlement quality, resulting in a lower likelihood of severe algal blooms and fishkills. All dredge material should be held in detention basins for a sufficient time to allow some nutrients and most of the particulate matter to settle out of the water. Some nutrients and turbidity remaining in supernatants after detention would be released, with the supernatant, outside of the Wall Lake watershed. As mentioned, further data and plan clarification would facilitate the best estimate of expected improvement.

With improved water quality after dredging, there should be reduced need for algacide applications. However, such applications could still occur with lower frequency. Again, the sponsor would have to address any such applications.

J. Dredging Lakeshore or Lakebed.

1. Effects of Dredging on the Lake. One hundred seventy-two acres of lakebed would be dredged 4 feet deep; this would destroy the benthic community of that area. A new benthic community, though initially less productive than the present community, would be established within 1 to 2 years after dredging.

The near-shore communities would not be dredged. However, depending on the rate and volume of water removal from the lake, some of these communities would be exposed above the new water line. These exposed communities would be destroyed, but would be restored soon after dredging.

As mentioned previously, ammonia concentrations and other factors due to dredging could prove lethal to fish, and could cause considerable reductions in fish populations. The State Department of Game, Fish and Parks would restock the lake after dredging.

2. Effects of Dredging on the Outlet Drainageway. The effects of supernatant release into downstream drainages would be moderate or nominal. The release volume

would not normally reach Skunk Creek or the Big Sioux River. During spring thaw or rains, when the release might be carried to these streams, dilution should render the supernatants harmless. The release of supernatants would not have a volume sufficient to cause significant erosion problems or damage to the pastures through which it would flow.

K. Effects on Wildlife and Habitat.

1. Effects of No Action. No action would have no impacts on any protected species, or on the existing tree stands, the wetlands, or on the lakeside vegetation.

2. Effects of Dredging. Dredging would have no impacts on any protected species or existing tree stands. The sponsor has recognized the wetlands for their habitat values. For this environmental analysis to be valid, dredging and dredge material handling should be conducted so as to avoid any interference with wetland communities.

OTHER ASPECTS OF PROJECT DESIGN AND EFFECTIVENESS

The 4-foot depth increase was chosen because it was seen as the deepest alteration possible with available funding. This approach was based on the expectations that the deeper the lake is after dredging, the less significant is the action of wind; the more compacted and less easily stirred are the sediments; and the larger are the winter oxygen volumes available to fish.

On the basis of core sample data reported in this addendum, dredging uniformly to a 4-foot increase may be unnecessary. An alternative to dredging 4 feet would seem to be indicated by the pronounced decrease in nutrient concentrations at depths below 2 feet, specifically at Sites A and D. At these sites and perhaps elsewhere significant nutrient removal could be effected by dredging only about 2 feet.

This approach would have results similar to 4-foot dredging as regards nutrient removal in certain sites. Environmentally, project impacts would be reduced as most impacts on the lake and on farmlands would be slightly reduced.

Also, Sample C from the center of the lake indicates that lakebeds exposed there after dredging 4 feet would still have high nutrient concentrations. Improvement there would thus depend on decreased effect of the wind.

Other considerations merit attention in planning lake restoration by dredging or any other means. For one, although the loose nutrient rich sediments would have been removed by dredging, a new stratum of loose floc would tend to accumulate over the exposed sediments. This floc would be derived from several short-term and long-term sources. The extent or rate of this floc buildup is undetermined.

Also, the prospects for improvement depend partly on measures not included in the current proposal. For example, the construction of feedlot containment structures may be required on adjacent farms. This would require landowner

cooperation and some expenditures by landowners and the Agricultural Stabilization and Conservation Service. The need for such structures, their support by landowners, their design, costs, and impacts are yet to be determined by the sponsor.

The EPA has published "Restoration of Publicly Owned Freshwater Lakes Authorized by Section 314 of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500)." This guide describes 8 categories of restorative techniques. One of these techniques, nutrient diversion, may be required by the EPA in the form of feedlot containment structures. This is discussed in the preceding paragraph. Another of the techniques, conservation farming, may also be required.

Supplementary information to 40 CFR part 35 states that EPA gives priority to water pollution controls or lake protection measures, over in-lake treatment measures. Those regulations also require project sponsors to describe any feasible alternatives to the proposed project.

Appendix B

Wall Lake Hydrology Study

STATE OF SOUTH DAKOTA
William J. Janklow, Governor

DEPARTMENT OF WATER AND NATURAL RESOURCES
Warren R. Heufeld, Secretary

GEOLOGICAL SURVEY
Duncan J. McGregor, State Geologist

Open-File Report No.30-UR

HYDROLOGY OF WALL LAKE

by

Kelly Carter

and

Assad Barari

Science Center
University of South Dakota
Vermillion, South Dakota
1981

CONTENTS

Page

INTRODUCTION .....

Coring the Lake Bottom .....

Water Budget of the Lake .....

CONCLUSIONS AND RECOMMENDATIONS .....

REFERENCES CITED .....

ILLUSTRATIONS

Figures Page

1. Map showing location of test holes drilled in the vicinity of Wall Lake .....

2. Depth contour map of Wall Lake and location of Coring sites .....

APPENDICES

A. Logs of test holes drilled in the Wall Lake area .....

B. Water levels for Wall Lake .....

C. Daily Precipitation and evaporation at Sioux Falls, South Dakota..

D. Description of cores from Wall Lake .....

INTRODUCTION

This report contains the results of a hydrological study conducted by the South Dakota Geological Survey from July 2, to July 16, 1979, in the vicinity of Wall Lake, Minnehaha County, South Dakota. The purpose of the study was to identify the extent of the ground water connection to the lake.

The project was financed by Minnehaha County, the Minnehaha Conservation District, the East Dakota Conservancy Sub-District, and the South Dakota Geological Survey.

Wall Lake is located approximately 10 miles west of Sioux Falls on Highway 42 (fig. 1). Wall Lake is a natural lake of glacial origin; its existence is due to the action of glacial ice which covered this part of the State in the geologic past. The terrain is undulating to nearly flat, with a relief of approximately 60 feet. At a pool elevation of 1559.5 feet above the mean sea level, the lake has a surface area of approximately 225 acres and an average depth of 9 feet (Corps of Engineers, 1979). The lake has approximately 4 square miles of contributing drainage area. Figure 2 shows the depth contour map of Wall Lake. There are two small inlets to the lake. The inlets are located on the northwest and west edges of the lake. The surface outlet to the lake is located on the southeast edge of the lake (fig. 1).

Twenty-five test holes were drilled in the area to identify the extent of the ground water connection to the lake. Observation wells were constructed in three of the test holes. The logs of the test holes are in appendix A (for map location, see fig. 1).

The results of drilling revealed that there is a small outwash deposit (sand and gravel) along the west inlet to the lake. Test hole 22 (app. A, fig. 1) penetrated a layer of sand and gravel which was 21 feet thick from a depth of 1 foot to 22 feet below the land surface. Also, layers of silty sand and gravel were penetrated from a depth of 22 to 45 feet. The depth to water in this observation well was 5.94 feet from the casing top. The sand and gravel thickness decreases in a very short distance from this location (see test holes 9, 10, 11, and 23, app. A). Test hole 10, located approximately 600 feet to the south, and test hole 11, located approximately 400 feet to the north of test hole 22, had no sand and gravel layers. Likewise, test hole 21, approximately 1 mile to the northwest and in the same drainageway did not penetrate any sand and gravel layer.

However, test hole 8 located east of the lake, penetrated a sand and gravel layer from a depth of 6 to 17 feet. The water level in this observation well was 8.32 feet. Test hole 7, located along the outlet of the lake, had a sand and gravel layer from a depth of 1 to 9 feet. The remaining test holes drilled in the area did not penetrate any significant thicknesses of sand

and gravel.

CORING THE LAKE BOTTOM

In February 1980, four sites were chosen for coring the lake sediments. Figure 2 shows the location of the sites. The descriptions of the cores are listed in appendix D. The core samples were sent to the U.S. Corps of Engineers in Omaha for analysis, and the results of these analyses are in an Addendum to the Wall Lake Dredging Feasibility Study by the Corps of Engineers.

WATER BUDGET OF THE LAKE

In order to determine the net ground water flow to Wall Lake, the following calculations are made:

$$h = P + Ri - Ro + Gn - E$$

where

h is the change in the lake level
P is the precipitation
Ri is runoff into the lake (surface water)
Ro is runoff out of the lake
Gn is net ground-water movement (into or out of the lake)
E is the lake evaporation

All variables are expressed in terms of inches of lake level rise or fall.

No precise lake level measurements were available. The only available data were obtained from the South Dakota Department of Wildlife, Parks and Forestry (app. B). For calculation purposes, it was assumed all measurements on the lake level were made in the morning before any precipitation and evaporation had occurred.

The precipitation and evaporation data were obtained from the Sioux Falls weather station (app. C). Pan evaporation data were converted to lake evaporation by using the conversion factor 0.72 (Kohler and others, 1959), and components of inflow and outflow to the lake from July 3 to July 19, 1979 were:

Precipitation was .12 inches (app. C)
Evaporation was 4.56 inches (app. C)
Lake level evaporation was 3.28 inches (4.56 x 0.72 = 3.28)
Lake level fluctuation was -6 inches (app B)

No significant surface inflow and outflow to the lake was observed during this period. Consequently, the previous equation

could be simplified to:

$$h = P + Gn - E$$

By substituting the proper values, into the above equation, one obtains

$$-6 = 0.12 + Gn - 3.28$$
$$-2.84 = Gn$$

That is, the lake level dropped 2.84 inches (.24 feet) due to the net ground-water exchange. This decline taken over the entire area of the lake would amount to 61.20 acre feet.

Lake Area x Change of Lake Level = Net Change
255 x -0.24 = -61.20 acre-feet

It should be noted that (1) the above calculation does not identify the actual ground-water recharge and discharge to and from the lake rather it gives the net ground-water exchange; (2) neither the lake level nor the surface recharge and discharge to the lake were precisely measured; and (3) the surface area of the lake was assumed to have stayed constant even though the area would have varied with the fluctuation in lake level.

Precipitation from July 26 to August 2, 1979, was 1.60 inches, and the lake level rose 4 inches during the same period (app. B). The 4-inch rise occurred even though there was 1.48 inches (2.06 x 0.72 = 1.48 inches) of evaporation. During this period no surface inflow and outflow was measured to calculate the ground-water's contribution. In any case, the data indicate that the lake level responded rapidly to precipitation. This probably indicates that the surface water contribution to the lake was more significant than that of the ground water during from July 26 to August 2, 1979.

CONCLUSIONS AND RECOMMENDATIONS

The results of test drilling in the area do not show any important ground-water connections to the lake. A few test holes and calculations based on limited data do show some ground-water connection to the lake does occur.

It is recommended that more accurate lake level data be collected, and that precipitation data should be collected near the lake so as to be more representative of the Wall Lake area. The inflow and outflow should be measured. Ground-water levels should be monitored in the observation wells. Together, this additional information would refine the different components of the lake's water budget.

REFERENCES CITED

Corps of Engineers, 1979, Wall Lake dredging feasibility study, Wall Lake, South Dakota, 22 p.

----- Addendum to the Wall Lake feasibility study, 15 p.

Kohler, M. A., Nordenson, T. J., and Baker, D. R., 1959, Evaporation maps for the United States: U.S. Weather Bureau technical Paper no. 37, 13 p., pls. 1-4.

U.S. Department of Commerce, Climatological data for South Dakota: July 1979, v. 84, no. 7, and August 1979, v. 84, no. 8.

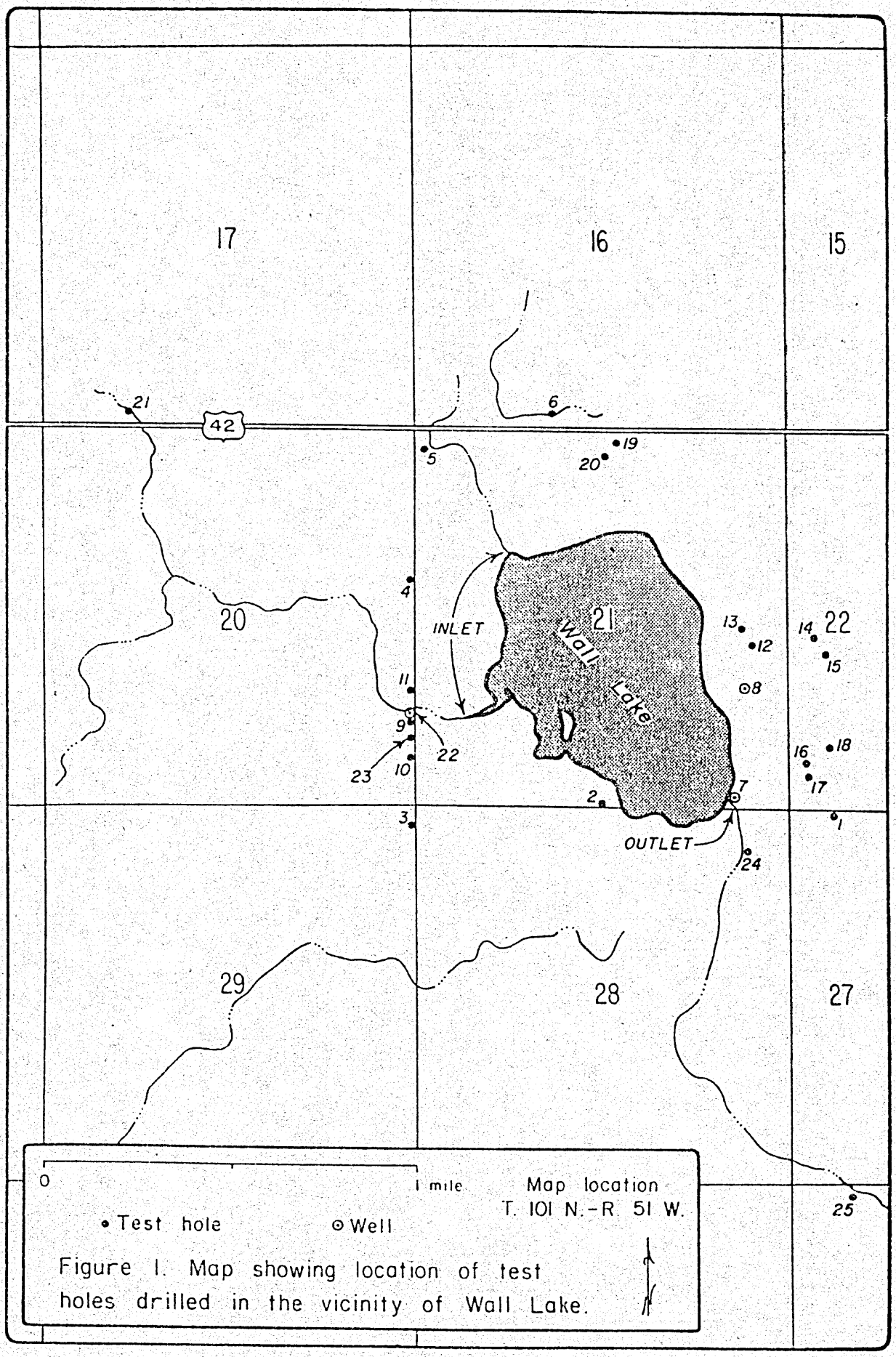
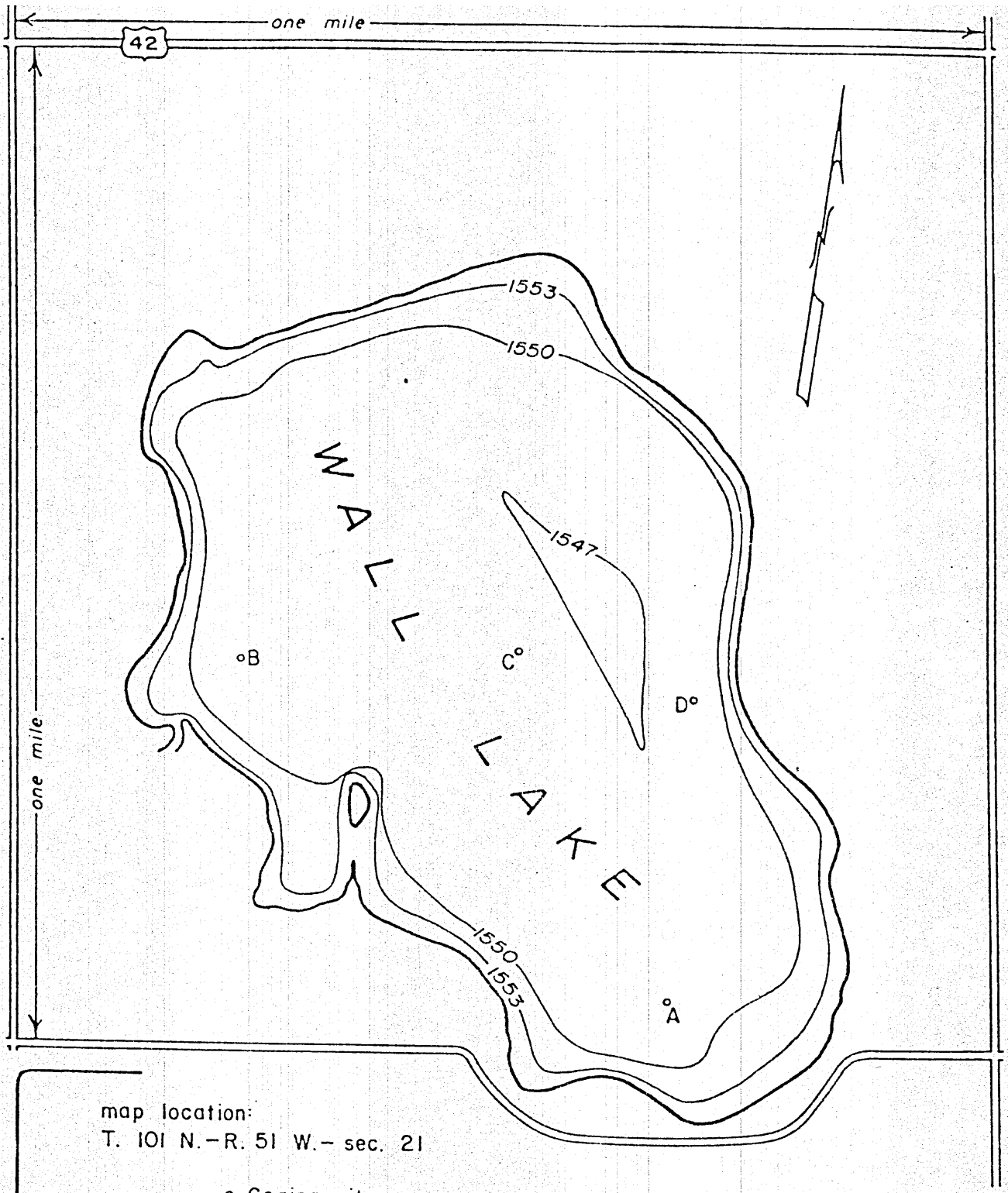


Figure 1. Map showing location of test holes drilled in the vicinity of Wall Lake.



map location:
T. 101 N.–R. 51 W.– sec. 21

° Coring site

1550 — Contour line on lake bottom showing equal elevation in feet above mean sea level. *Pool elevation on June 19, 1979 – 1559.5 feet above mean sea level.*

Figure 2. Depth contour map of Wall Lake and the location of coring sites. *(from Corps of Engineers, 1979).*

APPENDIX C

Daily precipitation and evaporation at Sioux Falls, South Dakota*

Day of Month		Precipitation in inches	Evaporation in inches
July	1	.01	.31
	2		.34
	3		.36
	4	Trace	.41
	5		.25
	6	Trace	.32
	7		.17
	8		.19
	9		.22
	10	Trace	.27
	11		.34
	12	.04	.37
	13	.08	.30
	14		.31
	15		.31
	16		.34
	17		.25
	18		.15
	19	.08	.33
	20	.31	.23
	21	.11	.39
	22	.88	--
	23		.30
	24	.02	.37
	25		.09
	26		.29
	27	Trace	.27
	28		.14
	29	1.59	--
	30	.01	.86
	31		.35
August	1		.15
	2	.35	.35

*U.S. Department of Commerce, Climatological Data for South Dakota, July 1979, v. 84, no. 7, and August 1979, v. 84, no. 8

Water Levels for
Wall Lake

South Dakota Department of Wildlife, Parks and Forestry

Division of Administration

September 24, 1979

Mr. Assad Barari
South Dakota Geological Survey
University of South Dakota
Vermillion, SD 57069

Dear Mr. Barari:

I am submitting the measurements taken by our Conservation Officer stationed at Sioux Falls. Be advised that these are more of an estimate than a measurement. No precision instruments were used to obtain them.

Wall Lake - Minnehaha County - 1979

July 3,	12,	19,	26,	August 2
-2 in.	-5 in.	-8 in.	-8 in.	-4 in.

Sincerely,

Lloyd F. Thompson
Deputy Secretary

LFT/ld

APPENDIX A

Logs of test holes drilled in the Wall Lake area (for map location, see fig. 1)

The locations are given as quarter sections, section number, township, and range.

All elevations have been estimated using a 7 1/2 minute topographic base and are presented in feet above mean sea level.

Test Hole 1
Location: NE NW NW NW sec. 27, T. 101 N., R. 51 W.
Elevation: 1580
Date Drilled: July 5, 1979

0- 1	Topsoil
1- 13	Clay, brown, silty, sandy, pebbly (oxidized till)
13- 70	Clay, gray, silty, sandy, pebbly (unoxidized till)

* * * *

Test Hole 2
Location: SW SW SW SE sec. 21, T. 101 N., R. 51 W.
Elevation: 1560
Date Drilled: July 5, 1979

0- 1	Topsoil
1- 18	Clay, yellow-brown, sandy, pebbly (oxidized till)
18- 31	Clay, brown, silty, sandy, pebbly
31- 60	Clay, dark gray, silty, sandy, pebbly

* * * *

Test Hole 3
Location: SE NE NE NE sec. 29, T. 101 N., R. 51 W.
Elevation: 1602
Date Drilled: July 5, 1979

0- 1	Topsoil
1- 23	Clay, yellow, silty, sandy, pebbly
23- 60	Clay, dark gray with rust spots, sandy, silty, pebbly

* * * *

Test Hole 4
Location: NE SE SE NE sec. 20, T. 101 N., R. 51 W.
Elevation: 1576
Date Drilled: July 6, 1979

0- 10	Sand, brown to orange, fine, gravel, well-rounded

10- 27	Clay, yellow, sandy, silty, pebbly (weathered till)
27- 57	Clay, gray, sandy, silty, pebbly (till)

* * * *

Test Hole 5
Location: NW NW NW NW sec. 21, T. 101 N., R. 51 W.
Elevation: 1570
Date Drilled: July 9, 1979

0- 1	Topsoil, black, sandy
1- 5	Sand, fine to medium, with clay
5- 21	Clay, yellow-brown, silty, sandy, pebbly (weathered till)
21- 66	Clay, gray, silty, sandy, pebbly (till)

* * * *

Test Hole 6
Location: SE SW SE SW sec. 16, T. 101 N., R. 51 W.
Elevation: 1573
Date Drilled: July 9, 1979

0- 3	Topsoil, black, sandy
3- 16	Clay, brown, sandy, silty, pebbly (weathered till)
16- 67	Clay, brownish-gray, sandy, silty, pebbly (till)

* * * *

Test Hole 7
Location: SE SW SE SE sec. 21, T. 101 N., R. 51 W.
Elevation: 1560
Date Drilled: July 9, 1979

0- 1	Topsoil, black, sandy
1- 9	Sand, fine to medium, with clay, buff colored
9- 22	Clay, yellow-brown, silty, sandy, pebbly (weathered till)
22- 76	Clay, gray, silty, sandy, pebbly (till)

Observation well placed in the shallow sand

* * * *

Test Hole 8
Location: SE SW NE SE sec. 21, T. 101 N., R. 51 W.
Elevation: 1572
Date Drilled: July 10, 1979

0- 3	Topsoil, black, clayey, sandy
3- 6	Clay, yellow, sandy
6- 17	Sand, fine, gravel, well-rounded
17- 65	Clay, brown to gray, silty, very sandy and pebbly
65	Very hard rock, possibly quartzite or granite

Observation well 1: 15 feet of plastic casing and 3-foot sandpoint

* * * *

Test Hole 9
Location: NE NE SE SE sec. 20, T. 101 N., R. 51 W.
Elevation: 1562
Date Drilled: July 10, 1979

0- 1	Clay, yellow, silty, sandy, pebbly (weathered till)
1- 7	Sand, fine with silt
7- 13	Gravel, fine to medium, with sand, fine to coarse
13- 15	Clay, yellow, silty, sandy, pebbly
15- 31	Gravel, fine to medium, with sand and silt
31- 86	Clay, gray, silty, sandy, and very pebbly (till)

* * * *

Test Hole 10
Location: NE SE SE SE sec. 20, T. 101 N., R. 51 W.
Elevation: 1571
Date Drilled: July 10, 1979

0- 20	Clay, brown, sandy, pebbly (weathered till)
20- 57	Clay, gray, sandy, pebbly (till)

* * * *

Test Hole 11
Location: SE SE NE SE sec. 20, T. 101 N., R. 51 W.
Elevation: 1570
Date Drilled: July 10, 1979

0- 1	Topsoil
1- 11	Clay, yellow-brown, silty, sandy, pebbly (weathered till)
11- 66	Clay, gray, silty, sandy, pebbly (till)

* * * *

Test Hole 12
Location: SW NE NE SW sec. 21, T. 101 N., R. 51 W.
Elevation: 1582
Date Drilled: July 11, 1979

0- 3	Topsoil, black, clayey
3- 11	Clay, brown, sandy, pebbly
11- 18	Sand, fine to gravel, well-rounded
18- 67	Clay, gray, sandy, silty, pebbly (till)

* * * *

Test Hole 13

Location: SW SE SE NE sec. 21, T. 101 N., R. 51 W.
Elevation: 1579
Date Drilled: July 11, 1979

0- 1	Topsoil, black, sandy, silty
1- 5	Sand, rust, fine to gravel
5- 20	Clay, yellow, silty, sandy, very pebbly (weathered till)
20- 50	Clay, gray, silty, sandy, pebbly (till)
50- 66	Clay, gray, silty, very sandy, pebbly

* * * *

Test Hole 14
Location: SW NW NW SW sec. 22, T. 101 N., R. 51 W.
Elevation: 1580
Date Drilled: July 11, 1979

0- 3	Topsoil, black, sandy
3- 6	Sand, rusty, fine, gravel, well-rounded
6- 15	Clay, brown, sandy, silty, pebbly (weathered till)
15- 67	Clay, gray, sandy, silty, pebbly (till)

* * * *

Test Hole 15
Location: SE NW NW SW sec. 22, T. 101 N., R. 51 W.
Elevation: 1567
Date Drilled: July 11, 1979

0- 1	Topsoil, black, clayey, sandy
1- 15	Clay, yellow-brown, silty, sandy, pebbly (weathered till)
15- 76	Clay, gray, silty, sandy, somewhat pebbly (till)

* * * *

Test Hole 16
Location: NW SW SW SW sec. 22, T. 101 N., R. 51 W.
Elevation: 1580
Date Drilled: July 11, 1979

0- 2	Topsoil, black, clayey, sandy
2- 6	Clay, yellow, silty
6- 19	Sand, fine to gravel, silty, well-rounded
19- 24	Clay, brown, sandy, silty, pebbly (weathered till)
24- 57	Clay, gray, sandy, silty, pebbly (till)

* * * *

Test Hole 17
Location: NW SW SW SW sec. 22, T. 101 N., R. 51 W.
Elevation: 1580
Date Drilled: July 12, 1979

0- 1	Topsoil, black, sandy
1- 9	Clay, yellow, silty, sandy, pebbly (weathered till)
9- 24	Clay, yellow, silty, sandy, very pebbly
24- 33	Clay, gray, silty, sandy, very pebbly (till)
33- 56	Sand, silt to medium, subrounded with much gray clay (sandy till)

* * * *

Test Hole 18
Location: SE NW SW SW sec. 22, T. 101 N., R. 51 W.
Elevation: 1570
Date Drilled: July 12, 1979

0- 4	Topsoil, black, clayey
4- 7	Clay, yellow, silty
7- 21	Clay, brown, sandy, silty, pebbly (weathered till)
21- 67	Clay, gray, sandy, silty, very pebbly after 25 feet (till)

* * * *

Test Hole 19
Location: SE NE NE NW sec. 21, T. 101 N., R. 51 W.
Elevation: 1560
Date Drilled: July 12, 1979

0- 1	Topsoil, black, sandy, clayey
1- 15	Clay, buff, silty, sandy, pebbly (weathered till)
15- 55	Clay, gray, silty, sandy, pebbly (till)
55- 76	Sand, gray, very clayey, silty (very sandy till)

* * * *

Test Hole 20
Location: NW SE NE NW sec. 21, T. 101 N., R. 51 W.
Elevation: 1560
Date Drilled: July 12, 1979

0- 4	Topsoil, black, sandy
4- 7	Clay, dark brown, sandy, silty
7- 13	Clay, brown, sandy, silty, pebbly
13- 17	Sand, gray, fine, silty
17- 25	Clay, brown, sandy, silty, pebbly
25- 27	Clay, black, very little sand or silt
27- 60	Clay, gray, sandy, pebbly, very silty (till)

* * * *

Test Hole 21
Location: SE SE SW SW sec. 17, T. 101 N., R. 51 W.
Elevation: 1575
Date Drilled: July 12, 1979

0- 3	Topsoil, black, silty, sandy
3- 25	Clay, yellow-brown, silty, sandy, pebbly (weathered till)
25- 46	Clay, gray, silty, sandy, pebbly (till)

* * * *

Test Hole 22
Location: NE NE SE SE sec. 20, T. 101 N., R. 51 W.
Elevation: 1561
Date Drilled: July 13, 1979

0- 1	Topsoil, black, sandy
1- 15	Sand, rusty, fine, gravel
15- 22	Sand, medium, silt
22- 45	Silty sand and gravel, somewhat sorted in layers, 3 to 5 feet thick
45- 66	Clay, gray, silty, sandy, pebbly (till)

Observation well 2: 38 feet of plastic casing and 3-foot sandpoint

* * * *

Test Hole 23
Location: SE NE SE SE sec. 20, T. 101 N., R. 51 W.
Elevation: 1570
Date Drilled: July 13, 1979

0- 5	Sand, rusty, fine to coarse, silty
5- 24	Clay, brown, sandy, pebbly
24- 33	Sand, fine, gravel, silty, well-rounded
33- 35	Sand, gray, fine, very silty
35- 57	Clay, gray, sandy, silty, pebbly (till)

* * * *

Test Hole 24
Location: SE NW NE NE sec. 28, T. 101 N., R. 51 W.
Elevation: 1560
Date Drilled: July 13, 1979

0- 1	Topsoil, black, clayey, sandy
1- 21	Clay, yellow, silty, sandy, pebbly (weathered till)
21- 56	Clay, gray, silty, sandy, pebbly (till)

* * * *

Test Hole 25
Location: NW NE NW NW sec. 34, T. 101 N., R. 51 W.
Elevation: 1550
Date Drilled: July 16, 1979

0- 3	Clay, brown, sandy

3- 6	Sand, fine, gravel, well-rounded
6- 30	Clay, grayish-brown, sandy, silty, pebbly
30- 45	Clay, gray, sandy, silty, pebbly (till)
45- 52	Silt, sandy, some clay samples
52- 67	Clay, gray, sandy, silty, gravelly (till)

* * * *

APPENDIX D

General Description of cores from Wall Lake

February 22, 1980

U.S. Army Corps of Engineers
Omaha District
215 North Seventeenth Street
Omaha, NE 68102

ATTENTION MROED-HF (John Anderson)

Dear Mr. Anderson:

Under separate cover the cores taken from the Wall Lake are being shipped to your office.

The locations of the sample sites are plotted on the enclosed air photo. In all samples the upper 6 inches to a foot of the sediments might have been compacted during the coring. The general descriptions of the sites and samples are:

SITE A

Located approximately 400 feet east-northeast of the Roller Rink which is located on the southwest shore of the Lake.

Sample A was collected from Site A. The depth to the bottom of the lake from the surface of the ice was approximately 11 feet. The core is approximately 26 inches long. This sample had more sand than any other sample collected from the lake.

SITE B

Located approximately 450 feet east-northeast of the inlet to the lake located on the west side of the lake. The depth to the bottom of the lake from the surface of the ice was approximately 11 feet. Three samples were collected from this site.

Sample B was 23 inches long.
Sample B2 was 18 inches long.
Sample B3 was 16 inches long.

It was intended that the top of Sample B2 to start from 23 inches below the bottom of the lake, but some caving had

occurred and Sample B2 might have some sediments from the upper deposits. The same problem exists in Sample B3.

SITE C

Located approximately 1600 feet east of the inlet located on the west side of the lake. The depth to the bottom of the lake from the surface of the ice was 12 feet 6 inches.

Two samples were collected from this site:

Sample C1 was 32 inches long.
Sample C2 was 24 inches long.

It was intended that the top of Sample C2 start from 32 inches below the bottom of the lake, but some caving had taken place and Sample C2 might have some sediments from the upper deposits.

SITE D

Located approximately 225 feet west of the east shore of the lake. The depth to the bottom of the lake from the surface of the ice was 12 feet 6 inches.

Sample D was collected from Site D.
The core is 2 feet 3 inches long.

If you have any further questions, please feel free to call or write our office.

Sincerely,

Assad Barari
Geologist

For the State Geologist

Appendix C

Project Coordinator
Final Report

FINAL REPORT

on the 208 Water Quality Contract
between the South Dakota Department
of Water and Natural Resources and
the Minnehaha Conservation District.

JANUARY 1982

JAN 14 1982

INDEX

INDEX	i
INTRODUCTION	1
DREDGING FEASIBILITY STUDY	1
OBSERVATION WELLS	2
CORE SAMPLES	2
BEACH CLEANUP AND PUBLIC PARTICIPATION	3
INFRARED AERIAL PHOTOGRAPHS	3
MEETINGS WITH LANDOWNERS	4
FIELD STUDIES	4
BUDGET PROPOSAL/WORK PLAN	4
MONITORING	4
COPPER EXPERIMENT	5
TRAINING AND INFORMATIONAL MEETINGS	5
APPLICATION FOR FINANCIAL ASSISTANCE	5
WATERSHED MAP	7
CANCELLING CONTRACT	7
APPENDICES	9
Test Hole Locations	A-1
Coring Site Locations	A-2
Contract Price Summary	A-3
Work Plan	A-5
Final Financial Report	A-12
Audit Report	A-13
State Water Plan Proposal	A-18
Wall Lake Watershed Map	A-22
Wall Lake Soils Map	A-23

FINAL REPORT - WALL LAKE RESTORATION PROJECT

In June of 1980 the Minnehaha Conservation District entered into a contract with the South Dakota Department of Water and Natural Resources (DWNR). The purpose of this contract was to promote further data collection studies and to establish a program with which the restoration of Wall Lake, South Dakota could be accomplished. Wall Lake is located twelve miles west of Sioux Falls, South Dakota. The lake has a surface area of about 225 acres and has a contributing drainage area of slightly over five square miles. The lake has an average depth of nine (9) feet and a maximum depth of twelve (12) feet.

Dredging Feasibility Study

The United States Army Corps of Engineers compiled a dredging feasibility study for the Wall Lake project in March of 1980. This study explored five alternatives and found one of these proposals as that which produced the most return on the investment.

The report noted that the major problem in Wall Lake was the high nutrient level. The shallow depths result in the stirring of bottom sediments which keeps greater amounts of nutrients suspended in the water. The shallow depths also result in winter fish kills.

The five alternatives included: (a) purchase of a horizontal auger cutterhead dredge to deepen the lake by four (4) feet, (b) using a conventional hydraulic cutterhead dredge to deepen the lake by four (4) feet, (c) using a conventional hydraulic cutterhead dredge to deepen selected areas of the lake, (d) draining the lake and using conventional earthmoving equipment to remove the material, and (e) reduction of the lake's nutrient levels through chemical inactivation.

Plan "a" was the preferred plan. This plan involved dredging to increase

the depth by four (4) feet inside of 172 acres of the lake. Key factors of the plan included that the Wall Lake Association would purchase a dredge, hire the operating crew, and hire a qualified engineer to devise a dredging plan and supervise its execution. An addendum to the study showed that the areas to be dredged could be reduced to the following: 122 acres to be dredged 4 feet and 50 acres to be dredged only 2 feet. This change was made because it was discovered that the sediment load in the lake was less than originally believed.

The study also tested the amount of copper in the lake sediments. This copper accumulation resulted from the use of copper sulfate as an algacide. The report stated that the copper concentrations were within the range found on agricultural soils, however, it recommended that further tests be conducted to insure the suitability of the bottom sediment before it was added to agricultural land.

The lake was also tested for pesticide and herbicide concentrations. Both the mud and the water were tested with the results indicating that the concentrations were all below the lower detection limit except in the case of the Atrazine in the mud. It appeared that the Atrazine was adhered to the soil particles and not being released into the water.

Observation Wells

Observation wells were established through the cooperation of the Minnehaha Conservation District, the East Dakota Conservancy Subdistrict, and the Wall Lake Homeowners Association. A total of 25 test wells were drilled in the Wall Lake vicinity (see appendix for locations) in July of 1979. These wells showed no important ground-water connections to the lake.

Core Samples

The Corps of Engineers and the Minnehaha Conservation District obtained

sediment core samples (see appendix for locations) through the ice in February, 1980. Analysis of these samples showed that sediment accumulation was not as great as originally believed and in turn the addendum to the dredging feasibility study was compiled. The South Dakota Geological Survey Office included the results of both the observation wells study and the core samples study in the publication entitled "Hydrology of Wall Lake".

Beach Cleanup and Public Information

The Minnehaha Conservation District and the Wall Lake Homeowners Association sponsored a "beach cleanup project" in June, 1979. Numerous concerned individuals aided in cleaning up the beach area. Local businessmen provided refreshments and local radio stations provided public service announcements. Other public information announcements concerning the total reclamation plan included articles in the Hartford, South Dakota "Herald", the Sioux Falls Argus Leader, the Conservation District newsletter, and television interviews on KELO television. Mailing lists of interested parties were also compiled and periodically updated.

Infrared Aerial Photographs

The Department of Water and Natural Resources contracted an aerial infrared photograph of Wall Lake to locate potential septic system problems. A total of eleven (11) sites showed up clearly on the photo however, after an inspection of these sites by Richard Fike (DWNR) and R.D. Filbey (Lockheed Remote Sensing Laboratory) three of these sites were ruled out. The project coordinator discussed the remaining sites with the president of the Wall Lake Association. The coordinator asked for the names of the homeowners of the potential problem sites shown on the photo, however, the Homeowners' president did not respond.

Meetings with Landowners

Meetings were held with the lake homeowners and watershed landowners in November of 1979, and in Jan., Mar., and April of 1980. Attendance at these meetings was poor however, we did receive letters of support from some of those who did not attend. The proposed plan was also presented to the Minnehaha County Commissioners at one of their meetings and they were kept updated at subsequent meetings.

Field Studies

Rich Whitston (DWNR), Herb Davis (SCS/DWNR), Doug Culhane (SCS), and Philip Kappen (project coordinator) conducted a field study of the Wall Lake watershed in the summer of 1980. Land uses and cropping systems were cross checked with existing maps and culverts and waterways were checked for sediment accumulation. Little sediment was found in the waterways and culverts checked.

Budget Proposal/Work Plan

The Conservation District worked up an estimated budget proposal and work plan. Copies of both documents are included (see appendix). Copies of the final financial statement and audit report are also included in the appendix.

Monitoring

A water quality monitoring system was established by the Minnehaha Conservation District. Samples were tested in the field for amount of dissolved oxygen, air and water temperatures, general weather conditions, and pH of the water. Samples were sent in to Pierre where they were tested for coliform bacteria counts, nutrient levels and dissolved solids. The sampling schedule was rotated so that each site was sampled once per month.

Copper Experiment

An experiment was run to determine what effect the copper content of the lake bottom sediments would have on agricultural crops. This experiment was suggested by the Corps of Engineers feasibility study. Corn and soybeans were grown on a sample of the lake bottom sediments and on a sample of Kranzburg soil, the predominant soil type in the watershed. During the period of growth the characteristics of the plants were noted. There appeared to be little difference between the samples. After the plants were grown, samples of the plants were taken to the Biochemistry Department at South Dakota State University (SDSU) for analysis of the copper content. The results were as follows - Kranzburg corn - 1.9 ppm, Kranzburg soybeans - 5.9 ppm, Wall Lake corn - 2.6 ppm, and Wall Lake soybeans - 6.5 ppm. Dr. Emmerick (SDSU) stated that he did not believe that these concentrations would be detrimental to animals or plants, however, he would need to make further studies before his results would be conclusive. No further tests were conducted.

Training and Information Meetings

The project coordinator attended an Environmental Protection Agency (EPA) workshop in October, 1980. The workshop was held in Kansas City, Missouri and dealt with the EPA 314 clean lakes program. The coordinator also attended various meetings held for the project coordinators across South Dakota. These meetings provided a means for the coordinators to keep each other posted on their various projects and exchange ideas.

Applications for Financial Assistance

The Minnehaha Conservation District and the East Dakota Conservancy Subdistrict worked together on a proposal to include the Wall Lake project in

the State Water Resource Management Plan. The coordinator attended an East Dakota meeting to explain the plan and also testified at the public meeting held in Sioux Falls to explain the various aspects of the Wall Lake Project. A copy of this proposal was submitted to the DWNR. A copy of the State Water Plan proposal is also included in the appendix.

The Minnehaha Conservation District and the DWNR cooperated in preparing the application for the Federal 314 grant. The project coordinator conducted topographic surveys of the inlet and outlet channels at Wall Lake as instructed by DWNR. This information was used in computing the detention time for the Lake to be included in the application. Charts and script were compiled showing the description of the drainage basin, public access and potential use, historic uses, pollution sources, limnological data, monitoring program, project benefits, sources of other funding, environmental impact, and public participation. The Corps Feasibility Plan and other water quality data were also included in this application. The application was completed in December, 1980.

The EPA rejected the application on the grounds that the application did not address quantification of internal nutrient loading. There was also no evidence that external loading had been reduced. As these were the major reasons cited for dredging the lake, the application was rejected.

In addition to the 314 application, applications were also made to the state for financial assistance and to the Army Corps of Engineers for a dredging permit.

The project coordinator also presented the plan to the state Agricultural Stabilization and Conservation Service (ASCS) committee at a meeting in Huron. It was proposed that Wall Lake be chosen as a Rural Clean Water Program (RCWP) project. The ASCS determined that another project than Wall Lake could be best served by RCWP. The RCWP funds are for use in watershed work rather than the dredging program around which the Wall Lake project was formed.

There was also an application for additional funds made to the East Dakota Conservancy Subdistrict. The Subdistrict promised that they would give whatever support that it was financially able to give. However, any financial support would by necessity be limited.

Watershed Map

The Minnehaha Conservation District had a map of the Wall Lake Watershed printed. This map showed the topography of the watershed and also included an overlay sheet which showed the soil types present. A copy of the map is found in the appendix.

Cancelling Contract

During the course of this contract the Minnehaha Conservation District has repeatedly requested the Wall Lake Association to call an Association meeting. The representative which we contacted always told me that they would call back about this but have never done so. To our knowledge there has been no association meeting since the Conservation District entered into the contract with DWNR. As the associations support is crucial in carrying out the project, the fact that they have not been remaining involved is detrimental to the continuance of the contract.

Through discussions with representatives of the SCS, DWNR, Lockheed Remote Sensing, and the East Dakota Conservancy Subdistrict we have come to assume that the majority of the nutrient loading is resulting from septic systems surrounding the lake.

Due to the reduced support from the Wall Lake Association and the Conservation District's lack of expertise in dealing with septic systems, the Minnehaha Conservation District requested that the contract be cancelled. A letter to that effect was sent out to the Wall Lake Association members in September of 1981. The

district received no replies or comments from any of the Association members concerning this action.

The District has informed the Wall Lake Association that should they decide in the future to once again work for the lake's renovation that we would be willing to help where we can, after they have shown us their renewed interest.

APPENDICES

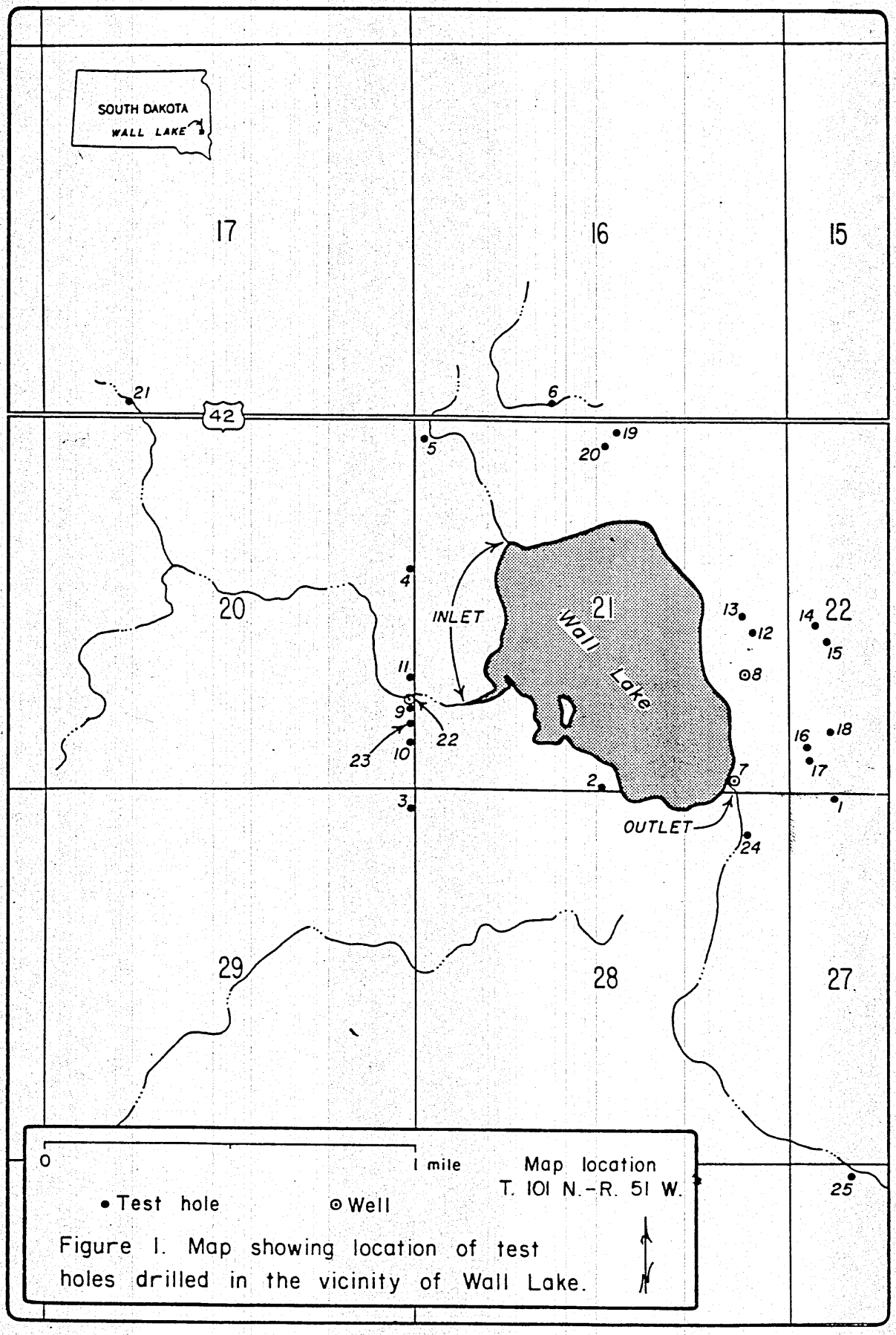
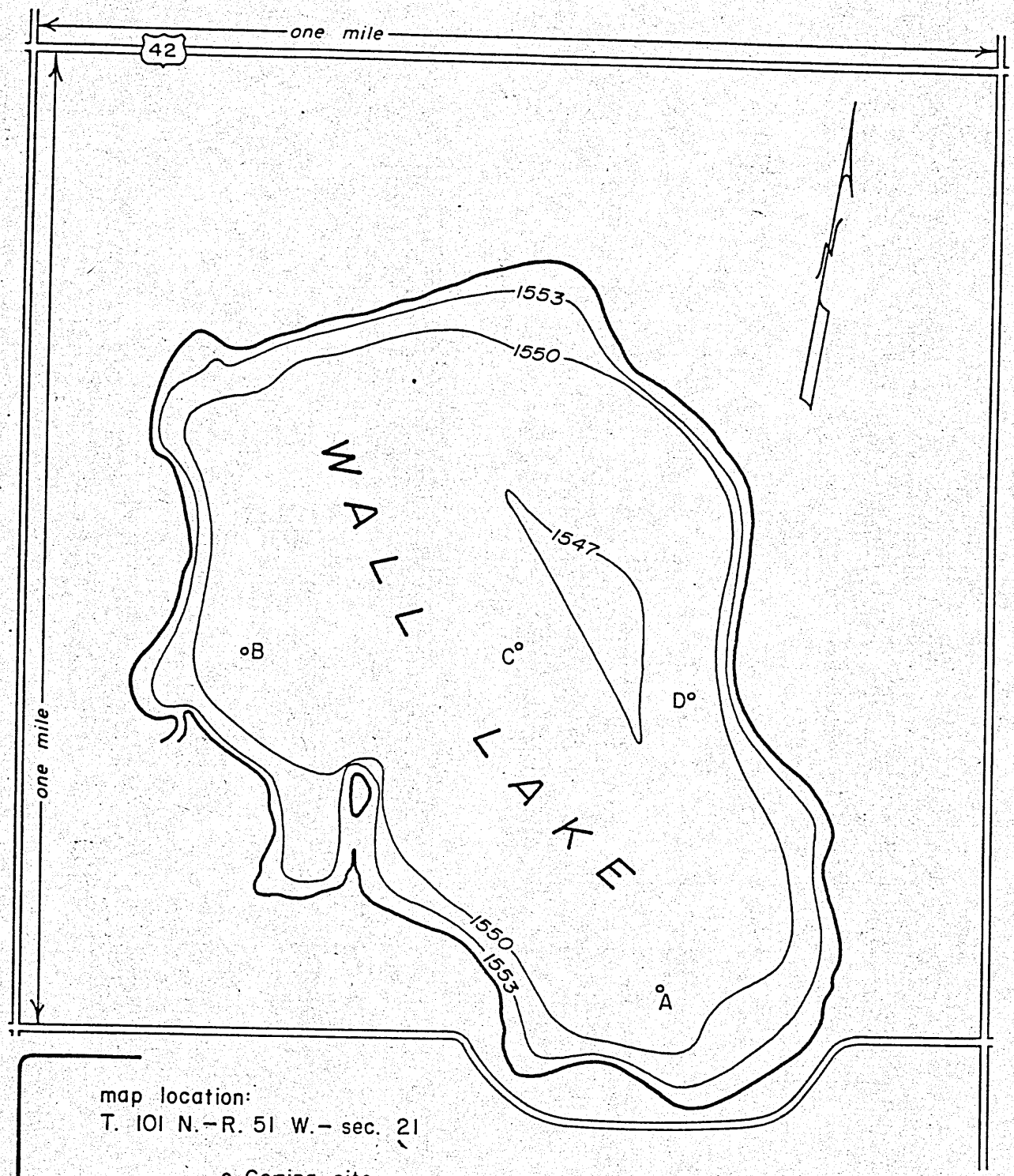


Figure 1. Map showing location of test holes drilled in the vicinity of Wall Lake.



map location:
T. 101 N.–R. 51 W.– sec. 21

° Coring site

1550— Contour line on lake bottom showing equal elevation in feet above mean sea level. *Pool elevation on June 19, 1979 – 1559.5 feet above mean sea level.*

Figure 2. Depth contour map of Wall Lake and the location of coring sites. *(from Corps of Engineers, 1979).*

COST OR PRICE SUMMARY FORMAT FOR SUBAGREEMENTS UNDER U.S. EPA GRANTS
(See accompanying instructions before completing this form)

Form Approved
OMB No. 158-R0144

PART I - GENERAL

1. GRANTEE
South Dakota Department of Water & Natural Resources

2. GRANT NUMBER
R008151

3. NAME OF CONTRACTOR OR SUBCONTRACTOR
Minnehaha County Conservation District

4. DATE OF PROPOSAL
7/1/80 to 6/30/81

5. ADDRESS OF CONTRACTOR OR SUBCONTRACTOR *(Include ZIP code)*
3812 North Cliff Avenue
Sioux Falls, South Dakota 57104

6. TYPE OF SERVICE TO BE FURNISHED
Coordination of Wall Lake Dredging Plan

PART II - COST SUMMARY

7. DIRECT LABOR *(Specify labor categories)*	ESTIMATED HOURS	HOURLY RATE	ESTIMATED COST	TOTALS
Coordinator (40% of time)	1000	$ 6.50	$ 6,500.00	
Secretary (10% of time)	260	3.50	900.00	
Conservation Supervisors	260	5.00	1,300.00	
Fringe Benefits: Unemp. Comp., FICA, Work Comp.			1,500.00	
DIRECT LABOR TOTAL:				$ 10,200.00

8. INDIRECT COSTS *(Specify indirect cost pools)*	RATE	× BASE =	ESTIMATED COST	
		$	$	
INDIRECT COSTS TOTAL:				$

9. OTHER DIRECT COSTS

a. TRAVEL	ESTIMATED COST	
(1) TRANSPORTATION 3,000 miles @ 20¢ per mile	$ 600.00	
(2) PER DIEM	$ 400.00	
TRAVEL SUBTOTAL:	$ 1,000.00	

b. EQUIPMENT, MATERIALS, SUPPLIES *(Specify categories)*	QTY	COST	ESTIMATED COST	
Film and development		$	$ 250.00	
Printing			700.00	
Equipment rental			700.00	
Office Supplies			340.00	
EQUIPMENT SUBTOTAL:			1,990.00	

c. SUBCONTRACTS	ESTIMATED COST	
Lab Tests (on plant residues)	$ 250.00	
Lab Tests (on water samples)	150.00	
SUBCONTRACTS SUBTOTAL:	$ 400.00	

d. OTHER *(Specify categories)*	ESTIMATED COST	
Telephone - 200.00, Audit - 600.00, Postage - 500.00	$	
Insurance - 140.00		
OTHER SUBTOTAL:	$ 1,440.00	
e. OTHER DIRECT COSTS TOTAL:		$ 4,800.00
10. TOTAL ESTIMATED COST		$ 15,000.00
11. PROFIT		$
12. TOTAL PRICE		$ 15,000.00

13. COMPETITOR'S CATALOG LISTINGS, IN-HOUSE ESTIMATES, PRIOR QUOTES (Indicate basis for price comparison)	MARKET PRICE(S)	PROPOSED PRICE
		$

PART IV - CERTIFICATIONS

14. CONTRACTOR

14a. HAS A FEDERAL AGENCY OR A FEDERALLY CERTIFIED STATE OR LOCAL AGENCY PERFORMED ANY REVIEW OF YOUR ACCOUNTS OR RECORDS IN CONNECTION WITH ANY OTHER FEDERAL GRANT OR CONTRACT WITHIN THE PAST TWELVE MONTHS?

☐ YES ☒ NO *(If "Yes" give name address and telephone number of reviewing office)*

14b. THIS SUMMARY CONFORMS WITH THE FOLLOWING COST PRINCIPLES

40 CFR 30.710

14c.

This proposal is submitted for use in connection with and in response to *(1)* "208" Water Quality Planning Contract. This is to certify to the best of my knowledge and belief that the cost and pricing data summarized herein are complete, current, and accurate as of *(2)* 10/1/80 and that a financial management capability exists to fully and accurately account for the financial transactions under this project. I further certify that I understand that the subagreement price may be subject to downward renegotiation and/or recoupment where the above cost and pricing data have been determined, as a result of audit, not to have been complete, current and accurate as of the date above.

(3) 10/10/80
DATE OF EXECUTION

Philip M. Kaffen
SIGNATURE OF PROPOSER

DISTRICT MANAGER
TITLE OF PROPOSER

14. GRANTEE REVIEWER

I certify that I have reviewed the cost/price summary set forth herein and the proposed costs/price appear acceptable for subagreement award.

4 Dec 80
DATE OF EXECUTION

Nancy Potts
SIGNATURE OF REVIEWER

Accountant
TITLE OF REVIEWER

16. EPA REVIEWER *(If applicable)*

DATE OF EXECUTION

SIGNATURE OF REVIEWER

TITLE OF REVIEWER

PLAN OF ACTION
Wall Lake Restoration Project

OBJECTIVE I - Maintain communication lines between all individuals and governmental agencies involved in the Wall Lake Project.

ACTION: WHAT	WHO	HOW	WHEN	PROGRESS
1. Keep lines of communication open to all individuals and agencies involved.	Project Coordinator	a. Compile a mailing list and keep it current.	Continuous	
2. Develop public information plan.	Project Coordinator	a. Set up schedule of news releases on water quality and project progress.	Jan. '81	
	Project Coordinator	b. Develop a brochure explaining the project and the need for the project.	Feb. '81	
	Project Coordinator	c. Set up schedule of news releases describing available cost sharing programs.	Jan. '81	
	Project Coordinator	d. Publish news releases according to news release schedule.	See Schedules	
	Coordinator & SCS	e. Set up visual display showing best management practices.	Jan.-Feb. '81	
	Coordinator & SCS	f. Assemble slide program explaining the project and the need for the project.	Jan.-Feb. '81	

OBJECTIVE I (Continued)

ACTION: WHAT	WHO	HOW	WHEN	PROGRESS
3. Keep contracting agencies informed of progress.	Project Coordinator	a. Furnish contracting agencies with monthly progress reports.	Monthly	
	Project Coordinator	b. Prepare annual progress report.	July '81	

OBJECTIVE II - Assist in monitoring activities as required by EPA for Federal 314 Grant.

ACTION: WHAT	WHO	HOW	WHEN	PROGRESS
1. Monitor water quality before project is implemented, during implementation and after completion.	Project Coordinator	a. Collect samples and and run basic tests.	Continuous according to EPA required schedule.	
	Project Coordinator	b. Submit samples to testing lab.	Continuous according to EPA required schedule.	
	Project	c. Assist in training other sample collectors.	As needed.	

OBJECTIVE III - Provide planning and technical assistance to land users within the Wall Lake watershed in order to reduce the amount of nutrients entering the lake.

ACTION: WHAT	WHO	HOW	WHEN	PROGRESS
1. Identify non-point source pollution areas in watershed.	SCS	a. Identify contributing feedlots.	Sept. '80	
	Coordinator & SCS	b. Determine capacity and season of use.	Sept. '80	
	SCS	c. Identify fields which maybe contributing nutrients to lake.	Sept. '80	
	DWNR	d. Identify potential septic failures around lake.	May '80	
	Project Coordinator	e. Determine hazardous soils in watershed.	June '80	
2. Identify Best Management Practices.	SCS	a. Determine conservation practices needed in the watershed.	Sept. '80	

OBJECTIVE IV: Obtain financing needed to implement project.

ACTION: WHAT	WHO	HOW	WHEN	PROGRESS
1. Apply for funding from governmental agencies and planning commissions.	Coordinator	a. Apply for Federal 314 funding.	Dec. '80	
	Coordinator	b. Apply for State funding.	Dec. '80	
	Coordinator	c. Apply to Conservancy Subdistrict.	Jan. '81	
	Coordinator	d. Apply to County.	Jan. '81	
	Coordinator	e. Apply to City.	Jan. '81	
	Coordinator	f. Apply to Old West Regional Commission.	Jan.-Feb. '81	
2. Obtain funding from individuals and organizations.	Coordinator	a. Obtain financial guarantee from Wall Lake Improvement Association.	Jan. '81	
	Coordinator	b. Check with various corporations and philanthropic groups for additional contributions.	Continuous	
	Coordinator	c. Approach Izaak Walton League regarding contributions.	Feb. '81	
	Coordinator	d. Meet with involved individuals to compile lists of other funding sources.	Jan. '81	

OBJECTIVE V - Determine whether proposed project will have any long range environmental impacts.

ACTION: WHAT	WHO	HOW	WHEN	PROGRESS
1. Determine whether sediment copper content will have adverse effects on plant materials.	Coordinator	a, Conduct experiment to determine whether copper will be absorbed by plants in toxic quanities.	Oct. '80-Apr. '81	

OBJECTIVE VI - Ensure that there will be sufficient sites for disposing of dredged material.

ACTION: WHAT	WHO	HOW	WHEN	PROGRESS
1. Determine whether proposed sites will be available.	Coordinator	a. Contact landowners of proposed disposal sites to see if they would be interested in leasing these sites for project duration.	Jan. '81	
2. Work out lease agreements.	Coordinator	a. Meet with landowners to work out details of leasing.	Mar.-Apr. '81	

MINNEHAHA CONSERVATION DISTRICT

FINANCIAL REPORT OF THE "208" WATER QUALITY GRANT BETWEEN

MINNEHAHA CONSERVATION DISTRICT

AND

SOUTH DAKOTA DEPARTMENT OF WATER AND NATURAL RESOURCES

SEPTEMBER 1, 1981 TO NOVEMBER 30, 1981

	Budgeted	Expenditures 9/1/81-11/30/81	Cumulative Expenditures	Remaining in Budget
Personnel	$ 8,700.00	$ 93.33	$ 1,908.93	$ 6,791.07
Fringe Benefits	1,500.00	37.42	259.69	1,240.31
Supplies	1,960.00	-	193.90	1,766.10
Travel	1,000.00	-	880.96	119.04
Subcontracts	400.00	-	60.00	340.00
Telephone	200.00	-	5.71	194.29
Audit	600.00	** 530.00	530.00	70.00
Postage	500.00	3.36	56.29	443.71
Insurance	140.00	* (86.80)	48.00	92.00
TOTALS	$15,000.00	$ 577.31	$ 3,943.48	$11,056.52

* Current period expenditures include adjustment to cumulative totals for prior classification errors. Workman's compensation insurance has been reclassified to fringe benefits.

** Amount was not paid as of November 30, 1981.

MINNEHAHA CONSERVATION DISTRICT

208 WATER QUALITY GRANT

AUDITED FINANCIAL STATEMENTS

NOVEMBER 30, 1981

To The Board of Supervisors
Minnehaha Conservation District

I have examined the balance sheet of Minnehaha Conservation District's 208 Water Quality Grant as of November 30, 1981, and the related statement of revenues and expenditures for the seventeen months then ended. My examination was made in accordance with generally accepted auditing standards and, accordingly, included such tests of the accounting records and such other auditing procedures as I considered necessary in the circumstances.

In my opinion, the financial statements referred to above present fairly the financial position of Minnehaha Conservation District's 208 Water Quality Grant as of November 30, 1981, and its revenues and expenditures for the seventeen months then ended, in conformity with generally accepted accounting principles.

Clair M. Wuebben
Certified Public Accountant

December 7, 1981
Dell Rapids, South Dakota

MINNEHAHA CONSERVATION DISTRICT
208 WATER QUALITY GRANT
BALANCE SHEET
NOVEMBER 30, 1981

ASSETS

DUE FROM SOUTH DAKOTA DEPARTMENT OF WATER AND NATURAL RESOURCES (Note 2)	$ 660.25
Total Assets	$ 660.25

LIABILITIES AND FUND BALANCE

AUDIT FEE PAYABLE	$ 530.00
DUE TO MINNEHAHA CONSERVATION DISTRICT GENERAL FUND	130.25
Total Liabilities	660.25
FUND BALANCE	-
Total Liabilities and Fund Balance	$ 660.25

See notes to financial statements.

MINNEHAHA CONSERVATION DISTRICT
208 WATER QUALITY GRANT
STATEMENT OF REVENUES AND EXPENDITURES
FOR THE PERIOD JULY 1, 1980 TO NOVEMBER 30, 1981

	BUDGET	ACTUAL	REMAINING BUDGET
REVENUES:			
Grant from South Dakota Department of Water and Natural Resources	$11,250.00	$ 2,957.61	$ 8,292.39
Minnehaha Conservation District matching	3,750.00	985.87	2,764.13
	15,000.00	3,943.48	11,056.52
EXPENDITURES:			
Personnel	8,700.00	1,908.93	6,791.07
Fringe benefits	1,500.00	259.69	1,240.31
Supplies	1,960.00	193.90	1,766.10
Travel	1,000.00	880.96	119.04
Subcontracts	400.00	60.00	340.00
Telephone	200.00	5.71	194.29
Audit	600.00	530.00	70.00
Postage	500.00	56.29	443.71
Insurance	140.00	48.00	92.00
	$15,000.00	$ 3,943.48	$11,056.52
Excess of revenues over disbursements	$ -0-	$ -0-	$ -0-

See notes to financial statements.

MINNEHAHA CONSERVATION DISTRICT
208 WATER QUALITY GRANT
NOTES TO FINANCIAL STATEMENTS
NOVEMBER 30, 1981

1. GENERAL:

The accompanying financial statements represent the financial position and revenues and expenditures of a jointly funded project of the Minnehaha Conservation District and the South Dakota Department of Water and Natural Resources. The purpose of the grant was to test and improve water quality of Wall Lake.

The project was funded 75% by the South Dakota Department of Water and Natural Resources and 25% by the Minnehaha Conservation District.

Revenues and expenditures are recorded using the accrual basis of accounting.

2. DUE FROM SOUTH DAKOTA DEPARTMENT OF WATER AND NATURAL RESOURCES:

This amount represents three unreimbursed claims for expenditures as follows:

Period	Amount
7/1/81 - 7/31/81	$ 103.46
8/1/81 - 8/31/81	199.59
9/1/81 - 11/30/81	577.31
	880.36
Reimbursement rate	x 75%
	$ 660.25

WALL LAKE RESTORATION - MINNEHAHA COUNTY
Proposed Facility for State Water Resource Management System
Preliminary Facility Summary
November, 1980

Project Description

This "clean lakes" project would involve removal of a portion of the sediments in the bottom of Wall Lake to improve the water quality of the lake, reduce fish kills, and improve the recreational aspects of the lake. Wall Lake is a shallow 225-acre lake located approximately ten miles west of Sioux Falls. The lake has an average depth of 9 ft. and a contributing drainage area of about four square miles.

Completed Studies

The Corps of Engineers, in cooperation with the S.D. Department of Water and Natural Resources, East Dakota Conservancy Sub-District, and Minnehaha Conservation District, made a feasibility study of Wall Lake dredging in 1978-1979 under Section 22 of the Water Resources Development Act of 1974. The plan evaluated five alternatives and selected a plan to dredge 172 acres of Wall Lake to a depth of 2 to 4 ft. greater than the existing depths using a horizontal auger cutterhead dredge. This would involve removal of .95 x 10^6 cubic yards of sediment requiring about 124 acres of disposal area. It was roughly estimated that 11.3 tons of nitrogen and 56.8 tons of phosphorus will be removed from the ecosystem by dredging.

During the course of the study it was recommended that a separate study should be made to determine the extent of glacial outwash around the lake and, thus, the amount of groundwater recharge to the lake. The groundwater study made by the S.D. Geological Survey showed very little potential recharge, meaning that dredge spoils should be placed so that the decant would flow back to the lake during the initial phases of dredging. During the last dredging season dredge material would be placed somewhere below the lake outlet to prevent the high nutrient decant from re-entering the lake.

The Corp's study indicated the presence of potentially harmful levels of copper in bottom sediments likely due to copper sulfate treatment of the lake for temporary control of algal blooms. The Minnehaha Conservation District is currently working with test plantings of corn and soybeans on samples of bottom sediments to assess the toxicity of these sediments.

The Department of Water and Natural Resources, Division of Water Quality, in cooperation with EPA, Soil Conservation Service, and the Conservation District, began a Section 208 Water Quality study of the lake in early 1979. Preliminary results indicate that there is not a heavy inflow of sediments or nutrients from watershed runoff and that lake improvement would primarily result from in-lake restoration such as dredging. An infrared photo has been taken and evaluated to assess and identify possible nutrient input from lakeshore homes and cottages

Need for the Project

According to the Corps' study report, the major problems at Wall Lake were the shallow depth and high nutrient levels, both of which contribute to the lake's eutrophic or hypereutrophic condition. This results in frequent and severe algal blooms during summer months and common fish winterkills during ice and snow cover. The report also notes that the shallow lake depths result in frequent stirring of the bottom sediments by strong winds which can impart additional nutrients from bottom sediments to the water column. The State Lakes Preservation Committee report, published in 1977, concluded that favorable water quality improvement in Wall Lake is conditioned on the removal of several feet of existing sediment.

Wall Lake is one of few natural lakes near the metropolitan Sioux Falls area, the largest population center in the state. Both the U.S. Bureau of Outdoor Recreation and the State Department of Game, Fish and Parks have concluded that water-based recreation is in short supply in the area. Recreational use of Wall Lake has diminished in recent years due to poor water quality. Dredging of Wall Lake and the resultant improvement of water quality would provide an excellent water-based recreational resource for this area.

Economic and Engineering Feasibility

Cost figures for the proposed dredging of Wall Lake are shown in Table I. Estimates are based on the assumptions that:

(1) The Lake Improvement Association will purchase a dredge capable of at least 30% production efficiency.

(2) The Lake Association will hire the necessary operators to run the dredge and contractors to build and maintain the containment areas.

(3) The Lake Association will engage a qualified engineer to devise a detailed plan and supervise its execution.

TABLE I

COSTS 1/

Items	Cost
Purchase of Dredge, Accessories and Booster Pump	$150,000
Fuel and Maintenence for Dredge	127,000
Build Containment Area Dikes (w/20 yd. scraper - 13,125 ft.)	55,000
Build Road Crossing Culverts, Wiers, and Drainage Channels	25,000
Salaries	242,000 2/
Contingencies	90,000
SUBTOTAL	689,000
Engineering and Design	55,000
Supervision and Administration	48,000
TOTAL PROJECT COST	792,000

1/ Costs shown are accurate for March, 1980.

2/ Salary Breakdown
$16.00 per hour, 24 hours per day, 7 days per week
2-3 man crew per shift

Dredging could commence in the spring as soon as weather and ice conditions would permit the completion of containment area construction. Assuming a production rate of 1800 cubic yards per day, the monthly dredge rate would be 54,000 cu. yd. At this rate the total volume of .95 million cubic yards could be dredged in about 18 months or two and one half 7-month dredging seasons.

Methods of Financing

The Minnehaha Conservation District is preparing an application for a Sec. 314 "clean lakes" grant from EPA for 50% of total project costs. The District hopes to secure state financing for 25% of project costs, leaving 25% to be raised from local resources.

Environmental Impacts

Construction of detention basins would temporarily remove from five to ten parcels of land, totalling 124 acres from cultivation. After dewatering, the land would be reworked to make it available for cultivation again.

Consideration is being given to using the dredge supernatant to irrigate nearby farmland.

Dredging could result in some stirring of bottom sediments and temporary loss of lake water. The lake improvement from dredging would likely encourage additional lakeshore development with impacts of some destruction of lakeside vegetation, increased septic tank inflow, etc. Significant lake improvement should occur once the project is completed.

Conformity with State and Local Plans

As noted, the lake has been included in State 208 Water Quality efforts. This work has concluded that in-lake restoration such as dredging is needed. The State Lakes Preservation Committee report also recommended dredging. The Interagency Water Quality Management Council being organized in the area has selected lake improvement as one of the highest priorities for area water quality improvement. The Council has also given its approval to the Wall Lake Project.

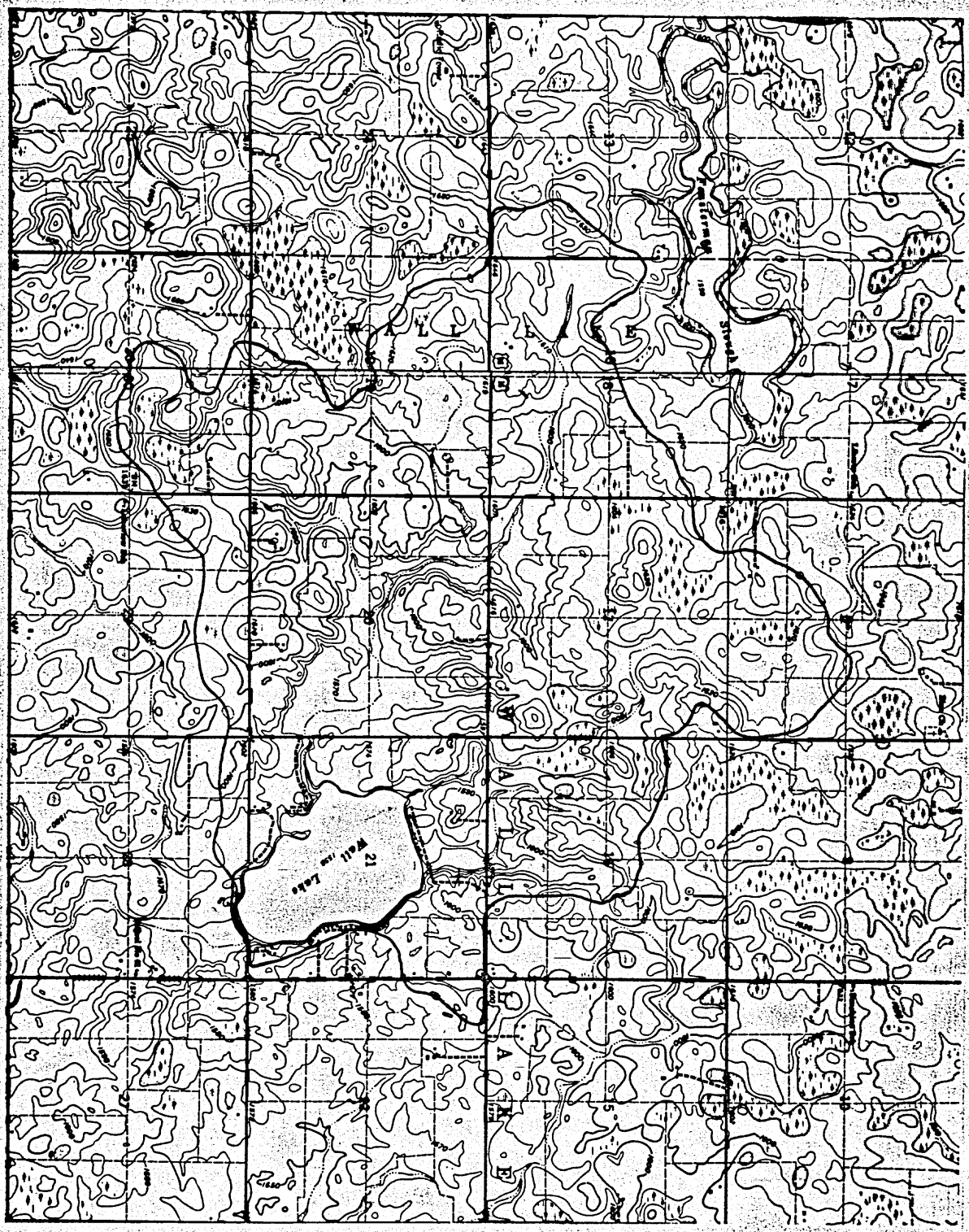
Local Support

A Wall Lake Improvement Association has been organized and has been working with the Minnehaha Conservation District on the dredging plan. The East Dakota Conservancy Sub-District and Minnehaha County Commissioners both provided financial support for the groundwater study.

In the summer of 1979 there was a community push to clean up the beach area of the lake. This project utilized local volunteer labor, donations of food from local businesses and public service advertising from local radio stations. Residents around the lake have expressed interest in either purchasing or leasing the dredge.

Need for Project's Inclusion in the State Water Facilities Management System

The state's 25% cost-sharing is needed to help the project reach fruition. The State have to be the agency to administer the desired federal Section 314 Clean Lakes Grant. The State will need to establish a priority for this project to assist in competition with other lake improvement projects which are in contention for 314 funds.



WALL LAKE WATERSHED

MINNEHAHA COUNTY, SOUTH DAKOTA

NORTH

A-22

Base Map

SCALE

Appendix D

SCS Soil Erosion and Sediment Yield Study in the Wall Lake Watershed

SECTION 208 - WATER QUALITY STUDY AREAS

SOIL EROSION AND SEDIMENT YIELD STUDY IN WALL LAKE WATERSHED MINNEHAHA COUNTY, SOUTH DAKOTA

SOIL CONSERVATION SERVICE
U. S. DEPARTMENT OF AGRICULTURE
HURON, SOUTH DAKOTA

ASSISTED BY
SOUTH DAKOTA DEPARTMENT OF WATER AND NATURAL RESOURCES
PIERRE, SOUTH DAKOTA

January 1981

SOIL EROSION AND SEDIMENT YIELD

IN

WALL LAKE WATER QUALITY STUDY AREA

IN

MINNEHAHA COUNTY, SOUTH DAKOTA

Introduction

Intense use of our natural resources over the years has caused a general deterioration of our environment. Some of our air, soil, and water resources have become polluted. Increased public awareness of this situation helped to bring about the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500). Section 208 of P.L. 92-500 addresses water pollution problems as it calls for management practices "...(to) be developed and implemented to assure adequate control of sources of pollutants in each state."

The South Dakota Department of water and Natural Resources has responsibility for formulating a section 208 water quality management plan for South Dakota. The watershed was one of six selected in 1980 for study to facilitate formulation of the plan. (See Figure 1.)

It is generally thought that sediment and nutrients are the principal pollutants in South Dakota lakes and streams. 1/, 2/, 3/

This report outlines more detailed information on soil erosion, sediment sources and quantitities, management practices to control sediment, and costs for those practices. This information was developed by the Soil Conservation Service (SCS) for the South Dakota Department of Water and Natural Resources.

1/ Mathew, F.L., "Water Pollution in South Dakota, Part I: Natural Water Quality and Pollution Sources," 1970, South Dakota Water Resources Institute, South Dakota State University, Brookings, South Dakota, 34 pages.

2/ "Development Components of the South Dakota Water Plan, Volume II-B" 1977, Division of Resources Management, South Dakota Department of Water and Natural Resources, Pierre, South Dakota.

3/ "A plan for the Classification-Preservation-Restoration of Lakes in Northeastern South Dakota" 1977, State Lakes Preservation Committee, State of South Dakota and the Old West Regional Commission, Pierre, South Dakota.

Summary

This study has determined relative percentages of erosion and sediment yield from cropland, grassland, gullies, streambanks, and other sources. The Universal Soil Loss Equation and direct volume methods were used to estimate gross erosion which was multiplied by estimated sediment delivery ratios developed by watershed shape analysis 1/ to obtain estimated sediment yields.

Sediment was determined to be a pollutant in the Wall Lake Water Quality Study Area (WQSA). Best management practices (BMP's) for this state section 208 water quality management plan thus became those management practices that reduced sediment yield.

A review of the Technical Guide for South Dakota (available at offices of the Soil Conservation Service) indicated soil and water conservation practices (management practices) that are potential BMP's. The relationships between runoff, sediment yield, and management practices, were outlined and, coupled with views of SCS district conservationists, a number of BMP's were selected for the WQSA. Costs for BMP's were generally abstrated from the SCS Cost-Return Handbook.

No quantification of reductions in sediment Yield due to application of BMP's was attempted. The reasons for this are twofold:
1. The technical data base was inadequate.
2. The potential combinations of BMP's were too great.

Definition and Outline of Study Methods

Erosion

Sheet erosion occurs as water flows overland and moves layers of soil particles loosened by raindrop impact. Rill erosion is movement of soil particles as overland flow concentrates into small channels, or rills, 2 to 12 inches deep. Soil particles are loosened in rills by shear force exerted on the bottom and banks of the rill by the channelized water. Bank sloughing, or miniature landslides, occur as the bottom and lower banks are eroded.

The Universal Soil Loss Equation (USLE), 2/, 3/ was used to estimate sheet and rill erosion in the WQSA's. SCS personnel familiar with each WQSA derived the data needed for the USLE from their field experience, Section III of the South Dakota Technical Guide and detailed soils maps.

1/ "Sediment yield was Gross Erosion in Minnesota" by O.M. Finkelson, Geologist, SCS, St. Paul, Minnesota 1978.

2/ Wischmeir, W.H., and Smith, D.D., "Prediction Rainfall Erosion Looses, A Guide to Conservation Planning", Agricultural Handbook, No. 537, December 1978, Science & Education Administration.

3/ "Estimating Soil Loss Resulting from Water and Wind Erosion in South Dakota," June 1977, South Dakota Technical Guide III-1, USDA, SCS, Huron, South Dakota.

Sheet and rill erosion from construction sites, roads and roadbanks was estimated using a direct volume method (multiplying the area of erosion by an estimated rate of erosion and the volume weight of the eroding soil. 1/ Sample areas were observed in each WQSA and county highway maps were used to expand the sample data.

Gully and streambank erosion is soil moved by water flowing in channels that are greater than 12 inches deep. The mechanisms of loosening and moving soil particles are the same as in rill erosion except for the larger scale. Lake shore erosion occurs as wave action loosens and moves soil particles. The direct volume method was used to estimate gully, streambank, and lake shore erosion. The effects of ice were also considered in the erosion rate. Sample areas were observed in each WQSA and aerial photographs were used to expand the sample data.

Sediment Yield

Sediment yield is the amount of soil removed from a drainage basin. 2/, 3/ It is measured (or estimated) at a point or a stream channel cross section and only represents a fraction of the total soil eroded in the basin above that point.

In this study, gross erosion was estimated and then multiplied by an estimated sediment delivery ratio to obtain sediment yield. This ratio is expressed as a percent and represents the amount of soil removed from a watershed (sediment) divided by the amount of soil moved in the watershed (erosion). It is thus inversely proportional to the amount of deposition occurring between points of erosion and the point where sediment yield is measured.

Many factors affect sediment yield - watershed size, shape, hydrology, channel density, land use, vegetative cover, geology and topography, soil structure, texture, and permeability. The interaction between all of these factors was subjectively analyzed after a delivery ratio was selected from a drainage area versus delivery ratio curve. This analysis resulted in raising or lowering the curve ratio and the adjusted ratio was used to estimate sediment yield from all sources of sheet and rill erosion. Much higher ratios were used to estimate sediment yield from gully, streambank, and lakeshore erosion.

1/ Method is outlined in the "Erosion and Sediment Inventory Handbook," USDA-SCS, Syracuse, New York (1972) and in "Guide to Sedimentation Investigations," Technical Guide 12, South Technical Service Center, USDA-SCS, Fort Worth, Texas (1976).

2/ "Sedimentation," 1975 National Engineering Handbook, Section 3, USDA, SCS, Washington, D.C.

3/ "Predicting Sediment Yields," in "Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water," 1977, American Society of Agricultural Engineers, Publication 4-77, St. Joseph, Michigan.

Best Management Practices

The Environmental Protection Agency (EPA) has defined best management practices, as published in the Federal Register, as follows:

> "The term, best management practices (BMP), means a practice, or combination of practices, that is determined by a State (or designated areawide planning agency) after problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals (40 CFR Part 130)."

Thus best management practices in section 208 water quality management plans are primarily those management practices that are believed to have a beneficial impact on water quality. 1/ Since sediment yield affects water quality adversely in these study areas, management practices that reduce sediment yield will be BMP's. Best management practices were selected from Section III of the South Dakota Technical Guide and costs were taken from the SCS Cost-Return Handbook.

Narrative Comments

The Soil Conservation Service completed a study of the Wall Lake Watershed. The purpose of this study was to identify the water erosion and sedimentation problems relative to Wall Lake which is located in Minnehaha County, South Dakota. The watershed was divided into four tributaries. (See Watershed Map)

This study brings out the kinds and amounts of erosion and sedimentation including the location, extent, and whether or not each tributary significantly contributes sediment into Wall Lake.

Table 1 shows the present "Land Uses and Estimated Acres Needing Treatment" of the Wall Lake Watershed Area. Figures are given for each tributary and a total for watershed. Wall Lake Watershed contains 3,072 acres. Figures are given for the following uses: cropland, grassland (both tame and native included), woodland, farmsteads, and urban, and non-sediment contributing areas. Estimated acres are listed for acres adequately treated, and acres needing treatment with recommended Best Management Practices (conservation practices) which will contribute to water quality improvement as well as erosion control on the land in the watershed area.

1/ "Environmental Impact of Land Use on Water Quality, Final Report on the Black Creek Project (Summary," 1977, U.S. Environmental Protection Agency 905/9-77-007-A, Great Lakes National Program Office, Chicago, Illinois.

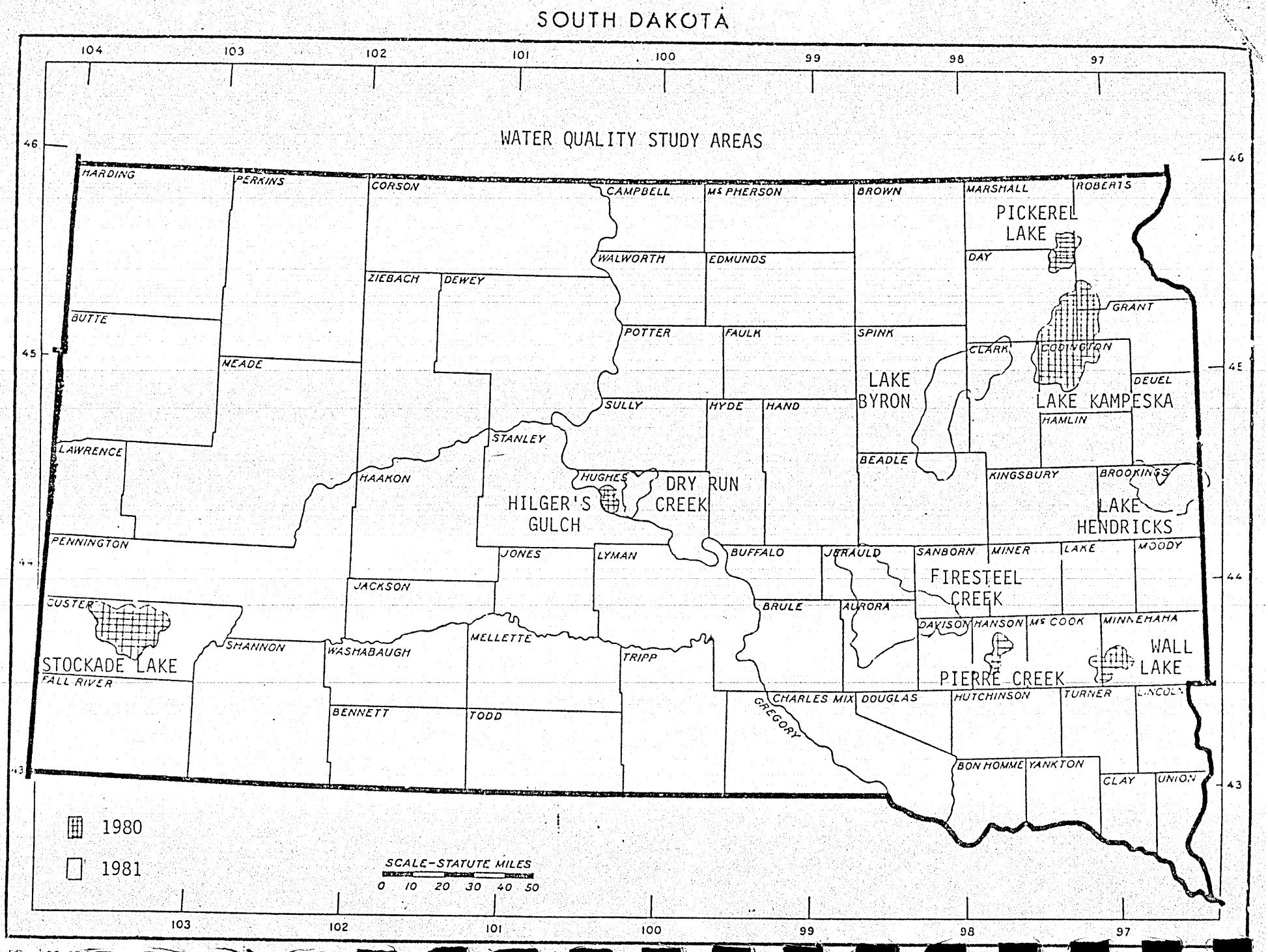
Narrative Comments (cont.)

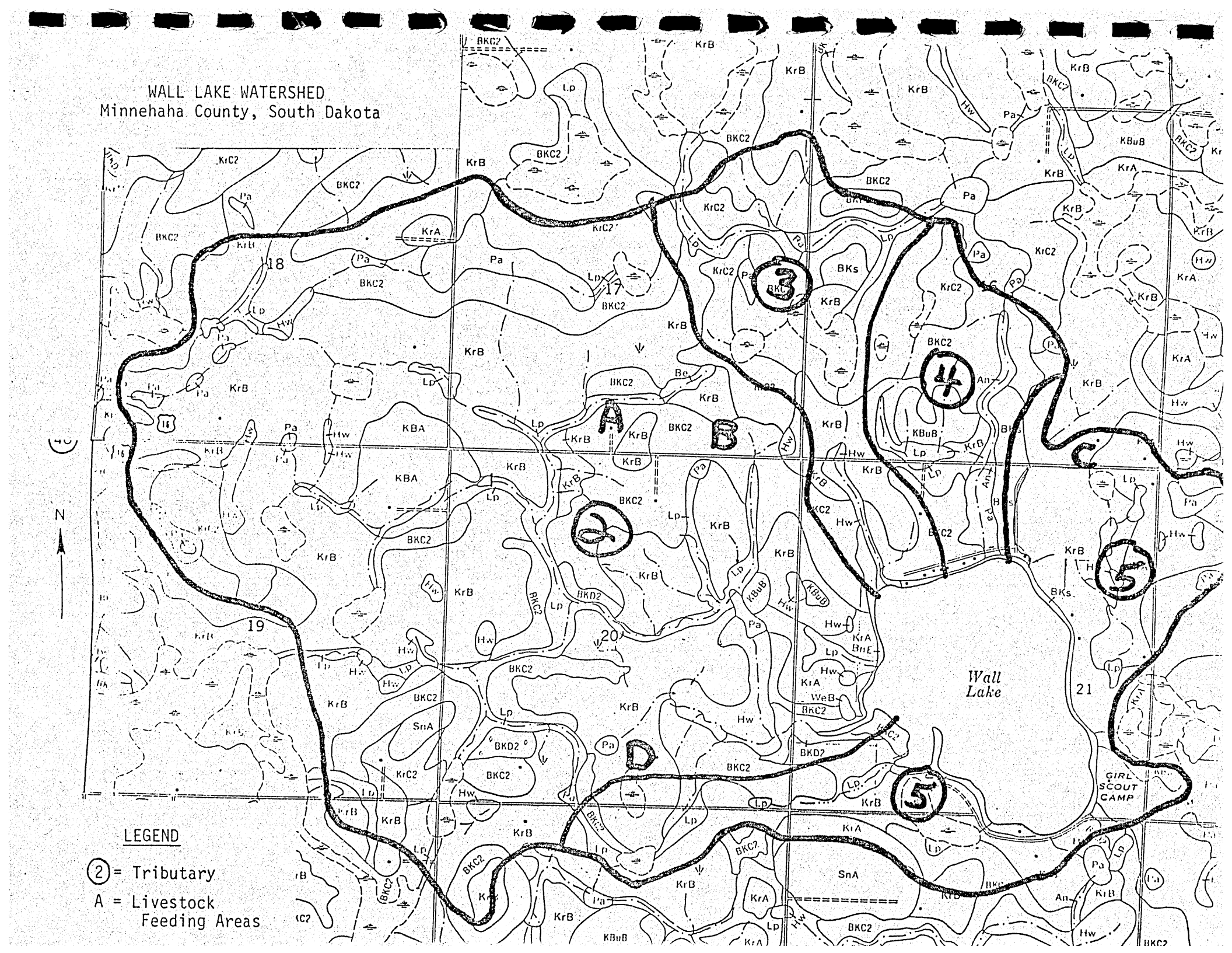
Table 2 - "Soil Erosion and Sediment Yield Estimates" lists erosion and sediment yield information. The figures are given by tributaries. They are further broken down by land use, sheet and rill erosion, and other erosion and sediment yields. A final total column shows estimated total tons of sediment per year for the watershed.

No figures were developed showing the extent of soil losses from erosion by wind. It was felt that an estimate of 1 to 1½ tons per acre per year could be used if this information is needed.

Table 3 - "Estimates of Best Management Practices (Conservation Practices and Measures) needed for Land Adequately Treated, Including Costs" shows the major land treatment needed in this watershed area. The chart also shows estimated amounts and probable costs to get the land in this watershed "adequately treated". It must be kept in mind, that these are "Estimates" only, and that specific practices, and accurate amounts together with precise costs can only be obtained in a planning process with the owners and operators of each tract of land, based on their decisions on how each field is to be used and treated. This study does not show this sort of detailed information.

FIGURE 1


SOUTH DAKOTA
WATER QUALITY STUDY AREAS
104
103
102
101
100
99
98
97
46
45
44
43
HARDING
PERKINS
CORSON
CAMPBELL
MC PHERSON
BROWN
MARSHALL
ROBERTS
PICKEREL LAKE
WALWORTH
EDMUNDS
DAY
ZIEBACH
DEWEY
GRANT
BUTTE
POTTER
FAULK
SPINK
CLARK
CODINGTON
MEADE
LAKE BYRON
DEUEL
LAKE KAMPESKA
SULLY
HYDE
HAND
HAMLIN
LAWRENCE
STANLEY
BEADLE
HAAKON
HUGHES
DRY RUN CREEK
KINGSBURY
BROOKINGS
HILGER'S GULCH
LAKE HENDRICKS
PENNINGTON
JONES
LYMAN
BUFFALO
JERAULD
SANBORN
MINER
LAKE
MOODY
FIRESTEEL CREEK
JACKSON
CUSTER
BRULE
AURORA
DAVISON
HANSON
MC COOK
MINNEHAHA
SHANNON
WASHABAUGH
MELLETTE
TRIPP
WALL LAKE
STOCKADE LAKE
FALL RIVER
PIERRE CREEK
CHARLES MIX
DOUGLAS
HUTCHINSON
TURNER
LINCOLN
GREGORY
BENNETT
TODD
BON HOMME
YANKTON
CLAY
UNION
1980
1981
SCALE-STATUTE MILES
0 10 20 30 40 50


WALL LAKE WATERSHED
Minnehaha County, South Dakota
N
LEGEND
(2) = Tributary
A = Livestock Feeding Areas
Wall Lake
GIRL SCOUT CAMP
18
17
19
20
21
16
1
2
3
4
5
A
B
D

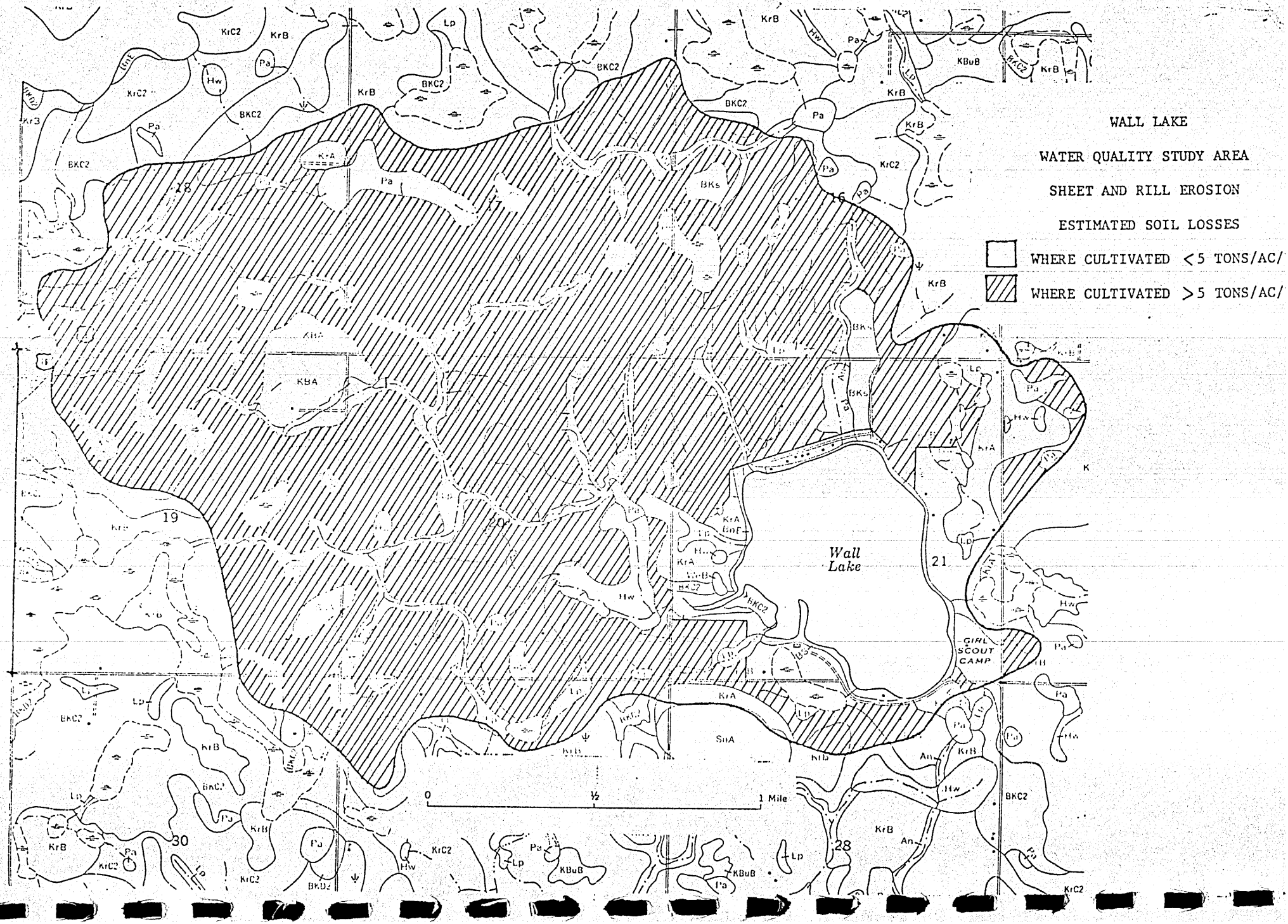

WALL LAKE
WATER QUALITY STUDY AREA
SHEET AND RILL EROSION
ESTIMATED SOIL LOSSES
WHERE CULTIVATED < 5 TONS/AC/
WHERE CULTIVATED > 5 TONS/AC/
N
Wall Lake
GIRL SCOUT CAMP
0
½
1 Mile
KrB
KrC2
BKC2
Pa
Lp
Hw
KBuB
BKs
KBA
KrA
BnF
An
SnA
18
17
16
19
20
21
30
28

TABLE 1

LAND USE AND ESTIMATED ACRES NEEDING TREATMENT
WALL LAKE WATERSHED AREA

WQSA or SUBWATERSHEDS	LAND USE (Acres) and TREATMENT (Acres and Percent)											
	CROPLAND		GRASSLAND		WOODLAND		FARMSTEAD AND URBAN		NON SEDIMENT CONTRIBUTING 1/		TOTAL	
	AC	%	AC	%	AC	%	AC	%	AC	%	AC	%
Tributary #2	1,122	100	657	100	-	-	63	100	38	100	1,880	100
Adequately Treated	269	24	177	27	-	-	61	97	38	100	545	29
Needs Treatment	853	76	480	73	-	-	2	3	-	-	1,335	71
Tributary #3	96	100	217	100	-	-	1	100	22	100	336	100
Adequately Treated	23	24	58	27	-	-	-	-	22	100	103	31
Needs Treatment	73	76	159	73	-	-	1	100	-	-	233	69
Tributary #4	100	100	100	100	-	-	1	100	4	100	205	100
Adequately Treated	23	24	27	27	-	-	-	-	4	100	54	27
Needs Treatment	77	76	73	73	-	-	1	100	-	-	151	73
Tributary #5 (+ lake)	184	100	160	100	-	-	67	100	240	100	651	100
Adequately Treated	44	24	43	27	-	-	61	90	220 2/	100	388 2/	60
Needs Treatment	140	76	117	73	-	-	6	10	-	-	263	40
TOTAL FOR WATERSHED	1,502	100	1,134	100	-	-	132	100	304	100	3,072	100
Adequately Treated	359	24	305	27	-	-	122	92	304	100	1,090	35
Needs Treatment	1,143	76	829	73	-	-	10	8	-	-	1,982	65

1/ Generally, water, marsh and sloughs. 2/ Includes Wall Lake contains approx. 220 acres.

TABLE 2

SOIL EROSION AND SEDIMENT YIELD
WALL LAKE WATERSHED AREA

WQSA or Subwatershed		Cropland	Grassland	Sub Total	Channels	Lake shore	Construction [1]	Sub Total	Total	Acre Feet Per Yr. [2]	Percent [3]
Tributary 2	Erosion Tons/Yr.	9,305	129	9,434	-	40		40	9,473		
	Sed. Yield [4] Tons/Yr.			679	-	40	-	40	719	.55	.035
Tributary 3	Erosion Tons/Yr.	1,011	76	1,087	-	-	-	-	1,087		
	Sed. Yield [4] Tons/Yr.			82	-	-	-	-	82	.06	.004
Tributary 4	Erosion Tons/Yr.	1,232	35	1,267	-	-	-	-	1,267		
	Sed. Yield [4] Tons/Yr.			151	-	-	-	-	151	.12	.007
Tributary 5	Erosion Tons/Yr.	1,145	32	1,177		116		116	1,293		
	Sed. Yield [4] Tons/Yr.			137		116	-	116	253	19	.012
Total	Erosion Tons/Yr.	12,693	272	12,965		156	-	156	13,121		
	Sed. Yield [4] Tons/Yr.			1.049		156		156	1,205	.92	.058

1/ Not estimated, but has high potential. Planned developments should include a sediment control plan for before, during, and after construction.

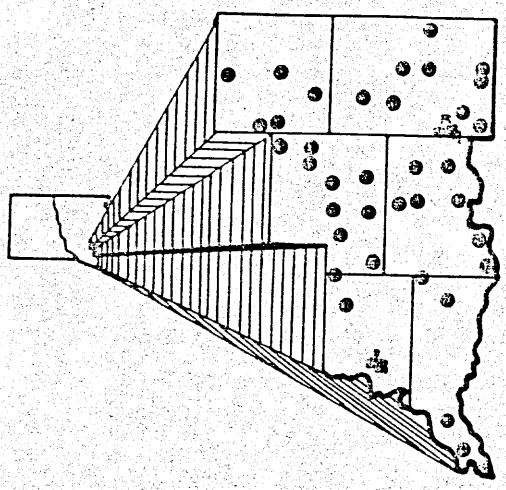
2/ Tons converted to acre feet. Sediment in lake volume computed at 60 pounds per cubic foot due to sediment being submerged.

3/ Annual sediment yield expressed as a percent of total lake volume. Lake volume of Wall Lake is 1,575 acre feet.

4/ Sediment deposited in Wall Lake.

Appendix E

Correspondence



"A COUNCIL OF ELECTED OFFICIALS"

SOUTH EASTERN COUNCIL OF GOVERNMENTS

MAIN OFFICE
208 E. 13th St.
P.O. Box 1859
Sioux Falls, S. D. 57101
605/339-6515

VERMILLION BRANCH
5 Court St.
Vermillion, S. D. 57069
605/624-8066

May 23, 1978

Mr. Randy Kueter
2504 Douglas
Yankton, South Dakota 57078

Dear Mr. Kueter:

In regard to your request for information about starting a project to clean up Wall Lake, I can tell you what we have done at Swan Lake and how this agency may be able to lend assistance.

First of all, SECOG is an agency made up of city and county governments. As such, we work at the direction of those local governments.

In the case of Swan Lake, we were asked by the city of Viborg to provide technical assistance for a project to clean up the lake. After meeting with concerned citizens and deciding what had to be done, we helped the city apply for and receive a 50/50 matching grant from the U.S. Environmental Protection Agency. The government provided $39,500 which the local groups had to match with an equal amount of donated labor or cash. The actual work of carrying out the project is being done by the Swan Lake Improvement Association, an association of cabin owners.

If there is to be a project at Wall Lake, and either federal or state funds are to be spent on it, the project must be sponsored by a governmental entity. In this case, that would probably be either Wall Lake Township or Minnehaha County. Of these two, I believe that the county would be the best able to handle a project such as this.

Until now, we have not heard about much interest in a project at Wall Lake. If there is substantial interest, I suggest that you contact the Minnehaha County Commission with specific information about what needs to be done and ask for their sponsorship.

If we are asked to help by the county or any other local government, SECOG will be happy to provide technical assistance in planning the project as well as in applying for and administering a grant.

I hope this provides you with some direction as to how to begin. If you would like to discuss it further, please call me.

Sincerely,

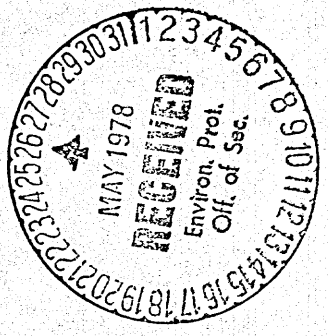
William S. Choate
Executive Director

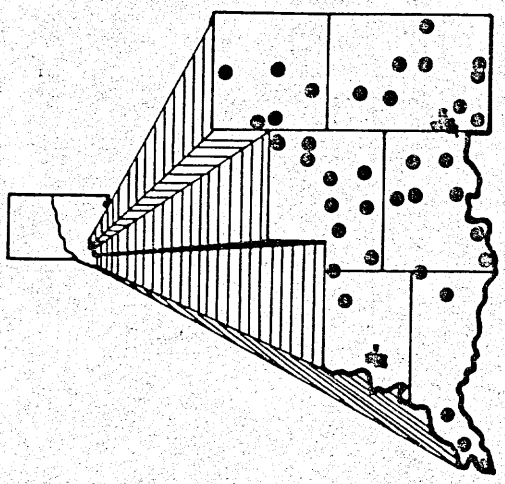
Bruce Gering

Bruce J. Gering
Public Information Specialist

BJG:jb

cc: Jim Seyfer, DEP





SOUTH EASTERN COUNCIL OF GOVERNMENTS

MAIN OFFICE
208 E. 13th St.
P.O. Box 1859
Sioux Falls, S. D. 57101
605/339-6515

VERMILLION BRANCH
5 Court St.
Vermillion, S. D. 57069
605/624-8066

"A COUNCIL OF ELECTED OFFICIALS"

February 22, 1979

Mr. Jim Nelson
South Dakota Dept. of
Environmental Protection
Pierre, SD 57501

Dear Mr. Nelson:

At the February 14th Executive Board meeting of the South Eastern Council of Governments, a motion was passed requesting designation of Wall Lake as a water quality study area. As we understand the program, a local grant recipient will eventually have to be designated to manage the project and supply the required match. Consequently, passage of the motion requesting designation does not commit the COG to the match requirement.

Please contact Mr. John Norton of the SECOG staff for any additional information you may desire to facilitate the study's progress.

Sincerely,

Ted Muenster
Chairman

TM:ks

February 28, 1979

Att: Planning Division
District Engineer
U.S. Army Engineering District, Omaha
215 N. 17th St.
Omaha, Nebraska 58102

Dear Mr. Ziemba:

The South Dakota Department of Environmental Protection has selected Wall Lake to be the subject of a study by the U.S. Army Corps of Engineers through the use of Sec. 22 funds for South Dakota. Wall Lake has also recently been selected by the South Eastern Council of Governments (SECOG) as a water quality study area candidate for their 208 program. Information on watershed land use, lake and runoff water quality, nutrient loading, and potential land treatment and lake restoration methods would be collected and developed as part of the 208 study. Our Department would like to see the Corps of Engineers' study compliment the 208 study.

We would like to see the Corps' study include the following study topics:

I. A dredging feasibility assessment, including:

   A. A sediment survey to determine the depth, volume and distribution of sediment.

   B. Sediment analysis for phosphorus, pesticides, herbicides, organic matter, and cesium-137.

   C. A review of existing pertinent information.

   D. Development of best dredging alternatives, including:

      1. estimated costs.
      2. identification of potential disposal sites.
      3. discussion of expected improvements and any future maintenance requirements.
      4. an evaluation of environmental impacts.

   E. Any other information felt necessary for the assessment.

II. Development of a hydrologic budget including an assessment of groundwater inflow and outflow.

I hope this proposal is agreeable to you. Please let me know if there are any problems. My number is (605) 773-4065. I have also attached some of the information our Department has on Wall Lake which might be of use to you.

Sincerely yours,

Craig Roesler
Environmental Analyst I
Office of Water Quality

A3/06

April 3, 1979

John Norton
South Eastern Council of Governments
P. O. Box 1869
208 E. 13th Street
Sioux Falls, South Dakota 57101

Dear John:

We have received your letter nominating Wall Lake as a potential Water Quality Study Area. After requesting comments from the various sub-contractors and reviewing our own information, I am pleased to announce that it is our decision to go with Wall Lake as a Water Quality Study Area.

Dave Pfahler traveled to the Sioux Falls Regional Office on March 20th to insure that all arrangements for the initiation of runoff and in-lake monitoring were finalized. A Senior Environmental Employment worker, Mel Hickenbotham, has been contacted and briefed in preparation for water quality sampling, and monitoring activities have been initated.

Thank you for your time and effort in nominating this area as a WQSA.

Sincerely,

Bill Markley

Bill Markley
Statewide "208" Coordinator
Office of Water Quality

cc: James D. Nelson, Acting Office Administrator
Office of Water Quality
Roger Dean, USEPA - Region VIII

A2/13

MEMORANDUM TO THE FILE

SUBJECT: Wall Lake Restoration

FROM: Jerry L. Siegel, Manager-Treasurer

DATE: August 30, 1979

1. I attended a meeting at Jack Majiers, SCS Office in Sioux Falls, with Jack, Paul Zimba, Mike Horne and John Anderson from the Corps of Engineers and Dick Reynolds, Wall Lake Association.

2. I relayed Assad Barari's groundwater study findings that there is very little outwash around the lake but he would still recommend placing the dredge material outside the lake watershed to eliminate return of nutrient enriched decant fluid to the lake.

3. The Corps provided detailed depth contour maps (attached) they had prepared and a table (attached) showing the cost to remove various depths of sediments from 172 acres of the lake below contour 1550 ft msl. Mike Horne based the estimates on 60¢/yd^3 or $970/acre-ft which assumes lease purchase of the Mudcat.

4. Jack Majiers showed 4-5 potential dredge disposal sites. He felt that disposal areas might limit the amount of sediment to be removed. We discussed various disposal concepts -- using high dikes to dispose of 6 ft deep sediment; shallow 3-4 ft deep areas on low quality pasture shallower 1-2 ft dikes on gently rolling farmland; pumping the decant fluid for big gun type irrigation, etc.

5. The consensus was to shoot for the 4 ft of sediment removal with dredging costs of $668,000; provision for land disposal site costs and other contingencies would make a $800,000 project.

6. Jack wants a meeting with landowners, etc. in October with a conceptural plan laid out to present. I offered to get Ron Eddy out to a meeting to discuss various dredging concepts, EPA rules, and use of in-kind match.

7. I also agreed to try to get the Department of Game, Fish & Parks to do a sediment depth probe and to get the State Geological Survey to take deeper sediment cores after the lake freezes up.

8. Dick Reynolds expressed confidence that the Wall Lake cabin owners could buy a Mudcat as part of the local match. Dick said they would need some loan program to spread out the cost over a number of years.

9. I visited with Ron Eddy briefly on September 4. He was leaving his office for a week. I will try to set a date for Ron to come out by telephone on September 10. We should have DEP and State Geological Survey personnel out also when Ron Eddy comes to Sioux Falls.

cc: Assad Barari
James Seyfer

OP attending this meeting?
~~MH~~
LV
RF-file

Minnehaha Conservation District
3812 N. CLIFF SIOUX FALLS, SOUTH DAKOTA 57104

APPROVED CONSERVATION PRACTICES
CONTOUR FARMING
CONTOUR STRIP CROPPING
WIND STRIP CROPPING
GRASSED WATERWAYS
TERRACING
PASTURE SEEDING
PASTURE IMPROVEMENT
CONTOUR PASTURE FURROWS
SEEDING PERMANENT HAY
TREE PLANTING
WOODLAND MANAGEMENT
CROP RESIDUE MANAGEMENT
CROP ROTATIONS
GREEN MANURE CROPPING
DRAINAGE
FARM DAMS
WATER DIVERSIONS
WILDLIFE AREA IMPROVEMENT
LAND CLEARING
WEED CONTROL
IRRIGATION
DIKES
ROADSIDE EROSION CONTROL

November 6, 1979

TO: Wall Lake Watershed Landowners

SUBJECT: Public Meeting on Lake Restoration Alternatives

FROM: Minnehaha Conservation District Board of Supervisors

A public meeting to present and discuss the various alternatives and approximate costs of restoring Wall Lake, in order to reverse it's present rate of deterioration, has been set for 7:30 P.M., Wednesday, November 28, 1979 in the Girl Scout Camp hall located on the southeast corner of the lake.

Weather permitting, personnel from the U.S. Army Corps of Engineers, S.D. Dept. of Natural Resources, S.D. Dept. of Game, Fish & Parks, East Dakota Conservancy Subdistrict, and the Minnehaha Conservation District will be on hand to discuss the results of the various data collection projects that were conducted on the lake this past year and will present various alternatives to restore the lake as well as approximate timetables and costs of conducting these alternatives.

In order to keep you informed about this project and receive your ideas and opinions of how you feel we should address this problem, the Conservation District needs your comments. So, please, plan to attend this meeting and let us know what you feel should be done.

Yours truly,

Walter Swanson

Walter Swanson, Chairman
Minnehaha Conservation District
Board of Supervisors

NOV 1979 RECEIVED

"WITH THE RIGHT TO USE GOES THE DUTY TO CONSERVE"

AGENDA

Wall Lake Restoration Project

Public Information Meeting

November 28, 1979

Girl Scout Camp Meeting Hall

Shores of Wall Lake

7:30 Call Meeting to Order - Rich Reynolds, Chairman, Wall Lake Improvement Association

7:35 Why A Wall Lake Restoration Project - Jack Majeres, Minnehaha Conservation District

7:40 Eastern South Dakota Restoration Projects - Jerry Siegal, East Dakota Conservancy Subdistrict

7:45 Federal Restoration Project Requirements and Funding Assistance - Ron Eddy, Environment Protection Agency

7:50 Wall Lake Water Quality - Richard Fike, South Dakota Dept. of Water and Natural Resources

8:00 Ground Water Recharging Potential of Wall Lake - Assad Barari, So. Dak. Geological Survey

8:05 Lake Restoration Alternatives - John Anderson, U.S. Army Corps of Engineers

8:20 Restoration Effects on Lake Ecosystems - Ron Brandt, So. Dak. Dept. of Game, Fish & Parks

8:30 Watershed Land Treatment Measures - Doug Culhane, USDA Soil Conservation Service

8:45 Open Discussion

NOV 1979
RECEIVED

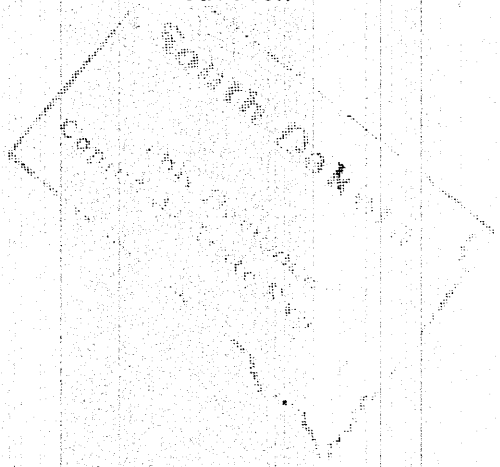
AGENDA FOR PROJECT COORDINATORS MEETING
December 17 and 18, 1980
Division of Conservation Meeting Room
Sigurd Anderson Building

Wednesday 12/17/80

8:30	Introduction	Seyfer
8:45	What's 208 and how did we get here?	Markley
9:00	The WQSA process	Pfahler
9:15	Special Water Quality Projects ASCS's role	Cundy
9:45	COFFEE	
10:00	The Lake Hanson/Pierre Creek Project	Bleeker
10:30	The Oakwood/Poinsett Lakes Project	Sprang
11:00	The Stockade Lake Project	Kujala
11:30	The Wall Lake Project	Kappen
12:00	LUNCH	
1:00	Lake Herman Slide Program	
1:15	The Lake Herman Experience	Spartz
1:45	The Mina Lake Experience	Gab
2:15	Project Coordination at Mina Lake	Karst
2:45	What DWNR expects	Seyfer
3:00	COFFEE	
3:15	Contract outputs available	Pfahler
3:45	Conservation Districts role in NPS control	
4:15	SCS involvement and available assistance	Davis/Nieman

Thursday 12/18/80

8:30	Other funding sources	Yocum
9:00	Assistance available from DWNR	Markley
9:30	COFFEE	
9:45	Information Programs	Watkins
10:15	Water Quality Sampling	Lutter
11:00	Discussion	



OCT 2 1 1981

Minnehaha Conservation District
3812 N. Cliff Ave. - Sioux Falls, South Dakota 57104 - Phone 605-336-2980 ext. 524

TO: Wall Lake Improvement Association Members

FROM: Minnehaha Conservation District

9/22/81

SUBJECT: Wall Lake Project

The Minnehaha Conservation District has been working for the past year on a project to clean up Wall Lake. Among the results of this project have been the inclusion of Wall Lake in the state's water plan and the application for money from the Federal Clean Lakes program to assist in the lake's restoration. The federal application was turned down because we were unable to show that the amount of nutrients which are polluting the lake had been reduced.

Through the observations which have been made in the lake and in the surrounding watershed and through study of the water samples which have been taken, it appears that the major source of these nutrients is some faulty septic systems around the lake. None of the soil types which surround the lake are very well suited for septic systems. The District has done extensive work throughout the county in helping prevent the erosion of agricultural and urban land. However, we have neither the authority or expertise to tackle septic problems.

The District has been inquiring into the possibility of having a Wall Lake Association Meeting where we could explain all that has taken place. As yet we are unaware of any such meeting being called. Our contract with the state Department of Natural Resources is expiring and we are not planning on renewing the contract. We are truly sorry that more could not be accomplished and offer what help we can give should your association decide to do some more work on the lake in the future.

Sincerely,

Philip M. Kappen
Wall Lake Project Coordinator

Curtis O. Eggers, Chairman
Minnehaha Conservation District
Board of Supervisors

Minnehaha Conservation District
3812 N. Cliff Ave. - Sioux Falls, South Dakota 57104 - Phone 605-336-2980 ext. 524

February 10, 1981

Jim Seypher
DWNR
Joe Foss Bldg.
Pierre, SD 57501

Dear Mr. Seypher,

We, the Minnehaha Conservation District Supervisors, fully support the Wall Lake Dredging Project. If the lake is dredged according to the plan it would enable the lake to be used for the extensive and varied recreational purposes for which it has served in the past.

The District has helped with the ground water and watershed studies conducted in the past. The District also provided assistance in obtaining the core samples from the lake.

South Dakota's largest city, Sioux Falls, and all of Minnehaha County are in need of quality water based recreational facilities and we, the Minnehaha Conservation District Supervisors, support this effort to provide such facilities to the people of this area.

Sincerely,

Curtis O Eggers

Curtis O. Eggers, Chairman
Minnehaha Conservation District
Board of Supervisors

cc: Warren R. Neufeld, Secretary, Natural Resource Development

Minnehaha Conservation District
3812 N. Cliff Ave. - Sioux Falls, South Dakota 57104 - Phone 605-336-2980 ext. 524

September 23, 1981

SEP 24 1981

Tim Bjork
Implementation Program Coordinator
Coordinator Director
Deptartment of Water and Natural Resources
Pierre, South Dakota 57501

Dear Tim,

At their regular monthly meeting of the Minnehaha Conservation District Board of Supervisors, the Board voted to discontinue the contract with the DWNR pertaining to the proposed renovation of Wall Lake. The Board felt that it was of no great advantage to continue the contract because we were not receiving the cooperation which we wished from the Wall Lake Association and because the District does not have the technical expertise to deal with septic problems. It appears to us that septics are the largest problem in the Wall Lake situation.

We also wish to have the contract extended to the end of October. This will enable us to inform the Wall Lake Association that we will no longer be the sponsoring agency, and will also provide the district necessary financial assistance to have an independent audit performed.

We thank you for your help in this project and hope we can still work with you through the Interagency Water Quality Management Council.

Sincerely,

Curtis O. Eggers

Curtis O. Eggers, Chairman
Minnehaha Conservation District
Board of Supervisors

DEPARTMENT OF THE ARMY
OMAHA DISTRICT, CORPS OF ENGINEERS
6014 U.S. POST OFFICE AND COURTHOUSE
OMAHA, NEBRASKA 68102

MROPD-P

14 March 1979

Mr. Craig Roesler, Environmental Analyst I
Office of Water Quality
South Dakota Dept. of Environmental Protection
Pierre, South Dakota 57501

Dear Mr. Roesler:

This is in reply to your letter of 28 February 1979 outlining the State of South Dakota's priority for Fiscal Year 1979 Section 22 funds at Wall Lake.

Although we are nearing the midpoint of this fiscal year, we anticipate that we can complete all the items listed in your letter during F.Y. 1979 except item D-4.

We are now in the process of establishing a study schedule. Paul Ziemba will contact you in the near future to set up a meeting with you and local interests in the Wall Lake area to discuss their needs and desires.

Sincerely yours,

JOHN E. VELEHRADSKY, P.E.
Chief, Planning Division

Received your letter today Feb 29
bout Lake Restoration meeting.
Generally I would favor such
a project but if I were at the
meeting I would personally
Question the cost per lot owner!
As I am retired and no
longer earn the salary I once
did I would not want to
commit myself to a program
that because of excessive cost
would endanger my ability
to continue owning the property.
If the cost repayment was
long enough range and not to
excessive I could go along.

Charles H Stapleton

Pres. Wall Lake Assn

Litchfield Park
Arizona 85340

Dear Dick:

The fall meeting having been a disaster, as your notice implied, We perhaps should ask ourselves why. The Chiefs get together and the Indians don't show up. Most of the Meetings I attended were not very productive. We were always told by the Agency Representatives the Property Owners would have to make substantial financial commitments - while the county and State either wouldn't or couldn't be counted on for any support. This fact makes it look like a grab for Federal Funds - ALL the Property Owners know that we cannot proceed as if Wall Lake was a private Lake - Some Property owners have indicated they don't want to make the Lake more attractive to the Public. - The reason being that beach and beer parties

go on Till daylight And Aee Never Challenged by law enforeeHENT Officers

Dick, I MUST ASSUREyou AT This Point, that I personally support The impaovement of Wall Lake, and that I will support you. but To Think That we could give Much More than Token support to dredging would be foolish.

Someone should Verify that Taxes levied To WALL LAKE Peopeaty owneas exceeds $100,000.- ANNUALly And Someone else Should enumeaATE the benefits we Recieve.

I'M Sorry I CANNOT ATTend your Meeting, but I do hope it goes well And that Some concrete steps can be TAKEN -

I Look foreward to SeeING you about the 1st of May. All good Wishes

Elmer L Gieske
Litchfield Park, Arizona
Box 1146-85340

3-6-80

We are unable to attend tonights meting. But have our support for the Wall Lake proposal project.

Mr. & Mrs. Jay Sadler

J.K. Sadler II
528-3997

Al Schock, President
Don H. Platt, General Manager
Fran D. Lavicky, Director Technical Services

NORDICA INTERNATIONAL
1501 WEST TENTH STREET SIOUX FALLS, S. DAK. 57104
(605) 336-2720

July 12, 1979

Mr. Walter Swanson, Chairman
Minnehaha Conservation District
3812 N. Cliff
Sioux Falls, SD 57104

Dear Walt;

I am responding to your letter of June 27, wherein you invited me to participate in the clean up of Wall Lake.

Walt, I just wanted you to know that I would have been there but I had other committments I could not break.

At any rate, I want to compliment you on the Minnehaha Conservation District for undertaking this worth while project.

Sincerely,

Al Schock

AS:sb

March 6, 1980

Dear Mr. Reynolds,

Due to illness in the family I am not able to attend the Wall Lake Assn. meeting tonight.

I wish, however, to express my heartiest endorsement of any plan that will enhance the quality of the lake for residents and the public.

Thank you for your hard work on behalf of the Lake Assn.

Sincerely,

Mr. & Mrs. Gordon Stewart

GS/bb

Stewart
HAIRSTYLISTS

EQUIPMENT
- POWER MOWERS
- INSECTICIDES
- FUNGICIDES
- FERTILIZERS
- GRASS SEED
- IRRIGATION
- GOLF GROUNDS SUPPLIES

DAKOTA TURF

SIOUX FALLS, S. D. 57105

Area Code No. 605
Phone 336-1873

Jacobsen - Devere - Rain Bird - Milorganite - Mallinckrodt
SALES — PARTS — SERVICE

February 27, 1980

Mr. Gary Joyce
P. O. Box 986
Sioux Falls, S. D. 57101

Reference to: Lake Restoration Meeting, March 6, 1980

Dear Mr. Joyce:

I'm sorry I will be out of town until April 1, so I will be unable to attend the meeting on March 6th.

I strongly support any means possible to restore the lake to its previous condition. One of the most important being a sanitary sewer system.

Upon my return, I will be happy to attend any meetings that you might have planned.

Sincerely yours,

C. Lonnie Anderson

CLA:gk

HAROLD'S

February 28, 1980

Mr. Gary Joyce
P.O. Box 986
Sioux Falls, South Dakota 57101

Dear Mr. Joyce:

I am writing to you on behalf of Harold E. Hanson, a property owner on the south side of Wall Lake. Harold is currently in Texas until early Spring and while I have forwarded to him the notice of the Lake Restoration Meeting, I am not certain he will receive it in time to reply in writing.

On behalf of Harold, my father, I would like to voice our support for the restoration project. It is our feeling that Wall Lake, being one of the "most used" recreational facilities in the state, is most deserving of consideration from the various state and federal agencies.

Good luck in your efforts to secure the needed committments for this project. It is needed and will benefit a large number of taxpayers and residents.

Sincerely,

R. H. Hanson

Richard H. Hanson
Vice President

FORTY-FIRST AT PRAIRIE · SIOUX FALLS, SOUTH DAKOTA 57105 • 605-336-2833
MAILING ADDRESS: P.O. DRAWER A, SIOUX FALLS, SOUTH DAKOTA 57101

Cliff & Judi Dunham
R.R. 1, Box 72
Hartford, SD 57033

February 28, 1980

Mr. Gary Joyce
P. O. Box 986
Sioux Falls, SD 57101

RE: Lake Restoration Project

Dear Mr. Joyce:

Although we are unable to attend the meeting on March 6th, Judi and I would like to voice our support for the Lake Restoration project.

Being the major water recreation area for the city of Sioux Falls and Minnehaha County, monies should be directed to secure this as a clean and pleasant facility for the most populated segment of the state to enjoy. Possible directions of action to take could involve:

1. Dredging of the lake to remove silt and debris. This operation would also deepen the lake making its water cooler and less likely to breed algae.
2. Stop run-off from area cattle operations and eliminate waste injection from lake residents.
3. Maintain public areas (beach, parking, etc.) on a regular basis by a responsible government agency.
4. Encourage business to operate a refreshment-toilet facility for the users of the public areas.

Many other items could be noted to assess funds to, but the main item is the allocation of these monies.

We would like to urge all government agencies to secure these funds for immediate action to be taken for the enjoyment of citizens of this area.

Yours truly,

CLIFF DUNHAM
CD/li

This is Tuesday
Mar 4 1980

Gary Joyce
PO Box 986
Sioux Falls, SD 57101

Ref: Meeting March 6th

Dear Gary:

The letter from Mr.Reynolds announcing a meeting of the WALL LAKE association, of necessity has been forwarded to me here in Texas where we are on vacation.

Accordingly it arrived here too late (today) to permit me to get a reply back to you before the meeting date...???

I want the association to know however that I do support the restoration project for the lake. It is a project that I have supported for years.

Seemingly 'no state or county organization' truly wants to help us. It has been thus so far too long a time, always some excuse of lack of funds, lack of interest, lack of leadership, etc. Yet the lake continues to have the highest use of any lake in the state..for it's size.

Good luck to those of you who continue so dedicated for the future of our lake. We will not be home for a while but mail is forwarded to me by son.

Harold E.Hanson
OUTDOOR RESORTS
South Padre Island, TX

PS: I don't believe I rec'd any notice relating to the late 1979 meeting which was held at the Girl Scout Camp..?? Or, we may have been gone again. Most effective meetings need to be held during the 'season' perhaps?

OFFICE OF
THE MAYOR
224 W. 9th St. 57102
(605) 339-7209

CITY OF
SIOUX FALLS, SOUTH DAKOTA
An Equal Opportunity Employer

July 2, 1979

Mr. Walter Swanson, Chairman
Minnehaha Conservation District
3812 N. Cliff
Sioux Falls, SD 57104

Dear Walt,

Sorry I wasn't able to attend your kick-off on the Wall Lake improvement project last Saturday. Let me assure you that you have my personal support, and if there is some effort you think the City of Sioux Falls can make to move this project along, please do not hesitate to contact my office.

As a citizen of this area for a number of years, I am extremely concerned about our recreational opportunities within a reasonable driving distance from the city. This project will once again bring Wall Lake to a state that will make us all proud.

Thanks for your leadership in this area.

Sincerely,

Rick W. Knobe
Mayor

RWK:mh

EQUAL HOUSING
OPPORTUNITY

EDMUND S. MUSKIE, MAINE
MIKE GRAVEL, ALASKA
LLOYD BENTSEN, TEX.
QUENTIN N. BURDICK, N. DAK.
JOHN C. CULVER, IOWA
GARY HART, COLO.
DANIEL PATRICK MOYNIHAN, N.Y.

ROBERT T. STAFFORD, VT.
HOWARD H. BAKER, JR., TENN.
PETE V. DOMENICI, N. MEX.
JOHN H. CHAFEE, R.I.
ALAN K. SIMPSON, WYO.
LARRY PRESSLER, S. DAK.

JOHN W. YAGO, JR., STAFF DIRECTOR
DAILEY GUARD, MINORITY STAFF DIRECTOR

United States Senate

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

WASHINGTON, D.C. 20510

July 2, 1979

Mr. Walter Swanson, Chairman
Minnehaha Conservation District
Board of Supervisors
3812 N. Cliff
Sioux Falls, SD 57104

Dear Walter:

Thank you for your recent letter and invitation to attend the lake shore clean-up day at Wall Lake.

Unfortunately, I didn't receive your letter until noon on Saturday, June 30. I hope that the event received a large turnout and that the afternoon sporting show was enjoyed by everyone.

I'm very pleased that the Minnehaha Conservation District is taking such an active hand in keeping a beautiful part of our State in a condition to be enjoyed for many years.

Thank you again for your invitation. I'm so sorry that I received it too late to attend. I look forward to hearing reports on the progress being made by the Wall Lake Restoration Project.

Sincerely,

Larry

Larry Pressler
United States Senate

LP/phh

AT DISTRICT, SOUTH DAKOTA

COMMITTEES:
AGRICULTURE
VETERANS

510 CANNON OFFICE BUILDING
WASHINGTON, D.C. 20515
(202) 225-2801

Congress of the United States

House of Representatives

Washington, D.C. 20515

DISTRICT OFFICES:
800 SOUTH CLIFF
BOX 1274
SIOUX FALLS, SOUTH DAKOTA 57101
(605) 334-9593

310 SOUTH LINCOLN
ABERDEEN, SOUTH DAKOTA 57401
(605) 225-8823

June 27, 1979

Minnehaha Conservation District
3812 North Cliff Ave.
Sioux Falls, South Dakota 57104

Dear Friends:

I wanted to send along this short message to you to let you know that had my schedule worked out differently I would have enjoyed spending the morning with you on your Community Involvement Project for cleaning up the public beaches at Wall Lake. I am a firm believer that any real work that is done is usually done at the community level and your presence here today and your accomplishments prove that.

I am certain that the general public which uses Wall Lake as a recreational facility and the people who live here, will all benefit from your efforts today. I appreciate what you have done and I hope it will serve as a model to other communities as they work to preserve the quality of living we have in South Dakota.

Again, my congratulations to you on a job well done and a special thank you to Carol Deters for inviting me to be with you today.

With best regards, I am,

Sincerely,

Tom Daschle
Member of Congress

United States Senate
WASHINGTON, D.C. 20510

July 5, 1979

Dear Mr. Swanson:

I would like to thank you for inviting me to attend the clean up day event at Wall Lake. Even though I was in the State, I was unable to attend due to other prior commitments. I hope this "kick-off" to the Wall Lake Restoration Project was a success.

The efforts of the Minnehaha Conservation District Board of Supervisors in the restoration of Wall Lake is to be commended. I wish you the best of luck on your ongoing project.

With every good wish, I am

Sincerely,

George McGovern

Walter Swanson
Chairman
Minnehaha Conservation District
Board of Supervisors
3812 N. Cliff
Sioux Falls, South Dakota 57104

2D DISTRICT, SOUTH DAKOTA

1224 LONGWORTH HOUSE OFFICE BUILDING
(202) 225-5165

VERNON C. LOEN
ADMINISTRATIVE ASSISTANT

PUBLIC WORKS
AND TRANSPORTATION

VETERANS' AFFAIRS

AGING

Congress of the United States

House of Representatives

Washington, D.C. 20515

July 9, 1979

Walter Swanson, Chairman
Minnehaha Conservation District
3812 N. Cliff
Sioux Falls, SD 57104

Dear Walt:

Thank you for your June 27th letter on the Wall Lake Restoration Project.

It is unfortunate that your letter did not reach my office until July 2nd for this June 30th event.

I think that it is very commendable that your office is undertaking this effort. Minnehaha county will be much the better for the project.

Understanding that the project will take several years, as you noted, I hope that at a future date I can lend my assistance to the program.

Thank you again for thinking of me and please continue to stay in touch.

Sincerely,

JAMES ABDNOR
Member of Congress

JA/sjl

Appendix F

Water Quality Summary
Tables and Figures

	Description
Site 46WA01	This site is located at a latitude of 43 Deg., 31 Min., 44 Sec., and a longitude of 96 Deg., 57 Min., 10 Sec. Site 46WA01 is on the outlet just northeast of Wall Lake's southeast beach. T101N, R51W, Section 21.
Site 46WA02	Located at a latitude of 43 Deg., 31 Min., 57 Sec., and a longitude of 96 Deg., 58 Min., 11 Sec., in T101N, R51W, Section 21, this site is on the west inlet.
Site 46WA03	Located at a latitude of 43 Deg., 32 Min., 20 Sec., and longitude of 96 Deg., 57 Min., 54 Sec., in T101N, R51W, Section 21, the site is on the northwest inlet.
Site 46WA04	This site, which is on the northeast inlet, is located at a latitude of 43 Deg., 32 Min., 23 Sec., and a longitude of 96 Deg., 57 Min., 32 Sec., in T101N, R51W, Section 21.
Site 46WA05	Located at a latitude of 43 Deg., 32 Min., 19 Sec., and at a longitude of 96 Deg., 57 Min., 40 Sec., in T101N, R51W, Section 21, the site is in-lake off the north beach.
Site 46WA06	Located at a latitude of 43 Deg., 31 Min., 59 Sec., and at a longitude of 96 Deg., 57 Min., 15 Sec., in T101N, R51W, Section 21, the site is in-lake off the souteast beach.
Site 46WA14A	This site, which is near the outlet, is located at a latitude of 43 Deg., 31 Min., 17 Sec., and at a longitude of 96 Deg., 57 Min., 13 Sec., in T101N, R51W, Section 21, SE1/4.
Site 46WA2A	This site is in the west inlet bay (in-lake) and is sited at a latitude of 43 Deg., 31 Min., 58 Sec., and at a longitude of 97 Deg., 31 Min., 58 Sec., in T101N, R51W, Section 21, SW1/4.
Site 46WA3A	Located at a latitude of 43 Deg., 32 Min., 18 Sec., and at a longitude of 96 Deg., 57 Min., 55 Sec., in T101N, R51W, Section 21, NW1/4. This site is near the northwest inlet (in-lake).
Site 46WA4A	This site is in-lake near the northeast inlet at a latitude of 43 Deg., 32 Min., 21 Sec., and at a longitude of 96 Deg., 57 Min., 32 Sec., in T101N, R51W, Section 21, NE1/4.

C91206FP.WQ

Table IV-1. Description of Wall Lake sampling sites.

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA01
43 31 44.0 096 57 10.0 2
WALL LAKE OUTLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 CLASS 00 CSN-RSP 0593324-0621719

/TYPA/AMBNT/STREAM/RUNOFF

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		21	10.7238	38.4469	6.20056	20.0000	.560000	79/03/30	79/06/18
00011	WATER	TEMP	FAHN		21	51.2857	124.215	11.1452	68.0000	33.0000	79/03/30	79/06/18
00020	AIR	TEMP	CENT		21	10.3695	62.9224	7.93237	22.2000	-.888E+01	79/03/30	79/06/18
00021	AIR	TEMP	FAHN		21	50.6667	203.935	14.2806	72.0000	16.0000	79/03/30	79/06/18
00300	DO		MG/L		20	9.13500	6.91401	2.62945	14.6000	3.30000	79/03/30	79/06/18
00310	BOD	5 DAY	MG/L		8	5.10749	6.49130	2.54780	8.64000	1.32000	79/04/03	79/05/31
				K	1	1.00000			1.00000	1.00000	79/05/24	79/05/24
				TOT	9	4.65111	7.55451	2.74855	8.64000	1.00000	79/04/03	79/05/31
00400	PH		SU		21	8.37142	.404175	.635747	10.0000	7.10000	79/03/30	79/06/18
00403	LAB	PH	SU		21	8.54095	.255005	.504980	9.22000	7.59000	79/03/30	79/06/18
00410	T ALK	CACO3	MG/L		21	194.048	2891.35	53.7713	280.000	92.0000	79/03/30	79/06/18
00500	RESIDUE	TOTAL	MG/L		21	925.809	50068.0	223.759	1152.00	504.000	79/03/30	79/06/18
00515	RESIDUE	DISS-105	C MG/L		21	916.190	49775.2	223.104	1143.00	498.000	79/03/30	79/06/18
00530	RESIDUE	TOT NFLT	MG/L		19	10.6053	50.2939	7.09182	29.0000	1.00000	79/03/30	79/06/18
				K	2	1.00000	.000000	.000000	1.00000	1.00000	79/05/07	79/05/31
				TOT	21	9.69048	53.6119	7.32202	29.0000	1.00000	79/03/30	79/06/18
00608	NH3+NH4-	N DISS	MG/L		1	.900000			.900000	.900000	79/04/03	79/04/03
00610	NH3+NH4-	N TOTAL	MG/L		17	.384117	.128601	.358609	1.50000	.030000	79/03/30	79/06/18
				K	3	.020000	-.232E-09	.000000	.020000	.020000	79/04/23	79/05/03
				TOT	20	.329500	.126089	.355090	1.50000	.020000	79/03/30	79/06/18
00613	NO2-N	DISS	MG/L		10	.014000	.000049	.006992	.030000	.010000	79/03/30	79/06/18
				K	11	.010000	.465E-10	.000007	.010000	.010000	79/04/12	79/05/31
				TOT	21	.011905	.000026	.005118	.030000	.010000	79/03/30	79/06/18
00618	NO3-N	DISS	MG/L		1	.700000			.700000	.700000	79/04/23	79/04/23
00620	NO3-N	TOTAL	MG/L		11	.927272	.848177	.920965	2.50000	.100000	79/03/30	79/06/07
				K	9	.100000	.000000	.000000	.100000	.100000	79/04/30	79/06/18
				TOT	20	.555000	.624708	.790384	2.50000	.100000	79/03/30	79/06/18
00625	TOT KJEL	N	MG/L		21	2.27571	.315362	.561571	3.61000	1.63000	79/03/30	79/06/18
00671	PHOS-DIS	ORTHO	MG/L P		2	.557000	.036451	.190920	.692000	.422000	79/04/03	79/04/26
31616	FEC COLI	MFM-FCBR	/100ML		9	942.222	3456088	1859.59	5600.00	3.00000	79/04/03	79/06/18
				K	10	3.00000	.000000	.000000	3.00000	3.00000	79/04/12	79/05/21
				TOT	19	447.895	1769069	1330.06	5600.00	3.00000	79/04/03	79/06/18
70505	T PO4	P-COL	MG/L		21	.573904	.015728	.125411	.926000	.431000	79/03/30	79/06/18
70507	PHOS-T	ORTHO	MG/L P		19	.466578	.008357	.091418	.683000	.314000	79/03/30	79/06/18

Table IV-2.

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA01
43 31 44.0 096 57 10.0 2
WALL LAKE OUTLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 CLASS 00 CSN-RSP 0593324-0621719

/TYPA/AMBNT/STREAM/RUNOFF

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		7	8.49142	58.9304	7.67661	22.2000	2.78000	83/03/10	83/06/29
00011	WATER	TEMP	FAHN		7	47.2857	190.908	13.8169	72.0000	37.0000	83/03/10	83/06/29
00020	AIR	TEMP	CENT		7	6.19714	60.7370	7.79339	18.9000	-.559E+00	83/03/10	83/06/29
00021	AIR	TEMP	FAHN		7	43.1428	196.145	14.0052	66.0000	31.0000	83/03/10	83/06/29
00061	STREAM	FLOW,	INST-CFS		4	.000000	.000000	.000000	.000000	.000000	83/02/22	83/03/03
00300	DO		MG/L		7	12.3571	6.11967	2.47380	14.8000	8.20000	83/03/10	83/06/29
00400	PH		SU		1	8.40000			8.40000	8.40000	83/05/25	83/05/25
00403	LAB	PH	SU		7	8.29999	.010498	.102460	8.44000	8.17000	83/03/10	83/06/29
00500	RESIDUE	TOTAL	MG/L		7	1005.57	136126	368.952	1179.00	170.000	83/03/10	83/06/29
00530	RESIDUE	TOT NFLT	MG/L		7	14.4286	78.2858	8.84792	26.0000	5.00000	83/03/10	83/06/29
00610	NH3+NH4-	N TOTAL	MG/L		7	.097143	.004257	.065247	.230000	.050000	83/03/10	83/06/29
00613	NO2-N	DISS	MG/L		1	.010000			.010000	.010000	83/06/29	83/06/29
				K	6	.010000	-.931E-10	.000000	.010000	.010000	83/03/10	83/05/25
				TOT	7	.010000	.776E-10	.000009	.010000	.010000	83/03/10	83/06/29
00620	NO3-N	TOTAL	MG/L		2	.200000	.020000	.141421	.300000	.100000	83/03/10	83/06/29
				K	5	.100000	-.279E-08	.000000	.100000	.100000	83/03/14	83/05/25
				TOT	7	.128571	.005714	.075593	.300000	.100000	83/03/10	83/06/29
00625	TOT KJEL	N	MG/L		7	1.43857	.393313	.627147	2.79000	1.06000	83/03/10	83/06/29
31616	FEC COLI	MFM-FCBR	/100ML		4	25.0000	900.000	30.0000	70.0000	10.0000	83/03/10	83/06/29
				K	3	7.66667	16.3334	4.04146	10.0000	3.00000	83/03/14	83/03/29
				TOT	7	17.5714	541.286	23.2655	70.0000	3.00000	83/03/10	83/06/29
70300	RESIDUE	DISS-180	C MG/L		7	991.143	132968	364.648	1153.00	165.000	83/03/10	83/06/29
70505	T PO4	P-COL	MG/L		7	.325285	.001357	.036840	.400000	.288000	83/03/10	83/06/29
70507	PHOS-T	ORTHO	MG/L P		7	.191428	.002532	.050316	.240000	.098000	83/03/10	83/06/29

Table IV-2. (continued)

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA02
43 31 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 CLASS 00 CSN-RSP 0593325-0621720

/TYPA/AMBNT/STREAM/RUNOFF

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		25	10.7556	49.3424	7.02441	23.3000	.560000	79/03/22	79/08/02
00011	WATER	TEMP	FAHN		25	51.3600	159.992	12.6488	74.0000	33.0000	79/03/22	79/08/02
00020	AIR	TEMP	CENT		25	10.7696	59.5981	7.71998	22.2000	-.777E+01	79/03/22	79/08/02
00021	AIR	TEMP	FAHN		25	51.4000	193.336	13.9045	72.0000	18.0000	79/03/22	79/08/02
00061	STREAM	FLOW,	INST-CFS		1	.000000			.000000	.000000	79/05/29	79/05/29
00300	DO		MG/L		23	8.00869	12.6008	3.54976	14.3000	.000000	79/03/22	79/08/02
00310	BOD	5 DAY	MG/L		10	6.49599	32.1850	5.67318	21.0000	1.60000	79/03/22	79/08/02
				K	1	1.00000			1.00000	1.00000	79/05/03	79/05/03
				TOT	11	5.99636	31.7125	5.63138	21.0000	1.00000	79/03/22	79/08/02
00335	COD	LOWLEVEL	MG/L		2	99.0000	722.000	26.8701	118.000	80.0000	79/03/22	79/03/26
00400	PH		SU		25	7.52799	.197906	.444867	8.30000	6.20000	79/03/22	79/08/02
00403	LAB	PH	SU		24	7.89666	.120574	.347237	8.92000	7.30000	79/03/22	79/08/02
00410	T ALK	CACO3	MG/L		22	209.818	8078.48	89.8804	372.000	55.0000	79/03/22	79/08/02
00500	RESIDUE	TOTAL	MG/L		24	1196.46	218904	467.872	2078.00	404.000	79/03/22	79/08/02
00515	RESIDUE	DISS-105	C MG/L		24	1184.87	223059	472.292	2070.00	380.000	79/03/22	79/08/02
00530	RESIDUE	TOT NFLT	MG/L		18	15.4167	608.655	24.6709	110.000	1.00000	79/03/22	79/08/02
				K	6	1.00000	.000000	.000000	1.00000	1.00000	79/04/05	79/06/21
				TOT	24	11.8125	490.539	22.1481	110.000	1.00000	79/03/22	79/08/02
00608	NH3+NH4-	N DISS	MG/L		5	.990000	.436650	.660795	1.78000	.150000	79/03/22	79/07/30
00610	NH3+NH4-	N TOTAL	MG/L		13	.152307	.028186	.167887	.470000	.020000	79/04/03	79/08/02
				K	6	.020000	.512E-09	.000023	.020000	.020000	79/04/16	79/05/21
				TOT	19	.110526	.022783	.150941	.470000	.020000	79/04/03	79/08/02
00613	NO2-N	DISS	MG/L		10	.016000	.000116	.010750	.040000	.010000	79/03/22	79/07/30
				K	15	.010000	.498E-10	.000007	.010000	.010000	79/04/19	79/08/02
				TOT	25	.012400	.000052	.007234	.040000	.010000	79/03/22	79/08/02
00618	NO3-N	DISS	MG/L		3	2.43333	4.44334	2.10792	4.20000	.100000	79/03/22	79/06/27
00620	NO3-N	TOTAL	MG/L		10	.699999	.726666	.852447	2.20000	.100000	79/03/26	79/06/21
				K	12	.100000	.108E-07	.000104	.100000	.100000	79/04/16	79/08/02
				TOT	22	.372727	.404935	.636345	2.20000	.100000	79/03/26	79/08/02
00625	TOT KJEL	N	MG/L		24	2.17875	1.07100	1.03489	5.37000	1.33000	79/03/22	79/08/02
00671	PHOS-DIS	ORTHO	MG/L P		5	.772399	.015576	.124803	.948000	.630000	79/03/22	79/07/30
31616	FEC COLI	MFM-FCBR	/100ML		19	3196.11	.341E+08	5847.10	23000.0	3.00000	79/03/26	79/08/02
				K	1	3.00000			3.00000	3.00000	79/04/19	79/04/19
				L	1	300.000			300.000	300.000	79/04/12	79/04/12
				TOT	21	2906.14	.316E+08	5622.33	23000.0	3.00000	79/03/26	79/08/02
70505	T PO4	P-COL	MG/L		24	.763249	.182016	.426633	1.95000	.183000	79/03/22	79/08/02
70507	PHOS-T	ORTHO	MG/L P		19	.618052	.192131	.438328	1.92000	.135000	79/04/03	79/08/02

Table IV-3.

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA02
43 31 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 CLASS 00 CSN-RSP 0593325-0621720

/TYPA/AMBNT/STREAM/RUNOFF

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		1	4.44000			4.44000	4.44000	82/03/01	82/03/01
00011	WATER	TEMP	FAHN		1	40.0000			40.0000	40.0000	82/03/01	82/03/01
00020	AIR	TEMP	CENT		1	5.00000			5.00000	5.00000	82/03/01	82/03/01
00021	AIR	TEMP	FAHN		1	41.0000			41.0000	41.0000	82/03/01	82/03/01
00300	DO		MG/L		1	2.00000			2.00000	2.00000	82/03/01	82/03/01
00500	RESIDUE	TOTAL	MG/L		1	194.000			194.000	194.000	82/03/01	82/03/01
00530	RESIDUE	TOT NFLT	MG/L	K	1	1.00000			1.00000	1.00000	82/03/01	82/03/01
00610	NH3+NH4-	N TOTAL	MG/L		1	1.61000			1.61000	1.61000	82/03/01	82/03/01
00613	NO2-N	DISS	MG/L		1	.060000			.060000	.060000	82/03/01	82/03/01
00620	NO3-N	TOTAL	MG/L		1	.100000			.100000	.100000	82/03/01	82/03/01
00625	TOT KJEL	N	MG/L		1	8.34000			8.34000	8.34000	82/03/01	82/03/01
00671	PHOS-DIS	ORTHO	MG/L P		1	1.42000			1.42000	1.42000	82/03/01	82/03/01
31616	FEC COLI	MFM-FCBR	/100ML		1	30.0000			30.0000	30.0000	82/03/01	82/03/01
70506	SOL PO4-	T P-COL	MG/L		1	1.54000			1.54000	1.54000	82/03/01	82/03/01

Table IV-3. (continued)

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA02
43 31 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 CLASS 00 CSN-RSP 0593325-0621720

/TYPA/AMBNT/STREAM/RUNOFF

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		11	4.64272	38.7245	6.22290	18.9000	.000000	83/02/22	83/06/29
00011	WATER	TEMP	FAHN		11	40.3636	125.656	11.2096	66.0000	32.0000	83/02/22	83/06/29
00020	AIR	TEMP	CENT		11	5.86454	51.3957	7.16908	18.9000	-.221E+01	83/02/22	83/06/29
00021	AIR	TEMP	FAHN		11	42.5454	166.075	12.8870	66.0000	28.0000	83/02/22	83/06/29
00300	DO		MG/L		10	12.2900	35.4210	5.95155	21.3000	2.50000	83/02/22	83/06/29
00400	PH		SU		2	8.49999	.980225	.990063	9.20000	7.80000	83/02/24	83/05/25
00403	LAB	PH	SU		10	7.88199	.183458	.428320	8.39000	7.08000	83/02/22	83/06/29
00500	RESIDUE	TOTAL	MG/L		11	987.454	119264	345.346	1508.00	316.000	83/02/22	83/06/29
00530	RESIDUE	TOT NFLT	MG/L		11	23.9091	345.292	18.5820	56.0000	1.00000	83/02/22	83/06/29
00610	NH3+NH4-	N TOTAL	MG/L		11	.637272	1.03112	1.01544	3.08000	.040000	83/02/22	83/06/29
00613	NO2-N	DISS	MG/L		2	.030000	.000800	.028284	.050000	.010000	83/02/22	83/06/29
				K	9	.010000	.582E-10	.000008	.010000	.010000	83/02/24	83/05/25
				TOT	11	.013636	.000145	.012060	.050000	.010000	83/02/22	83/06/29
00620	NO3-N	TOTAL	MG/L		7	.571428	.049048	.221468	.800000	.200000	83/02/22	83/06/29
				K	4	.100000	-.248E-08	.000000	.100000	.100000	83/03/13	83/05/25
				TOT	11	.400000	.086000	.293258	.800000	.100000	83/02/22	83/06/29
00625	TOT KJEL	N	MG/L		11	2.00273	3.13398	1.77031	6.36000	.780000	83/02/22	83/06/29
31616	FEC COLI	MFM-FCBR	/100ML		6	2231.67	.111E+08	3338.58	8400.00	40.0000	83/02/22	83/06/29
				K	5	8.60000	9.80005	3.13050	10.0000	3.00000	83/02/28	83/03/29
				TOT	11	1221.18	6920876	2630.76	8400.00	3.00000	83/02/22	83/06/29
70300	RESIDUE	DISS-180	C MG/L		11	963.545	126505	355.676	1500.00	260.000	83/02/22	83/06/29
70505	T PO4	P-COL	MG/L		11	.631818	.196128	.442864	1.33000	.132000	83/02/22	83/06/29
70507	PHOS-T	ORTHO	MG/L P		11	.496727	.139037	.372877	1.24500	.071000	83/02/22	83/06/29

Table IV-3. (continued)

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 CLASS 00 CSN-RSP 0593326-0621721

/TYPA/AMBNT/STREAM/RUNOFF

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		30	13.5136	49.5632	7.04011	23.3000	.560000	79/03/22	79/08/02
00011	WATER	TEMP	FAHN		30	56.3333	160.784	12.6801	74.0000	33.0000	79/03/22	79/08/02
00020	AIR	TEMP	CENT		30	13.0383	80.7368	8.98536	26.1000	-.943E+01	79/03/22	79/08/02
00021	AIR	TEMP	FAHN		30	55.4667	261.638	16.1752	79.0000	15.0000	79/03/22	79/08/02
00300	DO		MG/L		30	10.3233	10.8045	3.28702	16.5000	4.80000	79/03/22	79/08/02
00310	BOD	5 DAY	MG/L		10	3.57299	3.09523	1.75933	6.30000	1.00000	79/04/03	79/08/02
00335	COD	LOWLEVEL	MG/L		2	85.0000	162.000	12.7279	94.0000	76.0000	79/03/22	79/03/26
00400	PH		SU		30	7.74666	.113618	.337073	8.20000	7.00000	79/03/22	79/08/02
00403	LAB	PH	SU		29	8.04827	.111476	.333881	8.67000	7.12000	79/03/26	79/08/02
00410	T ALK	CACO3	MG/L		25	189.720	6294.83	79.3399	390.000	65.0000	79/03/26	79/08/02
00500	RESIDUE	TOTAL	MG/L		30	792.533	77123.8	277.712	1482.00	276.000	79/03/22	79/08/02
00515	RESIDUE	DISS-105	C MG/L		30	775.200	80572.1	283.852	1472.00	250.000	79/03/22	79/08/02
00530	RESIDUE	TOT NFLT	MG/L		25	20.7600	679.503	26.0673	126.000	1.00000	79/03/22	79/08/02
				K	5	1.00000	.000000	.000000	1.00000	1.00000	79/04/19	79/07/30
				TOT	30	17.4667	618.447	24.8686	126.000	1.00000	79/03/22	79/08/02
00608	NH3+NH4-	N DISS	MG/L		2	.205000	.031250	.176777	.330000	.080000	79/03/30	79/04/12
00610	NH3+NH4-	N TOTAL	MG/L		20	.136000	.038930	.197308	.720000	.020000	79/03/22	79/08/02
				K	7	.020000	.504E-09	.000022	.020000	.020000	79/04/16	79/06/07
				TOT	27	.105926	.031133	.176444	.720000	.020000	79/03/22	79/08/02
00613	NO2-N	DISS	MG/L		16	.021875	.000723	.026887	.110000	.010000	79/03/22	79/08/02
				K	14	.010000	.537E-10	.000007	.010000	.010000	79/04/19	79/07/05
				TOT	30	.016333	.000410	.020254	.110000	.010000	79/03/22	79/08/02
00618	NO3-N	DISS	MG/L		4	1.60000	1.40667	1.18603	3.10000	.600000	79/03/22	79/07/05
				K	1	.100000			.100000	.100000	79/04/26	79/04/26
				TOT	5	1.30000	1.50500	1.22678	3.10000	.100000	79/03/22	79/07/05
00620	NO3-N	TOTAL	MG/L		16	.681249	.408291	.638977	1.90000	.100000	79/03/30	79/08/02
				K	9	.100000	.000000	.000000	.100000	.100000	79/04/16	79/06/04
				TOT	25	.472000	.336266	.579885	1.90000	.100000	79/03/30	79/08/02
00625	TOT KJEL	N	MG/L		30	1.48166	.439635	.663049	3.55000	.850000	79/03/22	79/08/02
00671	PHOS-DIS	ORTHO	MG/L P		3	.441333	.085382	.292202	.752000	.172000	79/03/22	79/04/12
31616	FEC COLI	MFM-FCBR	/100ML		18	1733.50	.135E+08	3675.13	12000.0	3.00000	79/03/26	79/08/02
				K	9	3.00000	.000000	.000000	3.00000	3.00000	79/04/03	79/05/24
				TOT	27	1156.67	9522282	3085.82	12000.0	3.00000	79/03/26	79/08/02
70505	T PO4	P-COL	MG/L		30	.362499	.075454	.274688	1.60000	.187000	79/03/22	79/08/02
70507	PHOS-T	ORTHO	MG/L P		27	.265185	.012085	.109930	.545000	.141000	79/03/26	79/08/02

Table IV-4.

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 CLASS 00 CSN-RSP 0593326-0621721

/TYPA/AMBNT/STREAM/RUNOFF

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		2	1.11000	2.46420	1.56978	2.22000	.000000	82/02/22	82/02/23
00011	WATER	TEMP	FAHN		2	34.0000	8.00000	2.82843	36.0000	32.0000	82/02/22	82/02/23
00020	AIR	TEMP	CENT		2	7.80000	297.680	17.2534	20.0000	-.439E+01	82/02/22	82/02/23
00021	AIR	TEMP	FAHN		2	46.0000	968.000	31.1127	68.0000	24.0000	82/02/22	82/02/23
00300	DO		MG/L		2	10.0500	.005173	.071922	10.1000	10.0000	82/02/22	82/02/23
00500	RESIDUE	TOTAL	MG/L		2	198.500	4324.50	65.7609	245.000	152.000	82/02/22	82/02/23
00530	RESIDUE	TOT NFLT	MG/L		2	12.5000	12.5000	3.53553	15.0000	10.0000	82/02/22	82/02/23
00610	NH3+NH4-	N TOTAL	MG/L		2	.350000	.001800	.042426	.380000	.320000	82/02/22	82/02/23
00613	NO2-N	DISS	MG/L		2	.020000	.000200	.014142	.030000	.010000	82/02/22	82/02/23
00620	NO3-N	TOTAL	MG/L		2	1.25000	.045001	.212134	1.40000	1.10000	82/02/22	82/02/23
00625	TOT KJEL	N	MG/L		2	2.01500	.296450	.544472	2.40000	1.63000	82/02/22	82/02/23
31616	FEC COLI	MFM-FCBR	/100ML		2	935.000	884450	940.452	1600.00	270.000	82/02/22	82/02/23
70300	RESIDUE	DISS-180	C MG/L		2	186.000	3872.00	62.2254	230.000	142.000	82/02/22	82/02/23
70506	SOL PO4-	T P-COL	MG/L		2	.927000	.002180	.046692	.960000	.894000	82/02/22	82/02/23
70507	PHOS-T	ORTHO	MG/L P		2	.922000	.001568	.039596	.950000	.894000	82/02/22	82/02/23

Table IV-4. (continued)

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 CLASS 00 CSN-RSP 0593326-0621721

/TYPA/AMBNT/STREAM/RUNOFF

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		2	1.67000	2.46420	1.56978	2.78000	.560000	83/02/28	83/03/03
00011	WATER	TEMP	FAHN		2	35.0000	8.00000	2.82843	37.0000	33.0000	83/02/28	83/03/03
00020	AIR	TEMP	CENT		2	9.14999	34.4452	5.86900	13.3000	5.00000	83/02/28	83/03/03
00021	AIR	TEMP	FAHN		2	48.5000	112.500	10.6066	56.0000	41.0000	83/02/28	83/03/03
00061	STREAM	FLOW,	INST-CFS		5	.000000	.000000	.000000	.000000	.000000	83/02/22	83/05/25
00300	DO		MG/L		2	9.99999	.180267	.424579	10.3000	9.70000	83/02/28	83/03/03
00403	LAB	PH	SU		2	7.47500	.036453	.190927	7.61000	7.34000	83/02/28	83/03/03
00500	RESIDUE	TOTAL	MG/L		2	525.500	180.500	13.4350	535.000	516.000	83/02/28	83/03/03
00530	RESIDUE	TOT NFLT	MG/L		2	23.0000	578.000	24.0416	40.0000	6.00000	83/02/28	83/03/03
00610	NH3+NH4-	N TOTAL	MG/L		2	.260000	.072200	.268701	.450000	.070000	83/02/28	83/03/03
00613	NO2-N	DISS	MG/L		1	.010000			.010000	.010000	83/02/28	83/02/28
				K	1	.010000			.010000	.010000	83/03/03	83/03/03
				TOT	2	.010000	-.145E-10	.000000	.010000	.010000	83/02/28	83/03/03
00620	NO3-N	TOTAL	MG/L		2	.500000	.020000	.141421	.600000	.400000	83/02/28	83/03/03
00625	TOT KJEL	N	MG/L		2	1.19000	.135201	.367698	1.45000	.930000	83/02/28	83/03/03
31616	FEC COLI	MFM-FCBR	/100ML	K	2	6.50000	24.5000	4.94975	10.0000	3.00000	83/02/28	83/03/03
70300	RESIDUE	DISS-180	C MG/L		2	502.500	1404.50	37.4766	529.000	476.000	83/02/28	83/03/03
70505	T PO4	P-COL	MG/L		2	.364500	.004140	.064347	.410000	.319000	83/02/28	83/03/03
70507	PHOS-T	ORTHO	MG/L P		2	.279500	.003281	.057276	.320000	.239000	83/02/28	83/03/03

Table IV-4. (continued)

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 CLASS 00 CSN-RSP 0593327-0621722

/TYPA/AMBNT/STREAM/RUNOFF

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		21	9.91857	56.0898	7.48931	24.4000	.560000	79/03/20	79/08/02
00011	WATER	TEMP	FAHN		21	49.8571	182.030	13.4918	76.0000	33.0000	79/03/20	79/08/02
00020	AIR	TEMP	CENT		21	10.9576	50.9963	7.14117	22.2000	1.11000	79/03/20	79/08/02
00021	AIR	TEMP	FAHN		21	51.7143	165.115	12.8497	72.0000	34.0000	79/03/20	79/08/02
00061	STREAM	FLOW,	INST-CFS		2	.000000	.000000	.000000	.000000	.000000	79/05/17	79/05/21
00095	CNDUCTVY	AT 25C	MICROMHO		1	510.000			510.000	510.000	79/03/20	79/03/20
00300	DO		MG/L		20	7.16499	21.4329	4.62957	12.5000	.000000	79/03/20	79/08/02
00310	BOD	5 DAY	MG/L		3	8.69333	44.4506	6.66713	16.0000	2.94000	79/03/20	79/04/19
00335	COD	LOWLEVEL	MG/L		2	85.0000	162.000	12.7279	94.0000	76.0000	79/03/20	79/03/26
00400	PH		SU		21	7.49523	.190466	.436424	8.00000	6.70000	79/03/20	79/08/02
00403	LAB	PH	SU		20	7.87549	.190905	.436927	8.39000	6.98000	79/03/20	79/08/02
00410	T ALK	CACO3	MG/L		19	276.715	21862.3	147.859	496.000	51.8000	79/03/20	79/08/02
00500	RESIDUE	TOTAL	MG/L		21	1956.29	1399214	1182.88	3498.00	367.000	79/03/20	79/08/02
00515	RESIDUE	DISS-105	C MG/L		21	1928.86	1441424	1200.59	3481.00	355.000	79/03/20	79/08/02
00530	RESIDUE	TOT NFLT	MG/L		20	28.4750	4497.56	67.0639	310.000	1.00000	79/03/20	79/08/02
				K	1	1.00000			1.00000	1.00000	79/05/07	79/05/07
00608	NH3+NH4-	N DISS	MG/L	TOT	21	27.1667	4308.63	65.6401	310.000	1.00000	79/03/20	79/08/02
00610	NH3+NH4-	N TOTAL	MG/L		4	.702500	.265025	.514806	1.40000	.190000	79/03/22	79/08/02
					15	.305999	.155068	.393787	1.50000	.020000	79/03/20	79/06/21
				K	2	.020000	-.232E-09	.000000	.020000	.020000	79/04/19	79/04/23
00613	NO2-N	DISS	MG/L	TOT	17	.272352	.144706	.380403	1.50000	.020000	79/03/20	79/06/21
					9	.022222	.000419	.020480	.070000	.010000	79/03/20	79/07/30
				K	12	.010000	.634E-10	.000008	.010000	.010000	79/04/03	79/08/02
00618	NO3-N	DISS	MG/L	TOT	21	.015238	.000206	.014359	.070000	.010000	79/03/20	79/08/02
00620	NO3-N	TOTAL	MG/L		5	3.42000	2.81201	1.67690	4.90000	.700000	79/03/20	79/07/30
					6	1.06667	1.12267	1.05956	2.30000	.100000	79/03/30	79/05/14
				K	10	.100000	.000000	.000000	.100000	.100000	79/04/23	79/08/02
00625	TOT KJEL	N	MG/L	TOT	16	.462500	.607833	.779636	2.30000	.100000	79/03/30	79/08/02
00671	PHOS-DIS	ORTHO	MG/L P		21	2.59523	.955221	.977354	5.96000	1.74000	79/03/20	79/08/02
31616	FEC COLI	MFM-FCBR	/100ML		4	.453500	.069296	.263242	.837000	.237000	79/03/22	79/08/02
					9	1557.78	.103E+08	3212.81	10000.0	17.0000	79/04/12	79/08/02
				K	9	4.55556	9.52779	3.08671	10.0000	3.00000	79/03/20	79/05/07
70505	T PO4	P-COL	MG/L	TOT	18	781.166	5496075	2344.37	10000.0	3.00000	79/03/20	79/08/02
70507	PHOS-T	ORTHO	MG/L P		21	.913665	.425201	.652075	2.44000	.353000	79/03/20	79/08/02
					17	.900353	.444190	.666476	2.33000	.283000	79/03/20	79/06/21

Table IV-5.

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 CLASS 00 CSN-RSP 0593327-0621722

/TYPA/AMBNT/STREAM/RUNOFF

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		2	.550000	.604999	.777817	1.10000	.000000	82/02/22	82/02/24
00011	WATER	TEMP	FAHN		2	33.0000	2.00000	1.41421	34.0000	32.0000	82/02/22	82/02/24
00020	AIR	TEMP	CENT		2	7.74999	222.604	14.9199	18.3000	-.279E+01	82/02/22	82/02/24
00021	AIR	TEMP	FAHN		2	46.0000	722.000	26.8701	65.0000	27.0000	82/02/22	82/02/24
00300	DO		MG/L		2	10.1000	.500046	.707139	10.6000	9.60000	82/02/22	82/02/24
00301	DO	SATUR	PERCENT		1	67.6000			67.6000	67.6000	82/02/22	82/02/22
00500	RESIDUE	TOTAL	MG/L		2	205.500	264.500	16.2635	217.000	194.000	82/02/22	82/02/24
00530	RESIDUE	TOT NFLT	MG/L		2	34.0000	2.00000	1.41421	35.0000	33.0000	82/02/22	82/02/24
00610	NH3+NH4-	N TOTAL	MG/L		2	1.43500	.490050	.700036	1.93000	.940000	82/02/22	82/02/24
00613	NO2-N	DISS	MG/L		2	.050000	.000800	.028284	.070000	.030000	82/02/22	82/02/24
00620	NO3-N	TOTAL	MG/L		2	1.50000	.020001	.141426	1.60000	1.40000	82/02/22	82/02/24
00625	TOT KJEL	N	MG/L		2	3.50000	.423202	.650540	3.96000	3.04000	82/02/22	82/02/24
31616	FEC COLI	MFM-FCBR	/100ML		2	260.000	3200.00	56.5685	300.000	220.000	82/02/22	82/02/24
70300	RESIDUE	DISS-180	MG/L	C	2	171.500	220.500	14.8492	182.000	161.000	82/02/22	82/02/24
70506	SOL PO4-	T P-COL	MG/L		2	.725000	.008450	.091921	.790000	.660000	82/02/22	82/02/24
70507	PHOS-T	ORTHO	MG/L P		2	.696500	.010513	.102533	.769000	.624000	82/02/22	82/02/24

Table IV-5. (continued)

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 CLASS 00 CSN-RSP 0593327-0621722

/TYPA/AMBNT/STREAM/RUNOFF

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		5	1.22400	1.44828	1.20345	2.78000	.000000	83/02/22	83/03/10
00011	WATER	TEMP	FAHN		5	34.2000	4.70117	2.16822	37.0000	32.0000	83/02/22	83/03/10
00020	AIR	TEMP	CENT		5	4.99400	39.3552	6.27337	13.3000	-.221E+01	83/02/22	83/03/10
00021	AIR	TEMP	FAHN		5	41.0000	128.000	11.3137	56.0000	28.0000	83/02/22	83/03/10
00061	STREAM	FLOW,	INST-CFS		3	.000000	.000000	.000000	.000000	.000000	83/03/14	83/05/25
00300	DO		MG/L		5	5.66000	1.96305	1.40109	7.50000	4.20000	83/02/22	83/03/10
00403	LAB	PH	SU		5	7.45599	.095459	.308964	7.90000	7.09000	83/02/22	83/03/10
00500	RESIDUE	TOTAL	MG/L		5	850.600	108232	328.986	1380.00	518.000	83/02/22	83/03/10
00530	RESIDUE	TOT NFLT	MG/L		5	26.4000	228.800	15.1261	52.0000	16.0000	83/02/22	83/03/10
00610	NH3+NH4-	N TOTAL	MG/L		5	1.09800	.239520	.489408	1.66000	.430000	83/02/22	83/03/10
00613	NO2-N	DISS	MG/L		2	.015000	.000050	.007071	.020000	.010000	83/02/22	83/03/10
				K	3	.010000	.000000	.000000	.010000	.010000	83/02/24	83/03/03
				TOT	5	.012000	.000020	.004472	.020000	.010000	83/02/22	83/03/10
00620	NO3-N	TOTAL	MG/L		5	.520000	.092000	.303315	1.00000	.200000	83/02/22	83/03/10
00625	TOT KJEL	N	MG/L		5	2.31600	.784630	.885793	3.63000	1.36000	83/02/22	83/03/10
31616	FEC COLI	MFM-FCBR	/100ML		5	14.0000	80.0000	8.94427	30.0000	10.0000	83/02/22	83/03/10
70300	RESIDUE	DISS-180	C MG/L		5	824.200	114148	337.858	1360.00	466.000	83/02/22	83/03/10
70505	T PO4	P-COL	MG/L		4	.323000	.004678	.068396	.383000	.231000	83/02/24	83/03/10
70507	PHOS-T	ORTHO	MG/L P		4	.204000	.002362	.048600	.252000	.137000	83/02/24	83/03/10

Table IV-5. (continued)

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 CLASS 00 CSN-RSP 0585287-0554051

/TYPA/AMBNT/LAKE

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		15	15.0413	60.7194	7.79227	23.9000	.000000	79/04/19	79/12/06
00011	WATER	TEMP	FAHN		15	59.0667	196.782	14.0279	75.0000	32.0000	79/04/19	79/12/06
00020	AIR	TEMP	CENT		15	13.9253	72.4117	8.50951	22.2000	-.332E+01	79/04/19	79/12/06
00021	AIR	TEMP	FAHN		15	57.0667	234.925	15.3273	72.0000	26.0000	79/04/19	79/12/06
00300	DO		MG/L		15	9.24666	5.98697	2.44683	14.6000	6.60000	79/04/19	79/12/06
00310	BOD	5 DAY	MG/L		3	4.98000	1.53719	1.23984	6.00000	3.60000	79/04/19	79/08/16
00400	PH		SU		13	8.46923	.185689	.430917	9.00000	7.50000	79/04/19	79/12/06
00403	LAB	PH	SU		11	8.86635	.054590	.233645	9.17000	8.44000	79/04/19	79/09/06
00410	T ALK	CACO3	MG/L		9	225.000	359.250	18.9539	248.000	193.000	79/04/19	79/09/06
00500	RESIDUE	TOTAL	MG/L		15	1133.67	10316.6	101.571	1354.00	950.000	79/04/19	79/12/06
00515	RESIDUE	DISS-105	C MG/L		15	1121.40	9587.42	97.9154	1318.00	940.000	79/04/19	79/12/06
00530	RESIDUE	TOT NFLT	MG/L		13	14.1154	110.173	10.4963	36.0000	5.00000	79/04/19	79/12/06
				K	2	1.00000	.000000	.000000	1.00000	1.00000	79/06/21	79/11/08
				TOT	15	12.3667	115.731	10.7578	36.0000	1.00000	79/04/19	79/12/06
00608	NH3+NH4-	N DISS	MG/L		1	.080000			.080000	.080000	79/08/02	79/08/02
00610	NH3+NH4-	N TOTAL	MG/L		14	.122143	.006910	.083129	.290000	.020000	79/04/19	79/12/06
00613	NO2-N	DISS	MG/L		5	.010000	-.582E-10	.000000	.010000	.010000	79/04/19	79/12/06
				K	10	.010000	.517E-10	.000007	.010000	.010000	79/05/03	79/11/08
				TOT	15	.010000	.665E-10	.000008	.010000	.010000	79/04/19	79/12/06
00618	NO3-N	DISS	MG/L	K	2	.100000	-.372E-08	.000000	.100000	.100000	79/07/19	79/08/02
00620	NO3-N	TOTAL	MG/L		7	.328571	.062381	.249762	.700000	.100000	79/04/19	79/12/06
				K	6	.100000	-.223E-08	.000000	.100000	.100000	79/05/03	79/10/04
				TOT	13	.223077	.045256	.212736	.700000	.100000	79/04/19	79/12/06
00625	TOT KJEL	N	MG/L		15	2.10533	.107316	.327591	2.62000	1.56000	79/04/19	79/12/06
00671	PHOS-DIS	ORTHO	MG/L P		1	.580000			.580000	.580000	79/08/02	79/08/02
31616	FEC COLI	MFM-FCBR	/100ML		4	13.2500	68.9167	8.30160	20.0000	3.00000	79/06/07	79/08/16
				K	11	4.81818	11.1636	3.34120	10.0000	2.00000	79/04/19	79/12/06
				TOT	15	7.06667	37.6381	6.13499	20.0000	2.00000	79/04/19	79/12/06
70505	T PO4	P-COL	MG/L		15	.629000	.012032	.109692	.749000	.434000	79/04/19	79/12/06
70507	PHOS-T	ORTHO	MG/L P		14	.540642	.011403	.106784	.675000	.362000	79/04/19	79/12/06

Table IV-6.

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 CLASS 00 CSN-RSP 0585287-0554051

/TYPA/AMBNT/LAKE

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		3	.000000	.000000	.000000	.000000	.000000	80/01/10	80/02/28
00011	WATER	TEMP	FAHN		3	32.0000	.000000	.000000	32.0000	32.0000	80/01/10	80/02/28
00020	AIR	TEMP	CENT		3	-.721E+01	19.2893	4.39196	-.389E+01	-.121E+02	80/01/10	80/02/28
00021	AIR	TEMP	FAHN		3	19.0000	63.0000	7.93725	25.0000	10.0000	80/01/10	80/02/28
00300	DO		MG/L		3	12.7333	1.58362	1.25842	13.9000	11.4000	80/01/10	80/02/28
00400	PH		SU		2	8.74999	.005234	.072345	8.80000	8.70000	80/01/10	80/02/11
00403	LAB	PH	SU		1	1.57000			1.57000	1.57000	80/01/10	80/01/10
00500	RESIDUE	TOTAL	MG/L		3	1228.00	169.000	13.0000	1241.00	1215.00	80/01/10	80/02/28
00515	RESIDUE	DISS-105	C MG/L		3	1198.00	1789.00	42.2966	1233.00	1151.00	80/01/10	80/02/28
00530	RESIDUE	TOT NFLT	MG/L		3	30.0000	1659.00	40.7308	77.0000	5.00000	80/01/10	80/02/28
00610	NH3+NH4-	N TOTAL	MG/L		3	.253333	.010833	.104083	.370000	.170000	80/01/10	80/02/28
00613	NO2-N	DISS	MG/L		1	.020000			.020000	.020000	80/01/10	80/01/10
				K	1	.010000			.010000	.010000	80/02/28	80/02/28
				TOT	2	.015000	.000050	.007071	.020000	.010000	80/01/10	80/02/28
00620	NO3-N	TOTAL	MG/L		2	.250000	.005000	.070710	.300000	.200000	80/01/10	80/02/28
00625	TOT KJEL	N	MG/L		3	1.67667	.361433	.601193	2.20000	1.02000	80/01/10	80/02/28
31616	FEC COLI	MFM-FCBR	/100ML		1	3.00000			3.00000	3.00000	80/02/11	80/02/11
				K	2	3.00000	.000000	.000000	3.00000	3.00000	80/01/10	80/02/28
				TOT	3	3.00000	.000000	.000000	3.00000	3.00000	80/01/10	80/02/28
70505	T PO4	P-COL	MG/L		3	.643999	.004590	.067746	.722000	.600000	80/01/10	80/02/28
70507	PHOS-T	ORTHO	MG/L P		3	.498666	.050607	.224960	.683000	.248000	80/01/10	80/02/28

Table IV-6. (continued.

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 CLASS 00 CSN-RSP 0585287-0554051

/TYPA/AMBNT/LAKE

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		4	10.4150	140.385	11.8484	22.8000	.000000	82/08/26	82/12/20
00011	WATER	TEMP	FAHN		5	57.2000	549.204	23.4351	83.0000	32.0000	82/07/28	82/12/20
00020	AIR	TEMP	CENT		6	16.5883	104.621	10.2284	27.8000	1.11000	82/07/28	82/12/20
00021	AIR	TEMP	FAHN		6	61.8333	338.170	18.3894	82.0000	34.0000	82/07/28	82/12/20
00300	DO		MG/L		6	12.8167	11.0858	3.32953	17.2000	8.50000	82/07/28	82/12/20
00301	DO	SATUR	PERCENT		1	97.7000			97.7000	97.7000	82/08/26	82/08/26
00400	PH		SU		3	8.33333	.323448	.568725	8.80000	7.70000	82/08/26	82/11/29
00403	LAB	PH	SU		2	8.30499	.162674	.403329	8.59000	8.02000	82/09/27	82/12/20
00500	RESIDUE	TOTAL	MG/L		6	1326.00	14396.8	119.987	1445.00	1130.00	82/07/28	82/12/20
00530	RESIDUE	TOT NFLT	MG/L		6	31.0000	1204.00	34.6987	79.0000	3.00000	82/07/28	82/12/20
00608	NH3+NH4-	N DISS	MG/L	K	1	.020000			.020000	.020000	82/10/25	82/10/25
00610	NH3+NH4-	N TOTAL	MG/L		5	.052000	.000370	.019235	.080000	.030000	82/07/28	82/12/20
00613	NO2-N	DISS	MG/L	K	6	.010000	-.931E-10	.000000	.010000	.010000	82/07/28	82/12/20
00618	NO3-N	DISS	MG/L	K	1	.100000			.100000	.100000	82/10/25	82/10/25
00619	UN-IONZD	NH3-NH3	MG/L		1	.008000			.008000	.008000	82/08/26	82/08/26
00620	NO3-N	TOTAL	MG/L		1	.100000			.100000	.100000	82/11/29	82/11/29
				K	4	.100000	-.248E-08	.000000	.100000	.100000	82/07/28	82/12/20
00623	KJELDL N	DISS	MG/L	TOT	5	.100000	-.279E-08	.000000	.100000	.100000	82/07/28	82/12/20
00625	TOT KJEL	N	MG/L		1	1.26000			1.26000	1.26000	82/10/25	82/10/25
00671	PHOS-DIS	ORTHO	MG/L P		5	1.06400	.026031	.161342	1.33000	.890000	82/07/28	82/12/20
31616	FEC COLI	MFM-FCBR	/100ML		1	.165000			.165000	.165000	82/10/25	82/10/25
					4	44.0000	4130.66	64.2702	140.000	6.00000	82/07/28	82/10/25
70300	RESIDUE	DISS-180	C MG/L	K	2	6.50000	24.5000	4.94975	10.0000	3.00000	82/11/29	82/12/20
70505	T PO4	P-COL	MG/L	TOT	6	31.5000	2858.30	53.4631	140.000	3.00000	82/07/28	82/12/20
70506	SOL PO4-	T P-COL	MG/L		6	1295.00	9150.80	95.6598	1371.00	1127.00	82/07/28	82/12/20
70507	PHOS-T	ORTHO	MG/L P		2	.354500	.073344	.270822	.546000	.163000	82/07/28	82/12/20
					4	.309000	.016869	.129880	.480000	.197000	82/08/26	82/11/29
					5	.297200	.024627	.156931	.500000	.131000	82/07/28	82/12/20

Table IV-6. (continued)

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 CLASS 00 CSN-RSP 0585287-0554051

/TYPA/AMBNT/LAKE

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		4	9.72500	131.142	11.4517	22.2000	.000000	83/01/24	83/06/29
00011	WATER	TEMP	FAHN		4	49.5000	425.000	20.6155	72.0000	32.0000	83/01/24	83/06/29
00020	AIR	TEMP	CENT		4	9.58250	93.4038	9.66456	19.4000	-.166E+01	83/01/24	83/06/29
00021	AIR	TEMP	FAHN		4	49.2500	302.916	17.4045	67.0000	29.0000	83/01/24	83/06/29
00300	DO		MG/L		4	9.20000	4.92008	2.21813	12.1000	6.70000	83/01/24	83/06/29
00400	PH		SU		1	8.40000			8.40000	8.40000	83/05/25	83/05/25
00403	LAB	PH	SU		2	8.82999	.845169	.919331	9.48000	8.18000	83/02/28	83/06/29
00500	RESIDUE	TOTAL	MG/L		4	1068.25	109862	331.454	1328.00	582.000	83/01/24	83/06/29
00530	RESIDUE	TOT NFLT	MG/L		4	21.5000	169.667	13.0256	32.0000	3.00000	83/01/24	83/06/29
00610	NH3+NH4-	N TOTAL	MG/L		4	.272500	.091092	.301814	.700000	.050000	83/01/24	83/06/29
00613	NO2-N	DISS	MG/L		1	.010000			.010000	.010000	83/06/29	83/06/29
				K	3	.010000	.000000	.000000	.010000	.010000	83/01/24	83/05/25
				TOT	4	.010000	-.776E-10	.000000	.010000	.010000	83/01/24	83/06/29
00620	NO3-N	TOTAL	MG/L		1	.800000			.800000	.800000	83/02/28	83/02/28
				K	3	.100000	-.186E-08	.000000	.100000	.100000	83/01/24	83/06/29
				TOT	4	.275000	.122500	.350000	.800000	.100000	83/01/24	83/06/29
00625	TOT KJEL	N	MG/L		4	1.90250	.064293	.253562	2.27000	1.70000	83/01/24	83/06/29
31616	FEC COLI	MFM-FCBR	/100ML		3	123.333	9733.35	98.6577	190.000	10.0000	83/02/28	83/06/29
				K	1	3.00000			3.00000	3.00000	83/01/24	83/01/24
				TOT	4	93.2500	10108.9	100.543	190.000	3.00000	83/01/24	83/06/29
70300	RESIDUE	DISS-180	C MG/L		4	1046.75	116018	340.614	1325.00	550.000	83/01/24	83/06/29
70505	T PO4	P-COL	MG/L		3	.433667	.034759	.186437	.647000	.302000	83/02/28	83/06/29
70506	SOL PO4-	T P-COL	MG/L		1	.159000			.159000	.159000	83/01/24	83/01/24
70507	PHOS-T	ORTHO	MG/L P		4	.274000	.024845	.157624	.500000	.134000	83/01/24	83/06/29

Table IV-6. (continued)

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 CLASS 00 CSN-RSP 0585288-0554052

/TYPA/AMBNT/LAKE

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		13	15.9800	62.9888	7.93655	24.4000	.000000	79/05/03	79/12/06
00011	WATER	TEMP	FAHN		13	60.7692	204.361	14.2955	76.0000	32.0000	79/05/03	79/12/06
00020	AIR	TEMP	CENT		13	14.7392	96.9569	9.84667	23.9000	-.221E+01	79/05/03	79/12/06
00021	AIR	TEMP	FAHN		13	58.5384	314.604	17.7371	75.0000	28.0000	79/05/03	79/12/06
00300	DO		MG/L		12	8.69166	6.71356	2.59105	16.1000	6.30000	79/05/03	79/12/06
00310	BOD	5 DAY	MG/L		2	4.30500	.328049	.572755	4.71000	3.90000	79/07/19	79/08/16
00400	PH		SU		13	8.54615	.182719	.427456	9.10000	7.50000	79/05/03	79/12/06
00403	LAB	PH	SU		9	8.94111	.031952	.178751	9.18000	8.71000	79/05/03	79/09/06
00410	T ALK	CACO3	MG/L		7	232.857	165.823	12.8772	246.000	215.000	79/05/03	79/09/06
00500	RESIDUE	TOTAL	MG/L		13	1157.77	6532.00	80.8208	1349.00	1042.00	79/05/03	79/12/06
00515	RESIDUE	DISS-105	C MG/L		13	1146.85	6461.33	80.3824	1331.00	1019.00	79/05/03	79/12/06
00530	RESIDUE	TOT NFLT	MG/L		12	11.7917	43.6118	6.60392	23.0000	2.00000	79/05/03	79/12/06
				K	1	1.00000			1.00000	1.00000	79/11/08	79/11/08
				TOT	13	10.9615	48.9359	6.99542	23.0000	1.00000	79/05/03	79/12/06
00610	NH3+NH4-	N TOTAL	MG/L		13	.173077	.045906	.214258	.830000	.020000	79/05/03	79/12/06
00613	NO2-N	DISS	MG/L		1	.010000			.010000	.010000	79/12/06	79/12/06
				K	12	.010000	.634E-10	.000008	.010000	.010000	79/05/03	79/11/08
				TOT	13	.010000	.582E-10	.000008	.010000	.010000	79/05/03	79/12/06
00620	NO3-N	TOTAL	MG/L		6	.166667	.010667	.103279	.300000	.100000	79/05/17	79/12/06
				K	7	.100000	.000000	.000000	.100000	.100000	79/05/03	79/10/04
				TOT	13	.130769	.005641	.075107	.300000	.100000	79/05/03	79/12/06
00625	TOT KJEL	N	MG/L		13	1.99615	.133202	.364968	2.77000	1.45000	79/05/03	79/12/06
31616	FEC COLI	MFM-FCBR	/100ML		4	8.75000	22.2500	4.71699	13.0000	2.00000	79/06/07	79/11/08
				K	8	6.50000	14.0000	3.74166	10.0000	3.00000	79/05/03	79/12/06
				TOT	12	7.25000	16.2045	4.02549	13.0000	2.00000	79/05/03	79/12/06
70505	T PO4	P-COL	MG/L		13	.627538	.011549	.107467	.770000	.421000	79/05/03	79/12/06
70507	PHOS-T	ORTHO	MG/L P		13	.565307	.009988	.099938	.677000	.375000	79/05/03	79/12/06

Table IV-7.

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 CLASS 00 CSN-RSP 0585288-0554052

/TYPA/AMBNT/LAKE

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		2	.000000	.000000	.000000	.000000	.000000	80/01/10	80/02/28
00011	WATER	TEMP	FAHN		3	31.6667	.334351	.578231	32.0000	31.0000	80/01/10	80/02/28
00020	AIR	TEMP	CENT		2	-.804E+01	34.4451	5.86900	-.389E+01	-.121E+02	80/01/10	80/02/11
00021	AIR	TEMP	FAHN		3	19.0000	63.0000	7.93725	25.0000	10.0000	80/01/10	80/02/28
00300	DO		MG/L		3	15.0333	3.05359	1.74745	16.5000	13.1000	80/01/10	80/02/28
00400	PH		SU		2	7.70000	.080002	.282846	7.90000	7.50000	80/01/10	80/02/11
00403	LAB	PH	SU		1	1.60000			1.60000	1.60000	80/01/10	80/01/10
00500	RESIDUE	TOTAL	MG/L		3	1247.33	383.000	19.5704	1266.00	1227.00	80/01/10	80/02/28
00515	RESIDUE	DISS-105	C MG/L		3	1242.33	493.000	22.2036	1266.00	1222.00	80/01/10	80/02/28
00530	RESIDUE	TOT NFLT	MG/L		2	7.50000	12.5000	3.53553	10.0000	5.00000	80/01/10	80/02/28
				K	1	1.00000			1.00000	1.00000	80/02/11	80/02/11
				TOT	3	5.33333	20.3333	4.50925	10.0000	1.00000	80/01/10	80/02/28
00610	NH3+NH4-	N TOTAL	MG/L		3	.193333	.001733	.041633	.240000	.160000	80/01/10	80/02/28
00613	NO2-N	DISS	MG/L	K	2	.010000	-.145E-10	.000000	.010000	.010000	80/01/10	80/02/28
00620	NO3-N	TOTAL	MG/L		1	.300000			.300000	.300000	80/02/28	80/02/28
				K	1	.100000			.100000	.100000	80/01/10	80/01/10
				TOT	2	.200000	.020000	.141421	.300000	.100000	80/01/10	80/02/28
00625	TOT KJEL	N	MG/L		3	2.27667	.148635	.385532	2.60000	1.85000	80/01/10	80/02/28
31616	FEC COLI	MFM-FCBR	/100ML	K	3	3.00000	.000000	.000000	3.00000	3.00000	80/01/10	80/02/28
70505	T PO4	P-COL	MG/L		3	.611333	.000006	.002490	.614000	.610000	80/01/10	80/02/28
70507	PHOS-T	ORTHO	MG/L P		3	.555333	.000633	.025151	.575000	.527000	80/01/10	80/02/28

Table IV-7. (continued)

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 CLASS 00 CSN-RSP 0585288-0554052

/TYPA/AMBNT/LAKE

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		4	7.21500	75.6594	8.69824	18.3000	.000000	82/09/27	82/12/20
00011	WATER	TEMP	FAHN		4	45.0000	246.000	15.6844	65.0000	32.0000	82/09/27	82/12/20
00020	AIR	TEMP	CENT		4	12.4950	107.107	10.3492	23.3000	1.11000	82/09/27	82/12/20
00021	AIR	TEMP	FAHN		4	54.5000	347.666	18.6458	74.0000	34.0000	82/09/27	82/12/20
00300	DO		MG/L		4	14.7000	9.54663	3.08976	18.1000	11.7000	82/09/27	82/12/20
00400	PH		SU		3	8.33333	.023453	.153143	8.50000	8.20000	82/09/27	82/11/29
00403	LAB	PH	SU		2	8.50500	.022110	.148694	8.61000	8.40000	82/09/27	82/12/20
00500	RESIDUE	TOTAL	MG/L		4	1320.75	2075.67	45.5595	1370.00	1268.00	82/09/27	82/12/20
00530	RESIDUE	TOT NFLT	MG/L		4	12.2500	54.9167	7.41058	20.0000	3.00000	82/09/27	82/12/20
00610	NH3+NH4-	N TOTAL	MG/L		3	.053333	.002433	.049329	.110000	.020000	82/09/27	82/12/20
				K	1	.020000			.020000	.020000	82/10/25	82/10/25
				TOT	4	.045000	.001900	.043589	.110000	.020000	82/09/27	82/12/20
00613	NO2-N	DISS	MG/L	K	4	.010000	-.776E-10	.000000	.010000	.010000	82/09/27	82/12/20
00620	NO3-N	TOTAL	MG/L	K	4	.100000	-.248E-08	.000000	.100000	.100000	82/09/27	82/12/20
00625	TOT KJEL	N	MG/L		4	1.15250	.113825	.337380	1.48000	.680000	82/09/27	82/12/20
31616	FEC COLI	MFM-FCBR	/100ML		1	3.00000			3.00000	3.00000	82/10/25	82/10/25
				K	3	7.66667	16.3334	4.04146	10.0000	3.00000	82/09/27	82/12/20
				TOT	4	6.50000	16.3333	4.04145	10.0000	3.00000	82/09/27	82/12/20
70300	RESIDUE	DISS-180	C MG/L		4	1308.50	1639.00	40.4846	1350.00	1265.00	82/09/27	82/12/20
70505	T PO4	P-COL	MG/L		1	.142000			.142000	.142000	82/12/20	82/12/20
70506	SOL PO4-	T P-COL	MG/L		3	.200000	.004836	.069541	.274000	.136000	82/09/27	82/11/29
70507	PHOS-T	ORTHO	MG/L P		4	.139750	.002061	.045397	.206000	.103000	82/09/27	82/12/20

Table IV-7. (continued)

STORET RETRIEVAL DATE 84/06/26 - INVENT - VERSION OF SEP. 1981

46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 CLASS 00 CSN-RSP 0585288-0554052

/TYPA/AMBNT/LAKE

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		6	7.68666	88.9326	9.43041	22.2000	.000000	83/01/24	83/06/29
00011	WATER	TEMP	FAHN		6	45.8333	288.169	16.9756	72.0000	32.0000	83/01/24	83/06/29
00020	AIR	TEMP	CENT		6	6.57333	77.1517	8.78361	19.4000	-.166E+01	83/01/24	83/06/29
00021	AIR	TEMP	FAHN		6	43.8333	250.170	15.8167	67.0000	29.0000	83/01/24	83/06/29
00300	DO		MG/L		6	11.0500	6.44707	2.53911	13.8000	7.00000	83/01/24	83/06/29
00400	PH		SU		1	8.40000			8.40000	8.40000	83/05/25	83/05/25
00403	LAB	PH	SU		3	8.42666	.007416	.086115	8.51000	8.34000	83/02/28	83/06/29
00500	RESIDUE	TOTAL	MG/L		6	1004.00	193243	439.594	1338.00	124.000	83/01/24	83/06/29
00530	RESIDUE	TOT NFLT	MG/L		6	19.5000	150.300	12.2597	36.0000	2.00000	83/01/24	83/06/29
00610	NH3+NH4-	N TOTAL	MG/L		6	.121667	.007137	.084479	.230000	.040000	83/01/24	83/06/29
00613	NO2-N	DISS	MG/L		1	.010000			.010000	.010000	83/06/29	83/06/29
				K	5	.010000	-.582E-10	.000000	.010000	.010000	83/01/24	83/05/25
				TOT	6	.010000	-.931E-10	.000000	.010000	.010000	83/01/24	83/06/29
00620	NO3-N	TOTAL	MG/L		1	.200000			.200000	.200000	83/02/28	83/02/28
				K	5	.100000	-.279E-08	.000000	.100000	.100000	83/01/24	83/06/29
				TOT	6	.116667	.001667	.040825	.200000	.100000	83/01/24	83/06/29
00625	TOT KJEL	N	MG/L		6	1.65500	.625275	.790743	2.87000	.980000	83/01/24	83/06/29
31616	FEC COLI	MFM-FCBR	/100ML		1	80.0000			80.0000	80.0000	83/06/29	83/06/29
				K	5	8.60000	9.80005	3.13050	10.0000	3.00000	83/01/24	83/05/25
				TOT	6	20.5000	857.500	29.2831	80.0000	3.00000	83/01/24	83/06/29
70300	RESIDUE	DISS-180	C MG/L		6	984.500	194625	441.163	1336.00	104.000	83/01/24	83/06/29
70505	T PO4	P-COL	MG/L		5	.295400	.002634	.051322	.376000	.244000	83/02/28	83/06/29
70506	SOL PO4-	T P-COL	MG/L		1	.149000			.149000	.149000	83/01/24	83/01/24
70507	PHOS-T	ORTHO	MG/L P		6	.170833	.003086	.055554	.241000	.096000	83/01/24	83/06/29

Table IV-7. (continued)

719 STORET RETRIEVAL DATE 84/07/30 - INVENT - VERSION OF SEP. 1981
720
721 46WA1A
722 43 31 17.0 096 57 13.0 2
723 WALL LK NR OUTLET T101N R51W SE4 S21
724 46099 SOUTH DAKOTA MINNEHAHA
725 MISSOURI RIVER 090700
726 /TYPA/AMBNT/LAKE BIG SIOUX RIVER
727 21SDLAKE 820107
728 0000 CLASS 00 CSN-RSP 0642869-0653626
729

	PARAMETER				RNK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
730													
731	00010	WATER	TEMP	CENT		4	17.9250	133.709	11.7775	26.7000	.600000	81/02/26	81/08/13
732	00011	WATER	TEMP	FAHN		4	64.2500	450.916	21.2348	80.0000	33.0000	81/02/26	81/08/13
733	00020	AIR	TEMP	CENT		4	17.2250	132.869	11.5269	27.2000	.600000	81/02/26	81/08/13
734	00021	AIR	TEMP	FAHN		4	63.0000	432.666	20.8006	81.0000	33.0000	81/02/26	81/08/13
735	00300	DO		MG/L		4	12.7500	13.2034	3.63364	18.1000	10.1000	81/02/26	81/08/13
736	00400	PH		SU		4	7.90000	.026703	.163419	8.10000	7.70000	81/02/26	81/08/13
737	00530	RESIDUE	TOTAL	MG/L		4	1233.00	405425	636.732	1575.00	279.000	81/02/26	81/08/13
738	00515	RESIDUE	DISS-105 C	MG/L		4	1219.75	399269	631.877	1558.00	273.000	81/02/26	81/08/13
739	00530	RESIDUE	TOT NFLT	MG/L		4	13.2500	24.2500	4.92443	17.0000	6.00000	81/02/26	81/08/13
740	00608	NH3+NH4-	N DISS	MG/L		1	.070000			.070000	.070000	81/02/26	81/02/26
741	00610	NH3+NH4-	N TOTAL	MG/L		3	.183333	.015233	.123423	.320000	.080000	81/07/01	81/08/13
742	00613	NO2-N	DISS	MG/L	K	4	.010000	-.776E-18	.000000	.010000	.010000	81/02/26	81/08/13
743	00618	NO3-N	DISS	MG/L	K	1	.100000			.100000	.100000	81/02/26	81/02/26
744	00620	NO3-N	TOTAL	MG/L	K	3	.100000	-.186E-08	.000000	.100000	.100000	81/07/01	81/08/13
745	00625	TOT KJEL	N	MG/L		4	2.81250	2.14022	1.46295	4.80000	1.43000	81/02/26	81/08/13
746	00671	PHOS-DIS	ORTHO	MG/L P		1	.112000			.112000	.112000	81/02/26	81/02/26
747	31616	FEC COLI	MFM-FCBR	/100ML		1	10.0000			10.0000	10.0000	81/08/13	81/08/13
748					K	2	3.00000	.000000	.000000	3.00000	3.00000	81/02/26	81/07/30
749					TOT	3	5.33333	16.3333	4.04145	10.0000	3.00000	81/02/26	81/08/13
750	70507	T PO4	P-COL	MG/L		1	.132000			.132000	.132000	81/02/26	81/02/26
751	70586	COL PO4-	T P-COL	MG/L		3	.344000	.013033	.114143	.454000	.237000	81/07/01	81/08/13
752	78507	PHOS-T	ORTHO	MG/L P		3	.333666	.014675	.121139	.431000	.198000	81/07/01	81/08/13

753 STORET RETRIEVAL DATE 84/07/30 - INVENT - VERSION OF SEP. 1981

Table IV-8.

```
                                                    46WA2A
                                                    43 31 58.0 096 57 55.0  2
                                                    WALL LK WEST INLET BAY T101N R51W SW4 S21
                                                    46099 SOUTH DAKOTA      MINNEHAHA
                                                    MISSOURI RIVER          060700
                                                    BIG SIOUX RIVER
                                                    2130LAKE  820109
                                                     0000  CLASS 00 OBN-RSP 0642870-0653627
/TYPA/AMBNT/LAKE

PARAMETER                                    RNK   NUMBER     MEAN   VARIANCE STAN DEV MAXIMUM  MINIMUM  BEG DATE END DATE
00011 WATER      TEMP      FAHN                 2   73.0000  0.00000  0.00000  73.0000  73.0000 81/06/15 81/08/27
00020 AIR        TEMP      CENT                 2   22.2500  1.44556  1.20231  23.1000  21.4000 81/06/15 81/08/27
00021 AIR        TEMP      FAHN                 2   68.5000  4.50000  2.12132  70.0000  67.0000 81/06/15 81/08/27
00300 DO                   MG/L                 2   10.6000  30.4201  5.51544  14.5000  6.70000 81/06/15 81/08/27
00400 PH                   SU                   1   7.40000                    7.40000  7.40000 81/08/27 81/08/27
00500 RESIDUE    TOTAL     MG/L                 2   2594.00  2680320  1615.03  3736.00  1452.00 81/06/15 81/08/27
00515 RESIDUE    DISS-105  C MG/L               2   2576.50  2663432  1632.00  3730.00  1422.00 81/06/15 81/08/27
00530 RESIDUE    TOT NFLT  MG/L                 2   1883.00  6845000  2616.30  3730.00  36.0000 81/06/15 81/08/27
00610 NH3-NH4-   N TOTAL   MG/L                 2   1.69500  2.44205  1.56271  2.80000  .590000 81/06/15 81/08/27
00613 NO2-N      DISS      MG/L                 1   .200000                    .200000  .200000 81/06/15 81/06/15
                                               K   1   .010000                    .010000  .010000 81/06/27 81/08/27
                                               TOT 2   .105000  .018050  .134350  .200000  .010000 81/06/15 81/08/27
00620 NO3-N      TOTAL     MG/L                 1   2.50000                    2.50000  2.50000 81/06/15 81/06/15
                                               K   1   .100000                    .100000  .100000 81/08/27 81/08/27
                                               TOT 2   1.30000  2.88000  1.69706  2.50000  .100000 81/06/15 81/06/27
00625 NITR TOT KJEL N          MG/L                 2   5.71000  .124705  .353332  5.96000  5.46000 81/06/15 81/08/27
31616 FEC COLI   MTD-FCBR  /100ML                 2   1131.50  2283385  1511.06  2200.00  63.0000 81/06/15 81/08/27
70508 SOL PO4-   T P-COL   MG/L                 2   .545000  .046513  .215160  .698000  .393000 81/06/15 81/08/27
72507 PHOS-T     ORTHO     MG/L P               2   .347000  .128010  .357796  .600000  .094000 81/06/15 81/08/27
STORET RETRIEVAL DATE 84/07/30  - INVENT - VERSION OF SEP. 1981
```

Table IV-9.

```
                                                    46HA3R
                                                    43 32 18.0 096 57 55.0  2
                                                    WALL LK NR THE NW INLT INLK T101N R51W NW4 S 21
                                                    46099 SOUTH DAKOTA          MINNEHAHA
                                                    MISSOURI RIVER              090700
                                                    BIG SIOUX RIVER
                                                    21SDLAKE  920107
                                                    0000  CLASS 00 CSN-RSP 0642871-0653628
/TYPA/AMBNT/LAKE
```

PARAMETER				RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00011	WATER	TEMP	FAHN		3	62.0000	643.000	25.3574	80.0000	33.0000	81/02/26	81/06/27
00020	AIR	TEMP	CENT		3	16.2767	235.884	15.3324	27.8000	-.110E+01	81/02/26	81/06/27
00021	AIR	TEMP	FAHN		3	61.3333	761.336	27.5923	82.0000	30.0000	81/02/26	81/06/27
00300	DO		MG/L		3	11.2667	32.6432	5.71342	17.6000	6.50000	81/02/26	81/06/27
00400	PH		SU		3	7.43333	.003471	.058918	7.50000	7.40000	81/02/26	81/06/27
00500	RESIDUE	TOTAL	MG/L		3	1451.00	64371.0	253.714	1723.00	1216.00	81/02/26	81/06/27
00515	RESIDUE	DISS-105 C	MG/L		3	1400.33	46207.5	214.959	1610.00	1209.00	81/02/26	81/06/27
00530	RESIDUE	TOT NFLT	MG/L		3	42.6667	3404.34	58.3467	110.000	7.00000	81/02/26	81/06/27
00606	NH3+NH4-	N DISS	MG/L		1	.110000			.110000	.110000	81/02/26	81/02/26
00610	NH3+NH4-	N TOTAL	MG/L		2	.355000	.151250	.388907	.630000	.080000	81/07/01	81/06/27
00613	NO2-N	DISS	MG/L	K	3	.010000	.000000	.000000	.010000	.010000	81/02/26	81/06/27
00618	NO3-N	DISS	MG/L	K	1	.100000			.100000	.100000	81/02/26	81/02/26
00620	NO3-N	TOTAL	MG/L	K	2	.100000	.372E-08	.000000	.100000	.100000	81/07/01	81/06/27
00625	TOT KJEL	N	MG/L		3	2.32667	1.60844	1.26824	3.67000	1.15000	81/02/26	81/06/27
00671	PHOS-DIS	ORTHO	MG/L P		1	.341000			.341000	.341000	81/02/26	81/02/26
31616	FEC COLI	MFM-FCBR	/100ML		1	20.0000			20.0000	20.0000	81/03/27	81/06/27
				K	1	3.00000			3.00000	3.00000	81/02/26	81/02/26
				TOT	2	11.5000	144.500	12.0208	26.0000	3.00000	81/02/26	81/06/27
70506	T PO4	P-COL	MG/L		1	.300000			.300000	.300000	81/02/26	81/02/26
70507	SOL PO4-	T P-COL	MG/L		2	.378000	.061250	.247487	.553000	.203000	81/07/01	81/06/27
71867	PHOS-T	ORTHO	MG/L P		2	.309500	.042540	.206748	.455000	.164000	81/07/01	81/06/27

Table IV-10.

```
817 STORET RETRIEVAL DATE 84/07/30  -  INVENT - VERSION OF SEP. 1981
818                                                                  46JA4A
819                                                                  43 32 21.0 096 57 32.0  2
82P                                                                  WALL LK INLK NR THE NE INLET T101N R51W NE4 S 21
821                                                                  46099 SOUTH DAKOTA        MINNEHAHA
822                                                                  MISSOURI RIVER            090700
823                                                                  BIG SIOUX RIVER
824 /7YPA/AMBNT/LAKE                                                2190LAKE  8C8107
825                                                                  0000 CLASS 00 CBN-RSP 0642872-0653629
826
827
828 PARAMETER                                RNK  NUMBER    MEAN  VARIANCE STAN DEV MAXIMUM  MINIMUM  BEG DATE END DATE
829 00010  WATER      TEMP       CENT            1  21.1000                          21.1000  21.1000 81/07/30 81/07/30
830 00011  WATER      TEMP       FAHN            3  70.0000  7.00000  2.64575  70.0000  70.0000 81/06/15 81/08/13
831 00020  AIR        TEMP       CENT            3  20.7667  .083704  .289401  21.1000  20.6000 81/06/15 81/08/13
832 00021  AIR        TEMP       FAHN            3  69.3333  .335937  .579431  70.0000  69.0000 81/06/15 81/08/13
833 00300  DO         DO         MG/L            3  13.9333  38.1736  6.17648  20.6000  8.40000 81/06/15 81/08/13
834 00400  PH         PH         SU              2  7.70000  .000000  .000000  7.70000  7.70000 81/07/30 81/08/13
835 00500  RESIDUE    TOTAL      MG/L            3  1618.00  15769.0  125.575  1739.00  1487.00 81/06/15 81/08/13
836 00515  RESIDUE    DISS-105   C MG/L          3  1551.67  7316.09  85.5338  1638.00  1467.00 81/06/15 81/08/13
837 00530  RESIDUE    TOT NFLT   MG/L            3  58.3333  1698.34  40.1041  100.000  20.0000 81/06/15 81/08/13
838 00610  NH3-N      N TOTAL    MG/L            3  .206667  .026133  .161653  .380000  .060000 81/06/15 81/08/13
839 00613  NO2-N      DISS       MG/L    K       3  .010000  .000000  .000000  .010000  .010000 81/06/15 81/08/13
840 00630  NO3-N      TOTAL      MG/L    K       3  .100000-.136E-08  .000000  .100000  .100000 81/06/15 81/08/13
841 00625  TOT KJEL   N          MG/L            3  4.63333  9.01204  3.00201  7.57000  1.57000 81/06/15 81/08/13
842 31616  FEC COLI   MPN-FCBR   /100ML          2  83.0000  450.000  21.2132  166.000  76.0000 81/06/15 81/07/30
843                               K       1  10.0000                          10.0000  10.0000 81/08/13 81/08/13
844                               TOT     3  60.0000  2100.00  45.8258  100.000  10.0000 81/06/15 81/08/13
845 70500  T-PO4      P-COL      MG/L            1  .522000                          .522000  .522000 81/08/13 81/08/13
846 70507  SOL PO4-   T P-COL    MG/L            2  .454000  .002312  .048063  .488000  .420000 81/06/15 81/07/30
847 70507  PHOS-T     ORTHO      MG/L P          3  .349667  .017632  .132787  .445000  .198000 81/06/15 81/08/13
848 STORET RETRIEVAL DATE 84/07/30  -  INVENT - VERSION OF SEP. 1981
```

Table IV-11.

STORET RETRIEVAL DATE 84/06/26 - STAND - VERSION OF APR. 1983 STN 1.SUMMARY.1

46WA01
43 31 44.0 096 57 10.0 2
WALL LAKE OUTLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593324-0621719

/TYPA/AMBNT/STREAM/RUNOFF

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 79/03/30 TO 83/06/29

	00300 DO MG/L	00400 PH SU	31616 FEC COLI MPN-FCBR /100ML	70300 RESIDUE DISS-180 C MG/L	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00620 NO3-N TOTAL MG/L	00619 UN-IONZD NH3-NH3 MG/L	00011 WATER TEMP FAHN	70505 T PO4 P-COL MG/L
NO OF VALUES	27	22	26	7	28	27	27	21	28	28
MEAN	9.970	8.373	332.0	991.	10.88	0.2693	0.44	0.0389	50.29	0.512
MEDIAN	9.200	8.400	8.5	1122.	10.00	0.2100	0.10	0.0079	48.00	0.496
NO OF VIOLS	1	13	3	0	0	22	0	1	0	28
PERCENT VIOL	4.	59.	12.	0.	0.	81.	0.	5.	0.	100.
MINIMUM VIOL	3.300	8.400	500.0	0.	0.0	0.0500	0.0	0.4733	0.0	0.288
MEAN VIOL	3.300	8.731	2700.0	0.	0.0	0.3250	0.0	0.4733	0.0	0.512
MAXIMUM VIOL	3.300	10.000	5600.0	0.	0.0	1.5000	0.0	0.4733	0.0	0.926
MIN CRITERIA	4.000	6.500	********	********	********	********	********	********	********	********
MAX CRITERIA********		8.500	200.0	2500.	90.00	0.0400	50.00	0.0500	90.00	0.100

Table IV-12.

STORET RETRIEVAL DATE 84/06/26 - STAND - VERSION OF APR. 1983 STN 2.SUMMARY.1

46WA02
43 31 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593325-0621720

/TYPA/AMBNT/STREAM/RUNOFF

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 79/03/22 TO 83/06/29

	00300 DO MG/L	00400 PH SU	31616 FEC COLI MPN-FCBR /100ML	70300 RESIDUE DISS-180 C MG/L	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00620 NO3-N TOTAL MG/L	00619 UN-IONZD NH3-NH3 MG/L	00011 WATER TEMP FAHN	70505 T PO4 P-COL MG/L
NO OF VALUES	34	27	33	11	36	31	34	21	37	35
MEAN	9.091	7.600	2257.3	964.	15.21	0.3458	0.37	0.0156	47.78	0.722
MEDIAN	9.350	7.700	53.0	1048.	8.25	0.0500	0.10	0.0006	44.00	0.648
NO OF VIOLS	5	2	13	0	1	18	0	1	0	35
PERCENT VIOL	15.	7.	39.	0.	3.	58.	0.	5.	0.	100.
MINIMUM VIOL	0.0	6.200	210.0	0.	110.00	0.0500	0.0	0.2992	0.0	0.132
MEAN VIOL	1.620	7.700	5688.5	0.	110.00	0.5772	0.0	0.2992	0.0	0.722
MAXIMUM VIOL	3.500	9.200	23000.0	0.	110.00	3.0800	0.0	0.2992	0.0	1.950
MIN CRITERIA	4.000	6.500	********	********	********	********	********	********	********	********
MAX CRITERIA	********	8.300	200.0	2500.	90.00	0.0400	50.00	0.0500	90.00	0.100

Table IV-13.

STORET RETRIEVAL DATE 84/06/26 - STAND - VERSION OF APR. 1983 STN 3.SUMMARY.1

46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593326-0621721

/TYPA/AMBNT/STREAM/RUNOFF

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 79/03/22 TO 83/03/03

	00300 DO MG/L	00400 PH SU	31616 FEC COLI MPN-FCBR /100ML	70300 RESIDUE DISS-180 C MG/L	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00620 NO3-N TOTAL MG/L	00619 UN-IONZD NH3-NH3 MG/L	00011 WATER TEMP FAHN	70505 T PO4 P-COL MG/L
NO OF VALUES	34	30	31	4	34	31	29	27	34	32
MEAN	10.288	7.747	1068.2	344.	17.50	0.1316	0.53	0.0015	53.76	0.363
MEDIAN	10.200	7.800	10.0	353.	10.00	0.0600	0.10	0.0008	58.50	0.270
NO OF VIOLS	0	0	8	0	1	17	0	0	0	32
PERCENT VIOL	0.	0.	26.	0.	3.	55.	0.	0.	0.	100.
MINIMUM VIOL	0.0	0.0	270.0	0.	126.00	0.0500	0.0	0.0	0.0	0.187
MEAN VIOL	0.0	0.0	4051.2	0.	126.00	0.2206	0.0	0.0	0.0	0.363
MAXIMUM VIOL	0.0	0.0	12000.0	0.	126.00	0.7200	0.0	0.0	0.0	1.600
MIN CRITERIA	4.000	6.500	********	********	********	********	********	********	********	********
MAX CRITERIA	********	8.300	200.0	2500.	90.00	0.0400	50.00	0.0500	90.00	0.100

Table IV-14.

STORET RETRIEVAL DATE 84/06/26 - STAND - VERSION OF APR. 1983 STN 4.SUMMARY.1

46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593327-0621722

/TYPA/AMBNT/STREAM/RUNOFF

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 79/03/20 TO 83/03/10

	00300 DO MG/L	00400 PH SU	31616 FEC COLI MFM-FCBR /100ML	70300 RESIDUE DISS-180 C MG/L	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00620 NO3-N TOTAL MG/L	00619 UN-IONZD NH3-NH3 MG/L	00011 WATER TEMP FAHN	70505 T PO4 P-COL MG/L
NO OF VALUES	27	21	25	7	28	24	23	17	28	25
MEAN	7.104	7.495	586.0	638.	27.52	0.5412	0.57	0.0015	45.86	0.819
MEDIAN	9.500	7.700	10.0	691.	15.50	0.2450	0.10	0.0008	42.00	0.590
NO OF VIOLS	7	0	8	0	1	17	0	0	0	25
PERCENT VIOL	26.	0.	32.	0.	4.	71.	0.	0.	0.	100.
MINIMUM VIOL	0.0	0.0	220.0	0.	310.00	0.1000	0.0	0.0	0.0	0.231
MEAN VIOL	1.214	0.0	1792.5	0.	310.00	0.7529	0.0	0.0	0.0	0.819
MAXIMUM VIOL	3.600	0.0	10000.0	0.	310.00	1.9300	0.0	0.0	0.0	2.440
MIN CRITERIA	4.000	6.500	*********	*********	*********	*********	*********	*********	*********	*********
MAX CRITERIA	*********	8.300	200.0	2500.	90.00	0.0400	50.00	0.0500	90.00	0.100

Table IV-15.

STORET RETRIEVAL DATE 84/06/26 - STAND - VERSION OF APR. 1983 STN 5.SUMMARY.1

46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585287-0554051

/TYPA/AMBNT/LAKE

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 79/04/19 TO 83/06/29

	00300 DO MG/L	00400 PH SU	31616 FEC COLI MPN-FCBR /100ML	70300 RESIDUE DISS-180 C MG/L	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00620 NO3-N TOTAL MG/L	00619 UN-IONZD NH3-NH3 MG/L	00011 WATER TEMP FAHN	70505 T PO4 P-COL MG/L
NO OF VALUES	28	19	28	10	28	26	24	17	27	23
MEAN	10.379	8.474	24.2	1196.	19.55	0.1469	0.21	0.0113	54.30	0.582
MEDIAN	9.800	8.500	4.5	1271.	10.00	0.0900	0.10	0.0102	60.00	0.600
NO OF VIOLS	0	13	0	0	0	21	0	0	0	23
PERCENT VIOL	0.	68.	0.	0.	0.	81.	0.	0.	0.	100.
MINIMUM VIOL	0.0	8.400	0.0	0.	0.0	0.0500	0.0	0.0	0.0	0.163
MEAN VIOL	0.0	8.692	0.0	0.	0.0	0.1752	0.0	0.0	0.0	0.582
MAXIMUM VIOL	0.0	9.000	0.0	0.	0.0	0.7000	0.0	0.0	0.0	0.749
MIN CRITERIA	4.000	6.500	*********	*********	*********	*********	*********	*********	*********	*********
MAX CRITERIA	*********	8.300	200.0	2500.	90.00	0.0400	50.00	0.0500	90.00	0.100

Table IV-16.

STORET RETRIEVAL DATE 84/06/26 - STAND - VERSION OF APR. 1983 STN 6.SUMMARY.1

46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585288-0554052

/TYPA/AMBNT/LAKE

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 79/05/03 TO 83/06/29

	00300 DO MG/L	00400 PH SU	31616 FEC COLI MFM-FCBR /100ML	70300 RESIDUE DISS-180 C MG/L	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00620 NO3-N TOTAL MG/L	00619 UN-IONZD NH3-NH3 MG/L	00011 WATER TEMP FAHN	70505 T P04 P-COL MG/L
NO OF VALUES	25	19	25	10	26	26	25	19	26	22
MEAN	10.980	8.416	9.8	1114.	12.48	0.1438	0.13	0.0235	51.54	0.528
MEDIAN	10.500	8.500	10.0	1210.	12.50	0.1150	0.10	0.0063	53.50	0.569
NO OF VIOLS	0	12	0	0	0	19	0	1	0	22
PERCENT VIOL	0.	63.	0.	0.	0.	73.	0.	5.	0.	100.
MINIMUM VIOL	0.0	8.400	0.0	0.	0.0	0.0600	0.0	0.3050	0.0	0.142
MEAN VIOL	0.0	8.683	0.0	0.	0.0	0.1863	0.0	0.3050	0.0	0.528
MAXIMUM VIOL	0.0	9.100	0.0	0.	0.0	0.8300	0.0	0.3050	0.0	0.770
MIN CRITERIA	4.000	6.500	*********	*********	*********	*********	*********	*********	*********	*********
MAX CRITERIA	*********	8.300	200.0	2500.	90.00	0.0400	50.00	0.0500	90.00	0.100

Table IV-17.

STORET RETRIEVAL DATE 84/06/26 - STAND - VERSION OF APR. 1983 STN 7.SUMMARY.1

46WA1A
43 31 17.0 096 57 13.0 2
WALL LK NR OUTLET T101N R51W SE4 S21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 820109
0000 FEET DEPTH CLASS 00 CSN-RSP 0642869-0653626

/TYPA/AMBNT/LAKE

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 81/02/26 TO 81/08/13

	00300 DO MG/L	00400 PH SU	31616 FEC COLI MFM-FCBR /100ML	70300 RESIDUE DISS-180 C MG/L	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00620 NO3-N TOTAL MG/L	00619 UN-IONZD NH3-NH3 MG/L	00011 WATER TEMP FAHN	70505 T PO4 P-COL MG/L
NO OF VALUES	4	4	3	0	4	3	3	3	4	1
MEAN	12.750	7.900	5.3	0.	13.25	0.1833	0.10	0.0073	64.25	0.132
MEDIAN	11.400	7.900	3.0	*********	15.00	0.1500	0.10	0.0047	72.00	0.132
NO OF VIOLS	0	0	0	0	0	3	0	0	0	1
PERCENT VIOL	0.	0.	0.	0.	0.	100.	0.	0.	0.	100.
MINIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.0800	0.0	0.0	0.0	0.132
MEAN VIOL	0.0	0.0	0.0	0.	0.0	0.1833	0.0	0.0	0.0	0.132
MAXIMUM VIOL	0.0	0.0	0.0	0.	0.0	0.3200	0.0	0.0	0.0	0.132
MIN CRITERIA	4.000	6.500	*********	*********	*********	*********	*********	*********	*********	*********
MAX CRITERIA	*********	8.300	200.0	2500.	90.00	0.0400	50.00	0.0500	90.00	0.100

Table IV-18.

STORET RETRIEVAL DATE 84/06/26 - STAND - VERSION OF APR. 1983 STN 8.SUMMARY.1

46WA2A
43 31 58.0 096 57 55.0 2
WALL LK WEST INLET BAY T101N R51W SW4 S21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 820109
0000 FEET DEPTH CLASS 00 CSN-RSP 0642870-0653627

/TYPA/AMBNT/LAKE

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 81/06/15 TO 81/08/27

	00300 DO MG/L	00400 PH SU	31616 FEC COLI MPN-FCBR /100ML	70300 RESIDUE DISS-180 C MG/L	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00620 NO3-N TOTAL MG/L	00619 UN-IONZD NH3-NH3 MG/L	00011 WATER TEMP FAHN	70505 T PO4 P-COL MG/L
NO OF VALUES	2	1	2	0	2	2	2	1	2	0
MEAN	10.000	7.400	1131.5	0.	1880.00	1.6950	1.30	0.0378	73.00	0.0
MEDIAN	10.000	7.400	1131.5	*********	1880.00	1.6950	1.30	0.0378	73.00	*********
NO OF VIOLS	0	0	1	0	1	2	0	0	0	0
PERCENT VIOL	0.	0.	50.	0.	50.	100.	0.	0.	0.	0.
MINIMUM VIOL	0.0	0.0	2200.0	0.	3730.00	0.5900	0.0	0.0	0.0	0.0
MEAN VIOL	0.0	0.0	2200.0	0.	3730.00	1.6950	0.0	0.0	0.0	0.0
MAXIMUM VIOL	0.0	0.0	2200.0	0.	3730.00	2.8000	0.0	0.0	0.0	0.0
MIN CRITERIA	4.000	6.500	*********	*********	*********	*********	*********	*********	*********	*********
MAX CRITERIA	*********	8.300	200.0	2500.	90.00	0.0400	50.00	0.0500	90.00	0.100

Table IV-19.

STORET RETRIEVAL DATE 84/06/26 - STAND - VERSION OF APR. 1983 STN 9.SUMMARY.1

46WA3A
43 32 18.0 096 57 55.0 2
WALL LK NR THE NW INLT INLK,T101N R51W NW4 S 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 820109
0000 FEET DEPTH CLASS 00 CSN-RSP 0642871-0653626

/TYPA/AMBNT/LAKE

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 81/02/26 TO 81/08/27

	00300 DO MG/L	00400 PH SU	31616 FEC COLI MFM-PCBR /100ML	70300 RESIDUE DISS-180 C MG/L	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00620 NO3-N TOTAL MG/L	00619 UN-IONZD NH3-NH3 MG/L	00011 WATER TEMP FAHN	70505 T PO4 P-COL MG/L
NO OF VALUES	3	3	2	0	3	2	2	2	3	1
MEAN	11.267	7.433	11.5	0.	42.67	0.3550	0.10	0.0056	62.00	0.380
MEDIAN	9.700	7.400	11.5 *********		11.00	0.3550	0.10	0.0056	73.00	0.380
NO OF VIOLS	0	0	0	0	1	2	0	0	0	1
PERCENT VIOL	0.	0.	0.	0.	33.	100.	0.	0.	0.	100.
MINIMUM VIOL	0.0	0.0	0.0	0.	110.00	0.0800	0.0	0.0	0.0	0.380
MEAN VIOL	0.0	0.0	0.0	0.	110.00	0.3550	0.0	0.0	0.0	0.380
MAXIMUM VIOL	0.0	0.0	0.0	0.	110.00	0.6300	0.0	0.0	0.0	0.380
MIN CRITERIA	4.000	6.500 *********	*********	*********	*********	*********	*********	*********	*********	*********
MAX CRITERIA**********		8.300	200.0	2500.	90.00	0.0400	50.00	0.0500	90.00	0.100

Table IV-20.

STORET RETRIEVAL DATE 84/06/26 - STAND - VERSION OF APR. 1983 STN 10.SUMMARY.1

46wA4A
43 32 21.0 096 57 32.0 2
WALL LK INLK NR THE NE INLET T101N R51W NE4 S 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 820109
0000 FEET DEPTH CLASS 00 CSN-RSP 0642872-0653629

/TYPA/AMBNT/LAKE

SUMMARY OF VIOLATIONS ON SAMPLES COLLECTED FROM 81/06/15 TO 81/08/13

	00300 DO MG/L	00400 PH SU	31616 FEC COLI MFM-FCBR /100ML	70300 RESIDUE DISS-180 C MG/L	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00620 NO3-N TOTAL MG/L	00619 UN-IONZD NH3-NH3 MG/L	00011 WATER TEMP FAHN	70505 T PO4 P-COL MG/L
NO OF VALUES	3	2	3	0	3	3	3	2	3	1
MEAN	13.933	7.700	60.0	0.	58.33	0.2067	0.10	0.0076	73.00	0.522
MEDIAN	12.800	7.700	70.0	*********	55.00	0.1800	0.10	0.0076	74.00	0.522
NO OF VIOLS	0	0	0	0	1	3	0	0	0	1
PERCENT VIOL	0.	0.	0.	0.	33.	100.	0.	0.	0.	100.
MINIMUM VIOL	0.0	0.0	0.0	0.	100.00	0.0600	0.0	0.0	0.0	0.522
MEAN VIOL	0.0	0.0	0.0	0.	100.00	0.2067	0.0	0.0	0.0	0.522
MAXIMUM VIOL	0.0	0.0	0.0	0.	100.00	0.3800	0.0	0.0	0.0	0.522
MIN CRITERIA	4.000	6.500	*********	*********	*********	*********	*********	*********	*********	*********
MAX CRITERIA	*********	8.300	200.0	2500.	90.00	0.0400	50.00	0.0500	90.00	0.100

Table IV-21.

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
STATION=21SDLAKE 46WA01					
ORGN	20	1.910	0.331	1.580	2.790
INORGN	19	0.810	0.827	0.130	3.030
STATION=21SDLAKE 46WA02					
ORGN	19	1.668	0.266	1.260	2.190
INORGN	18	0.306	0.384	0.130	1.660
STATION=21SDLAKE 46WA03					
ORGN	27	1.365	0.561	0.780	3.390
INORGN	23	0.504	0.564	0.130	2.030
STATION=21SDLAKE 46WA04					
ORGN	17	2.224	0.635	1.550	4.460
INORGN	15	0.660	0.883	0.130	2.830
STATION=21SDLAKE 46WA05					
ORGN	14	1.969	0.367	1.430	2.530
INORGN	13	0.358	0.239	0.130	0.890
STATION=21SDLAKE 46WA06					
ORGN	13	1.823	0.294	1.280	2.330
INORGN	13	0.314	0.227	0.130	0.940

Table IV-22.

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
STATION=21SDLAKE 46WA05					
ORGN	3	1.423	0.565	0.850	1.980
INORGN	2	0.535	0.205	0.390	0.680
STATION=21SDLAKE 46WA06					
ORGN	3	2.083	0.350	1.690	2.360
INORGN	2	0.410	0.085	0.350	0.470

Table IV-23.

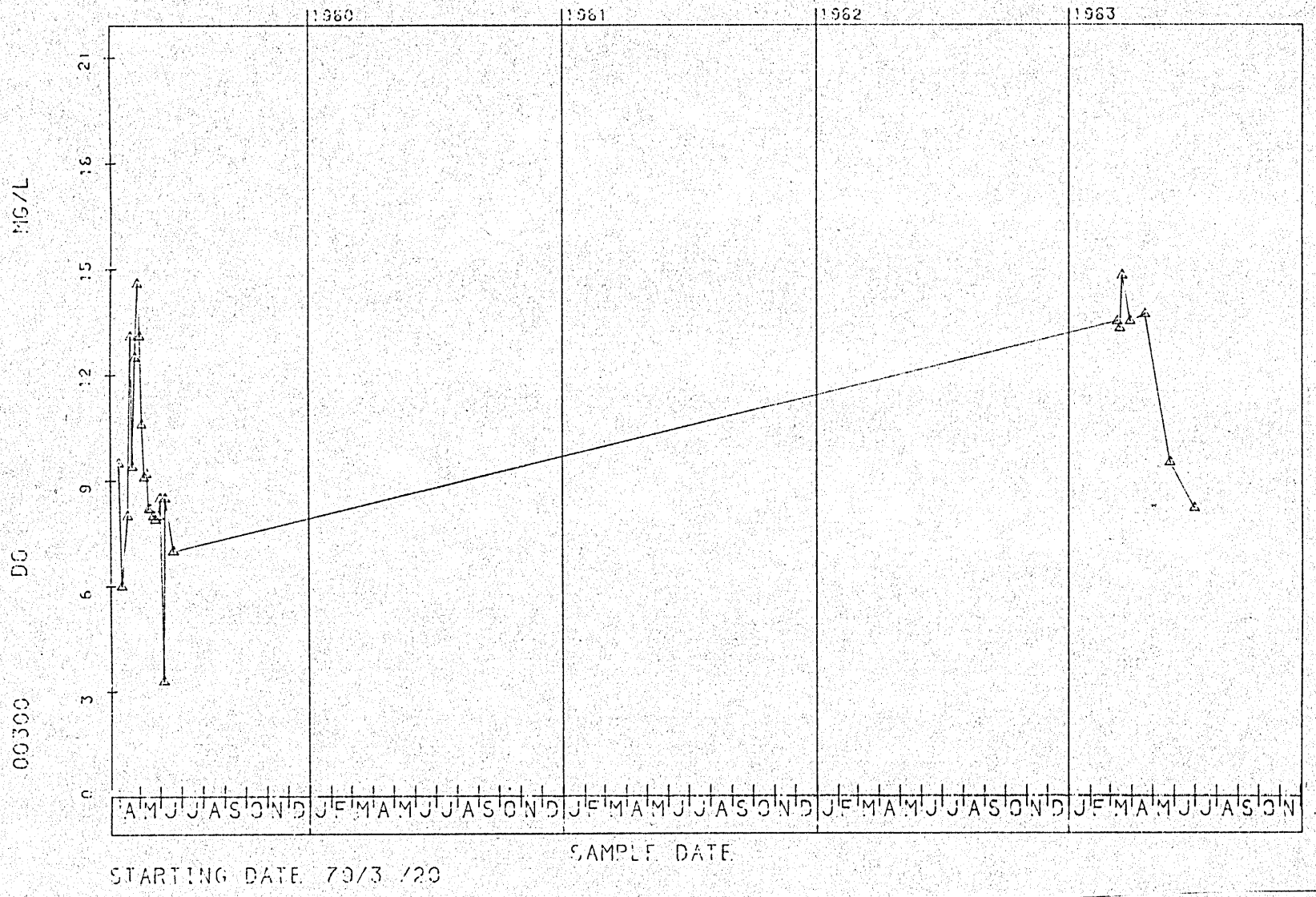
VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
STATION=21SDLAKE 46WA02					
ORGN	1	6.730	.	6.730	6.730
INORGN	1	1.770	.	1.770	1.770
STATION=21SDLAKE 46WA03					
ORGN	2	1.665	0.587	1.250	2.080
INORGN	2	1.620	0.156	1.510	1.730
STATION=21SDLAKE 46WA04					
ORGN	2	2.065	0.049	2.030	2.100
INORGN	2	2.985	0.587	2.570	3.400
STATION=21SDLAKE 46WA05					
ORGN	5	1.012	0.159	0.860	1.280
INORGN	5	0.162	0.019	0.140	0.190
STATION=21SDLAKE 46WA06					
ORGN	4	1.107	0.309	0.660	1.370
INORGN	4	0.155	0.044	0.130	0.220

Table IV-24.

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
STATION=21SDLAKE 46WA01					
ORGN	7	1.341	0.566	1.000	2.560
INORGN	7	0.236	0.104	0.160	0.420
STATION=21SDLAKE 46WA02					
ORGN	11	1.365	0.801	0.370	3.280
INORGN	11	1.051	1.211	0.150	3.890
STATION=21SDLAKE 46WA03					
ORGN	2	0.930	0.099	0.860	1.000
INORGN	2	0.770	0.127	0.680	0.860
STATION=21SDLAKE 46WA04					
ORGN	5	1.218	0.442	0.890	1.970
INORGN	5	1.630	0.715	0.840	2.670
STATION=21SDLAKE 46WA05					
ORGN	4	1.630	0.130	1.510	1.810
INORGN	4	0.557	0.643	0.160	1.510
STATION=21SDLAKE 46WA06					
ORGN	6	1.533	0.746	0.940	2.640
INORGN	6	0.248	0.113	0.150	0.430

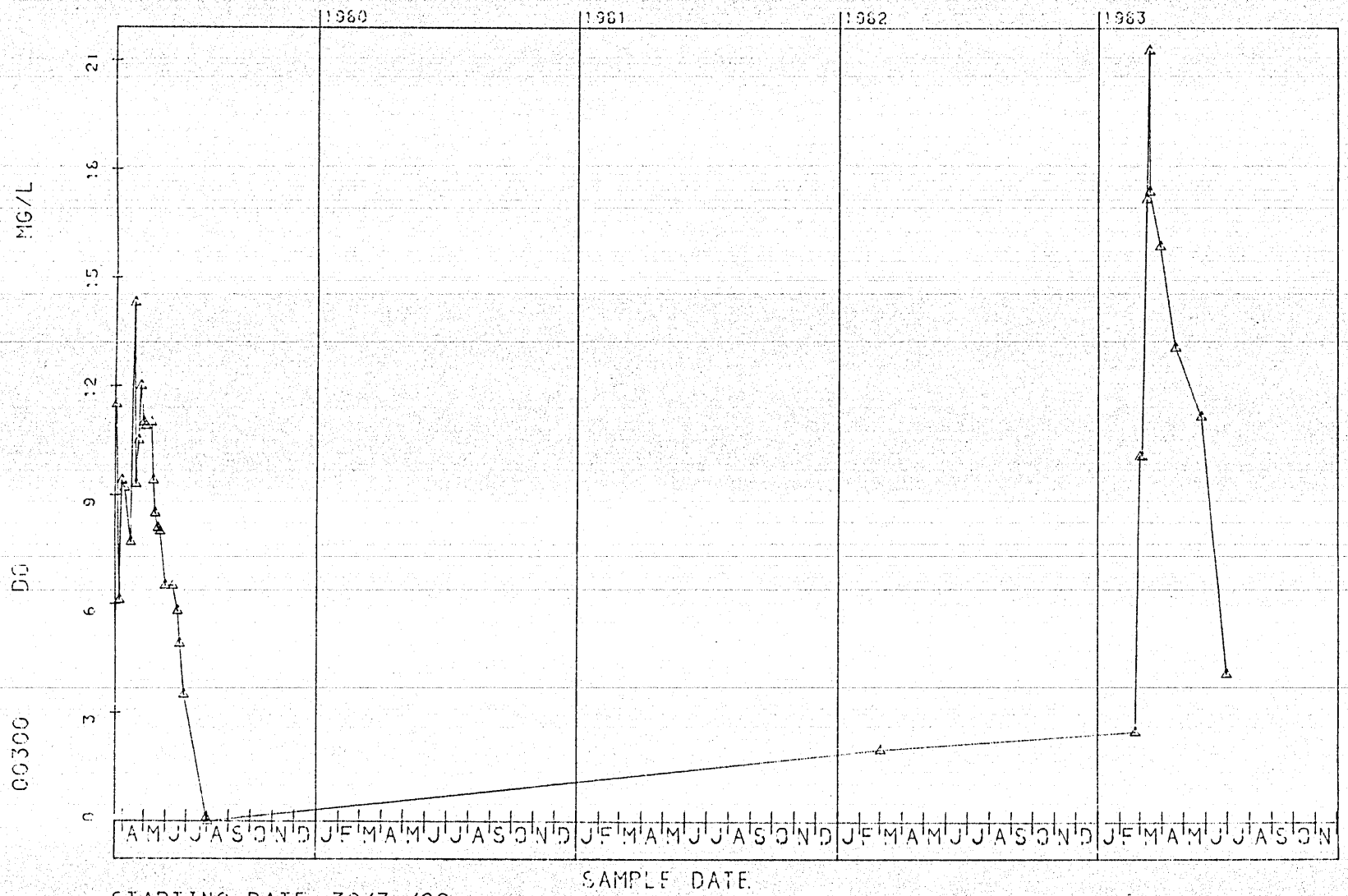
Table IV-25.

Figure IV-1.


46WA01
43 31 44.0 096 57 10.0 2
WALL LAKE OUTLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 000700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593324-0621719
1980
1981
1982
1983
MG/L
DO
00300
0
3
6
9
12
15
18
21
AMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASON
SAMPLE DATE
STARTING DATE 79/3 /20

46WA02
43 31 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0503325-0621720

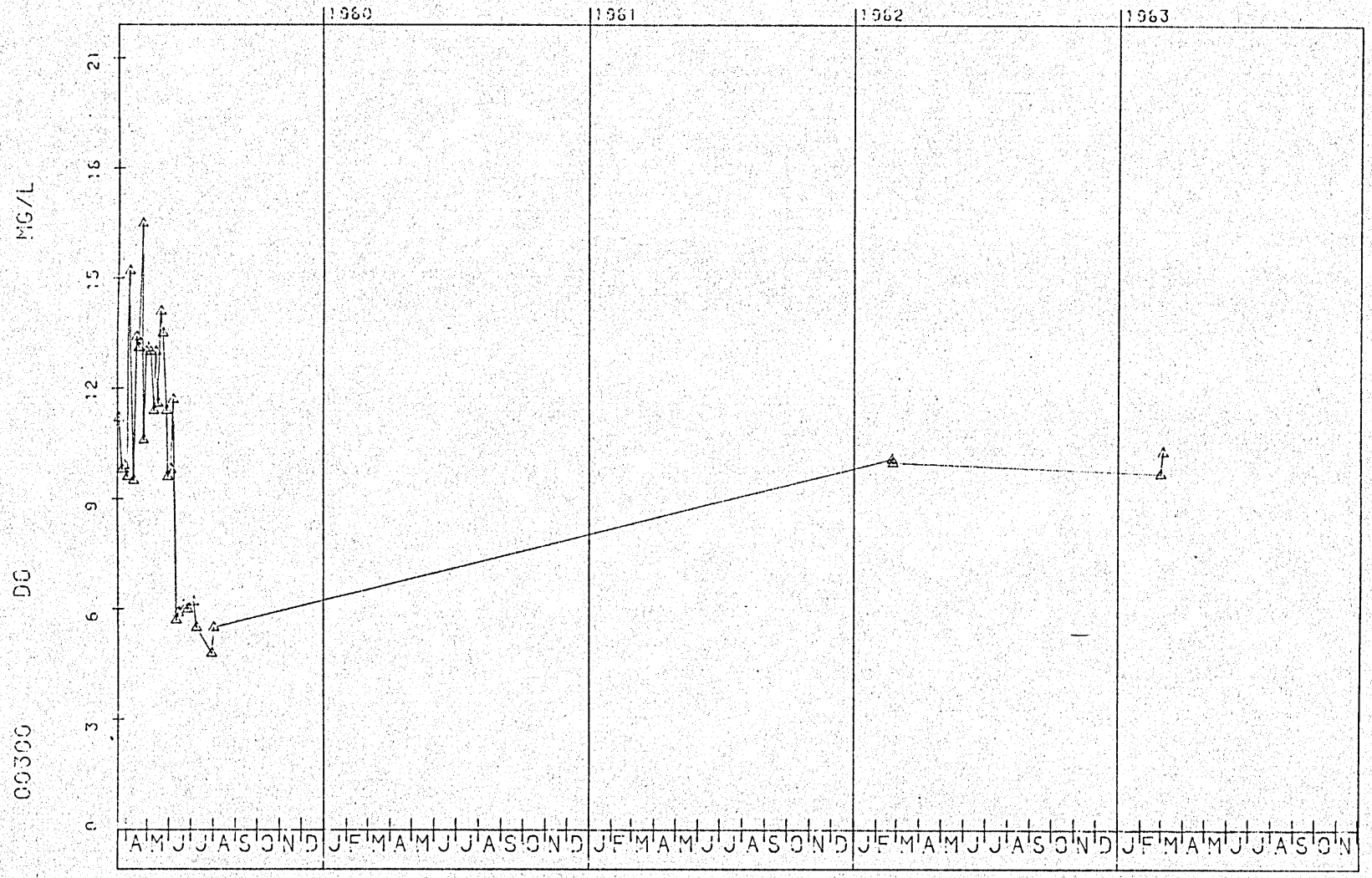
Figure IV-2.



STARTING DATE 79/3 /20

STORET
46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 OSN-RSP 0593326-0621721

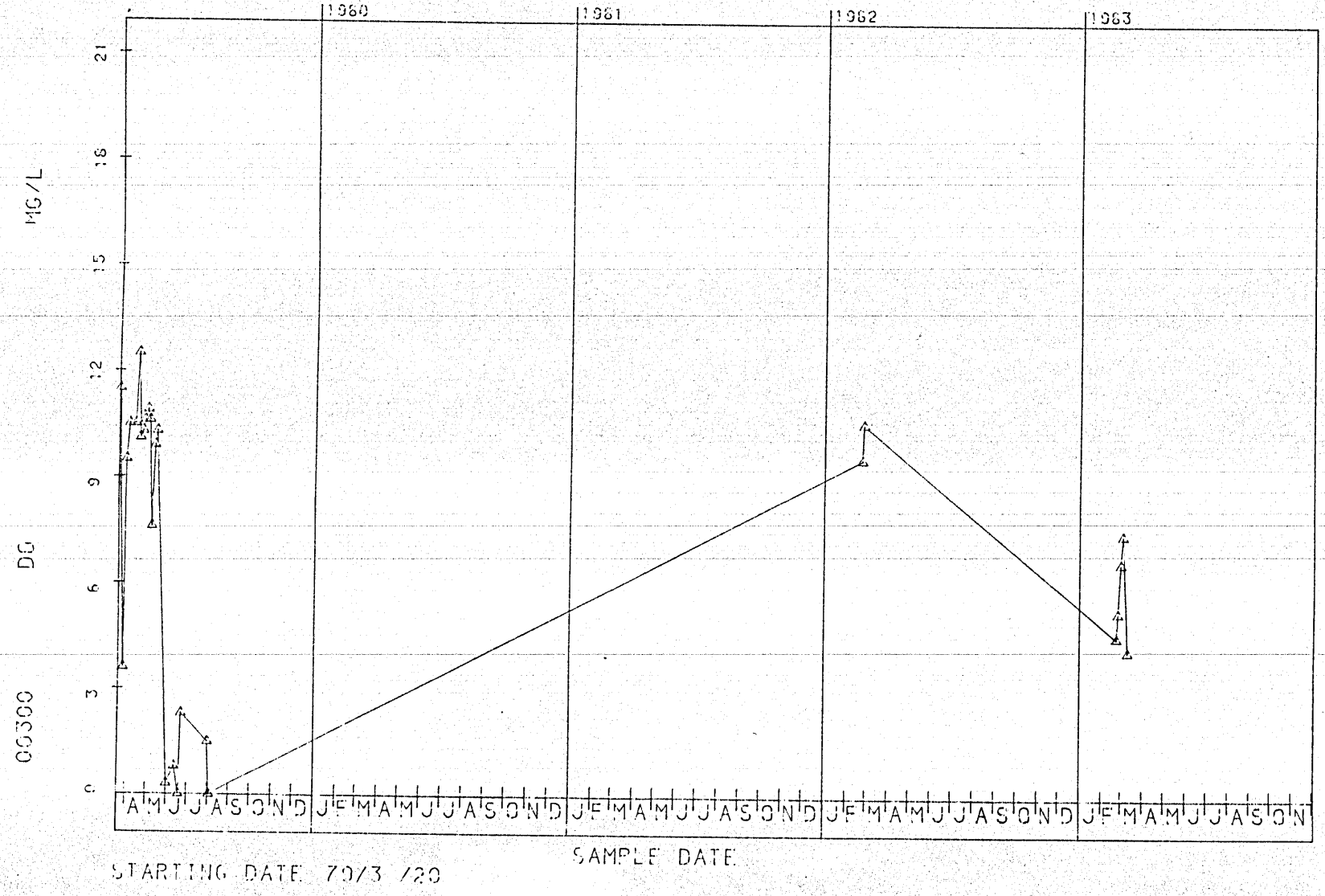
Figure IV-3.



STARTING DATE 79/3 /20

46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593327-0621722

Figure IV-4.



STARTING DATE 7073 /20

Figure IV-5.

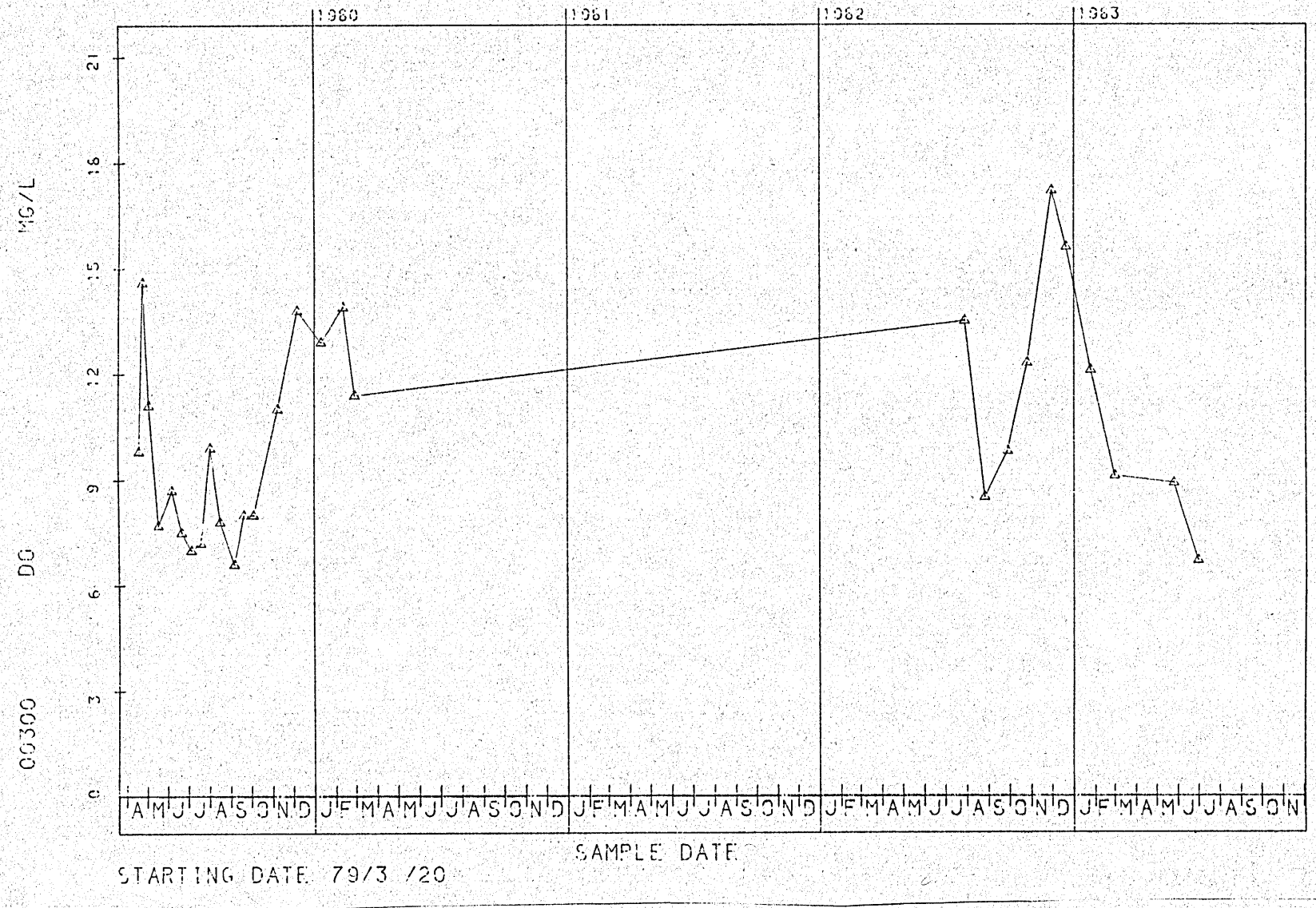
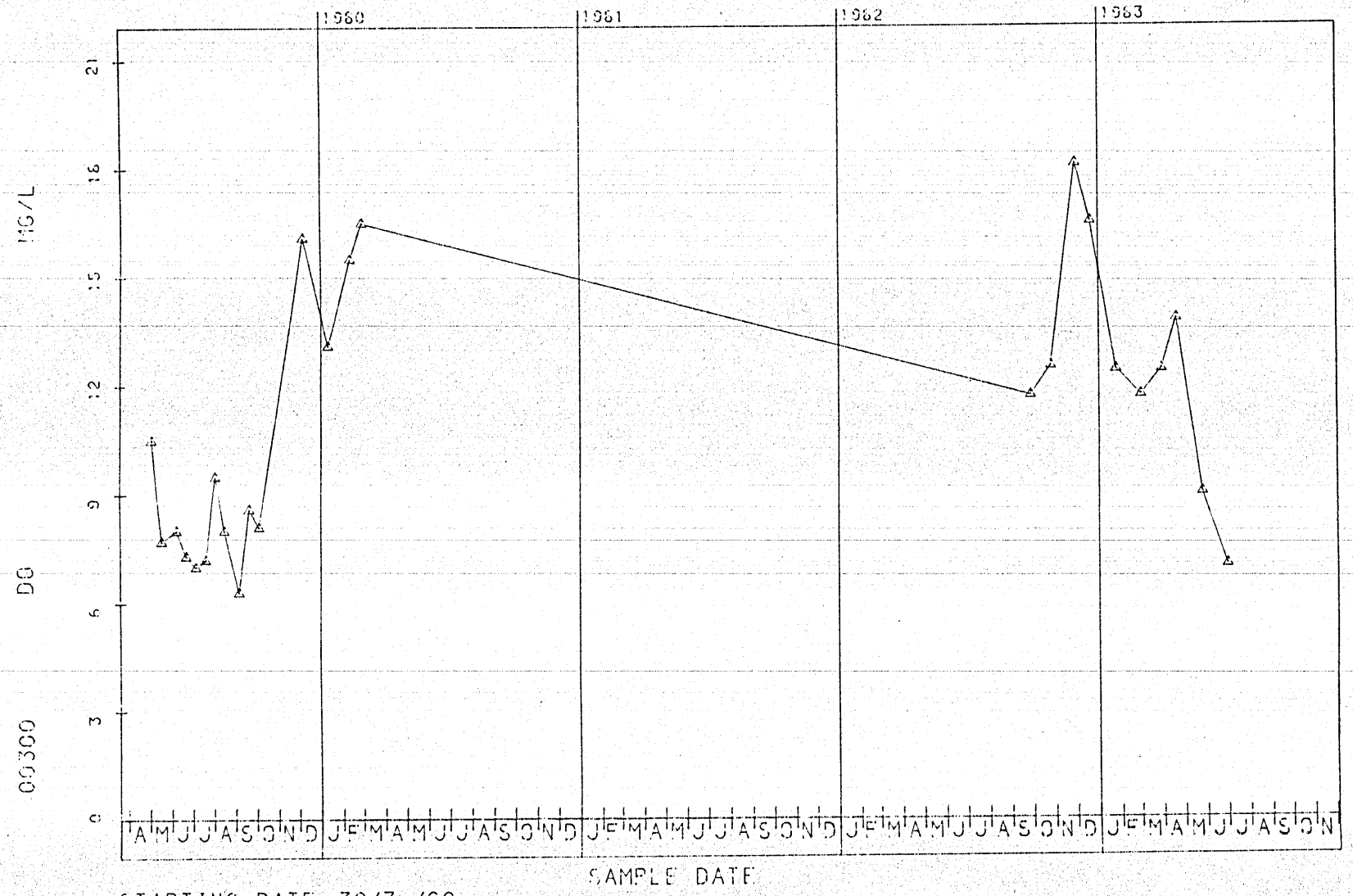

46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585287-0554051
1980
1981
1982
1983
MG/L
DO
00300
0
3
6
9
12
15
18
21
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N
SAMPLE DATE
STARTING DATE 79/3 /20

Figure IV-6.


46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585288-0554052
1960
1961
1962
1963
MG/L
DO
00300
0
3
6
9
12
15
18
21
SAMPLE DATE
STARTING DATE 79/3 /20

46WA01
43 31 44.0 096 57 10.0 2
WALL LAKE OUTLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0503324-0621719

Figure IV-7.

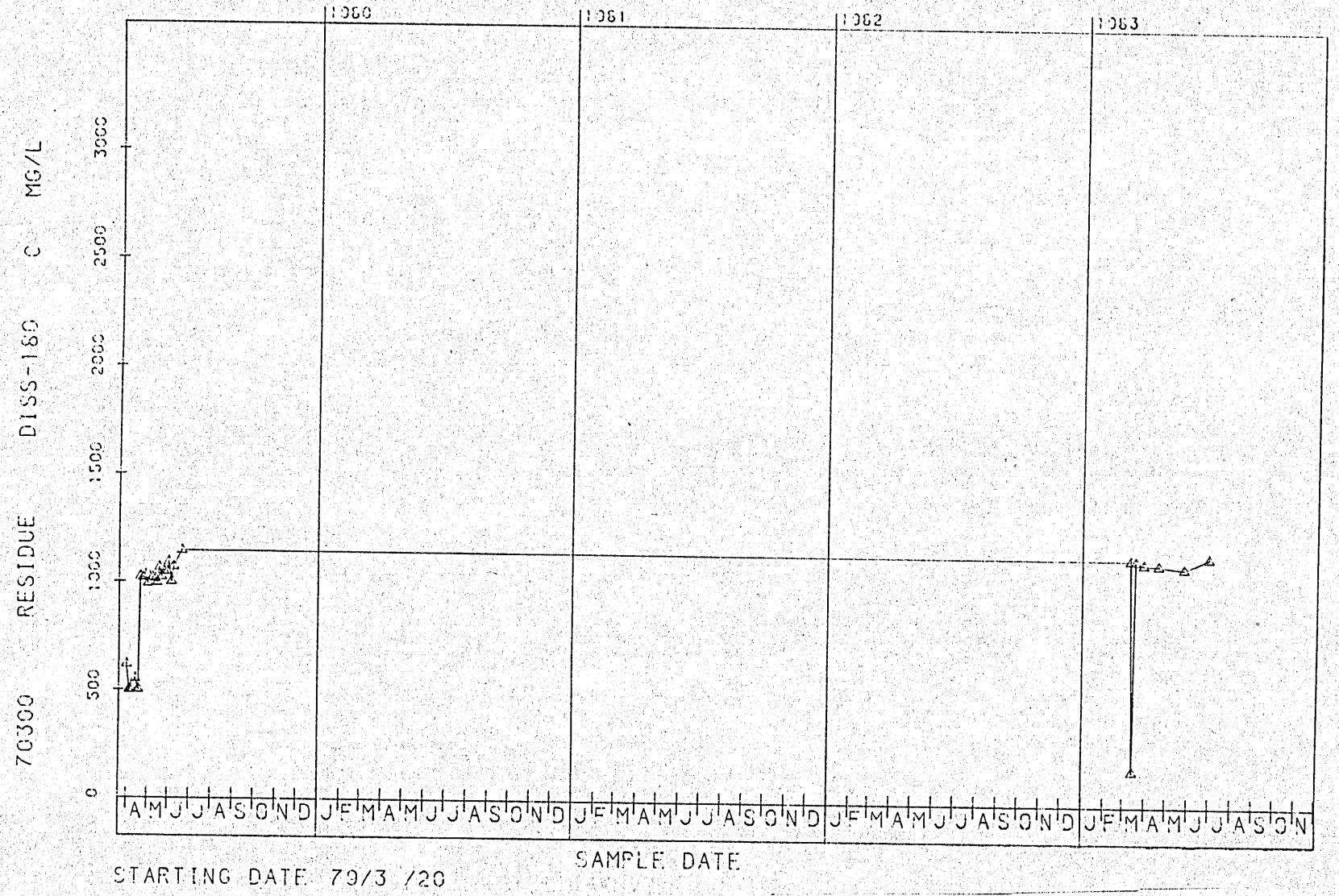
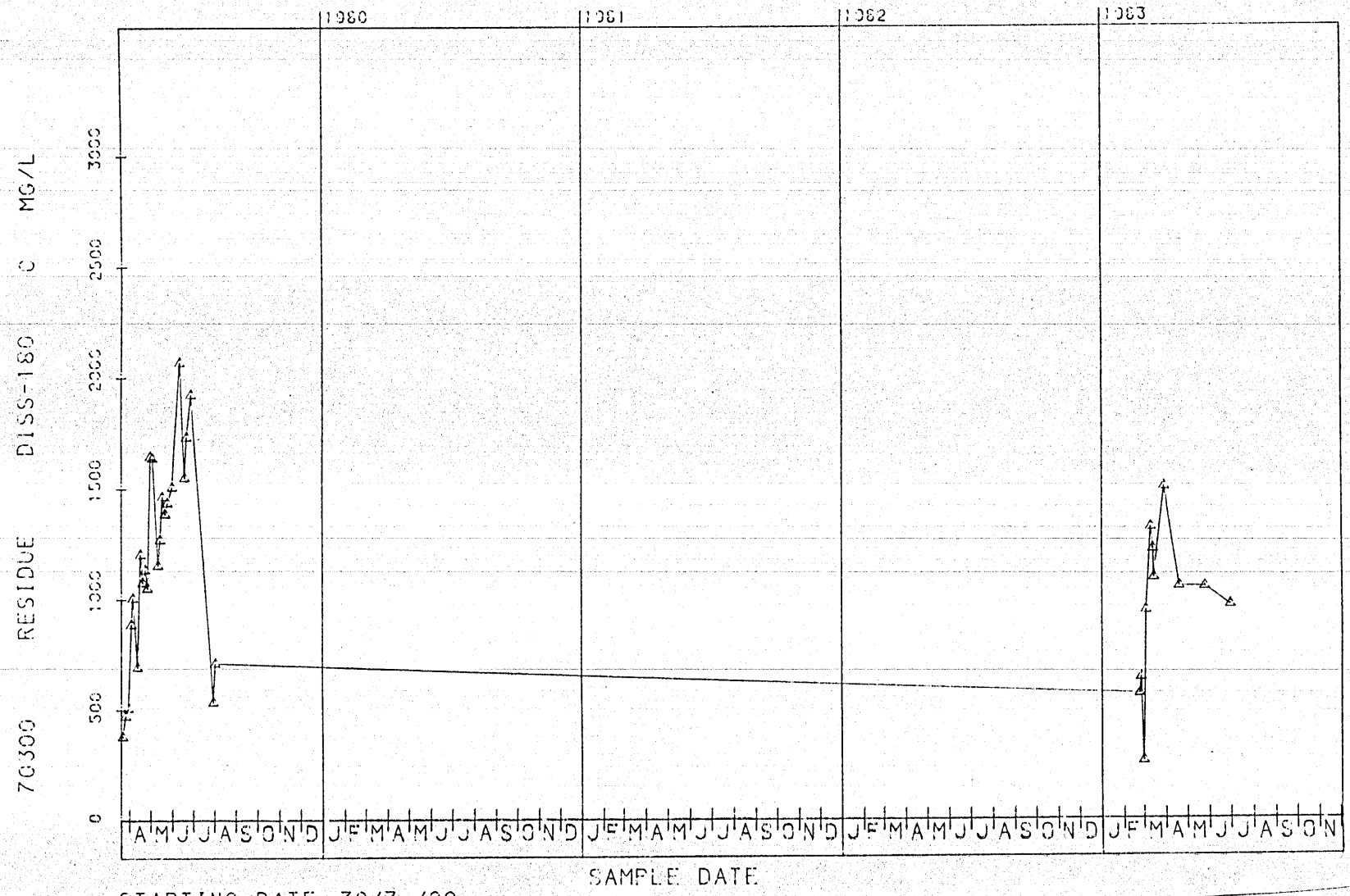
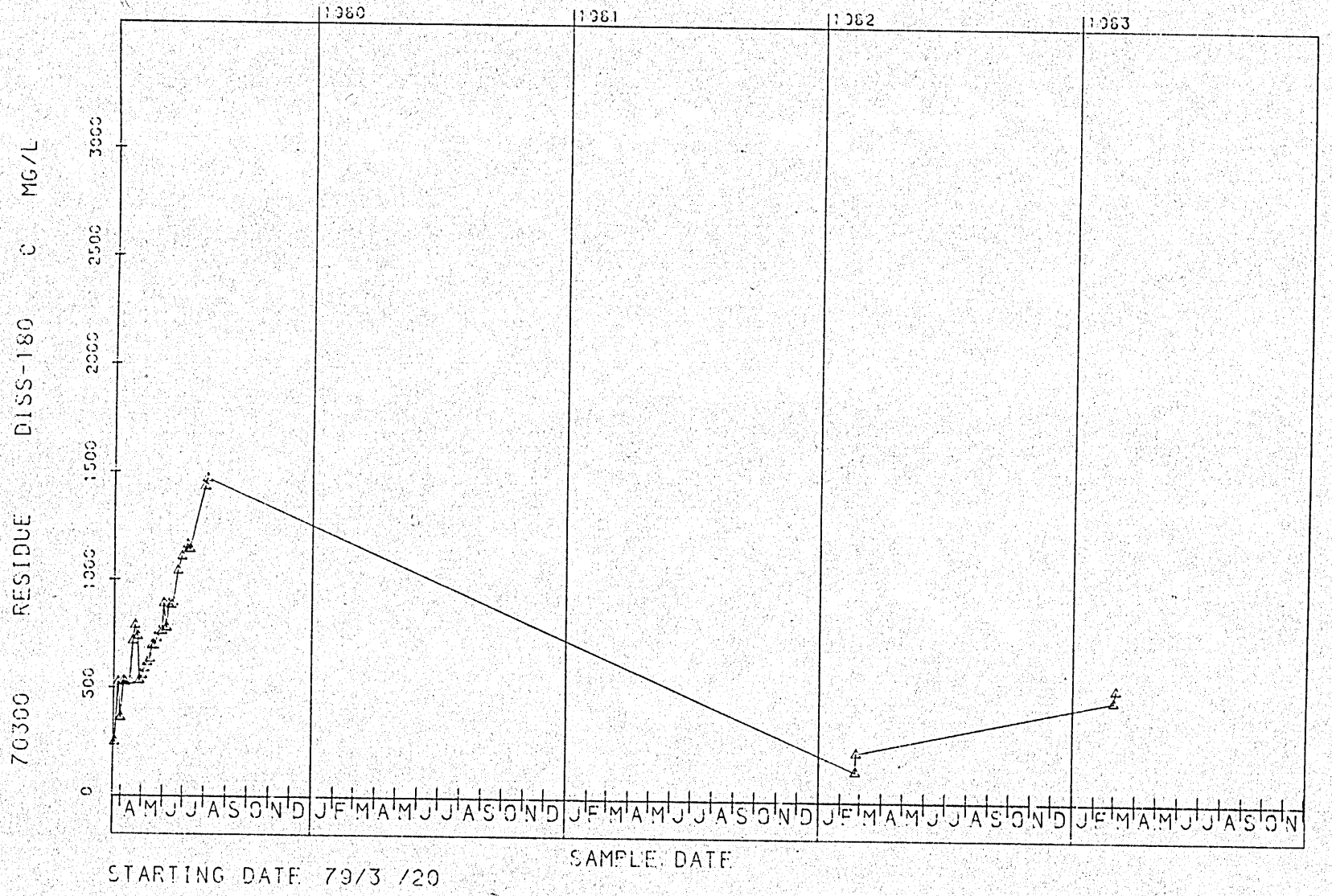


Figure IV-8.


46WA02
43 3i 57.0 096 58 i1.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593325-0621720
1980
1981
1982
1983
70300 RESIDUE DISS-180 C MG/L
0
500
1000
1500
2000
2500
3000
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N
SAMPLE DATE
STARTING DATE 79/3 /20

46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593326-0621721

Figure IV-9.



46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593327-0621722

Figure IV-10.

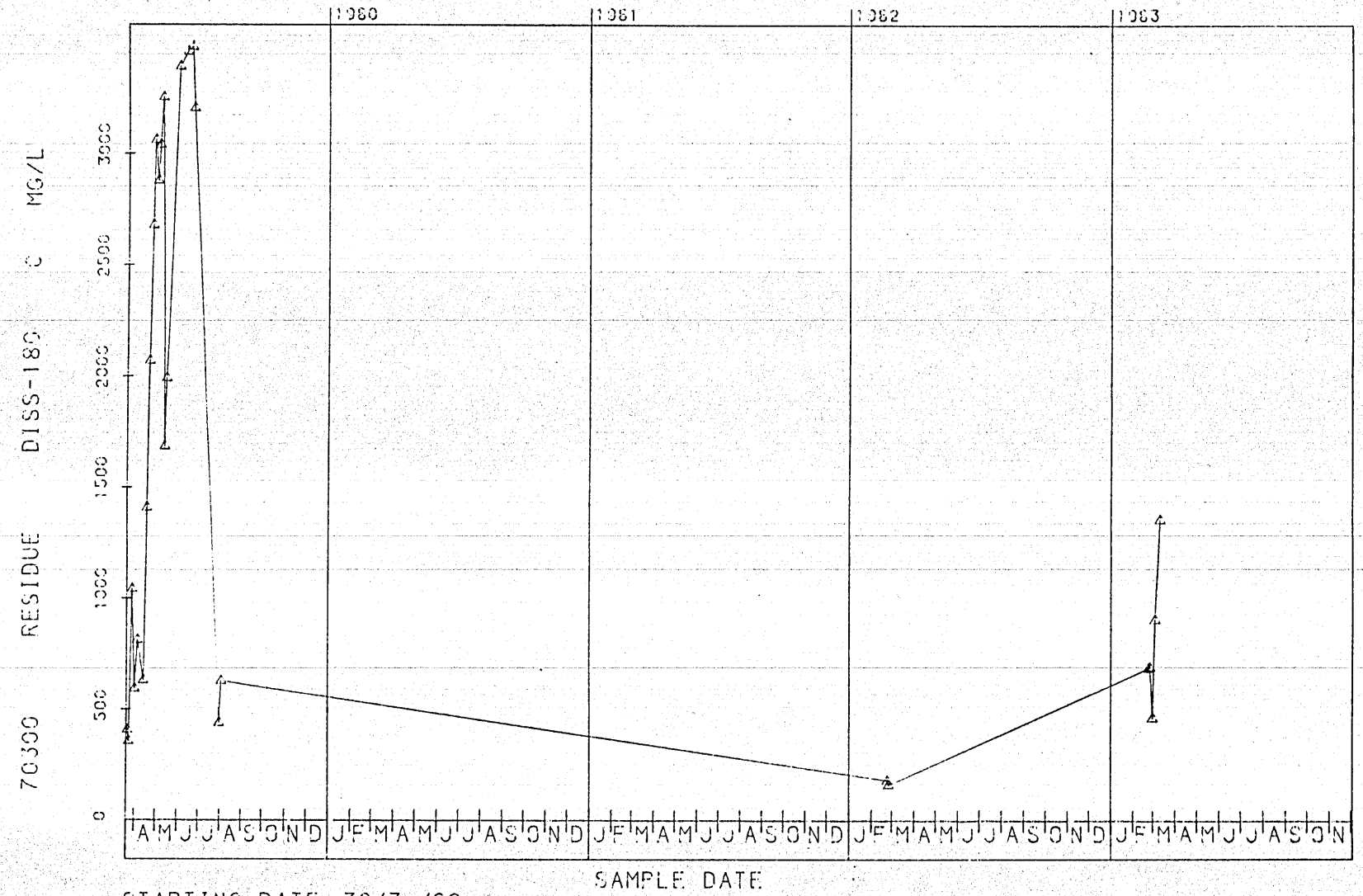
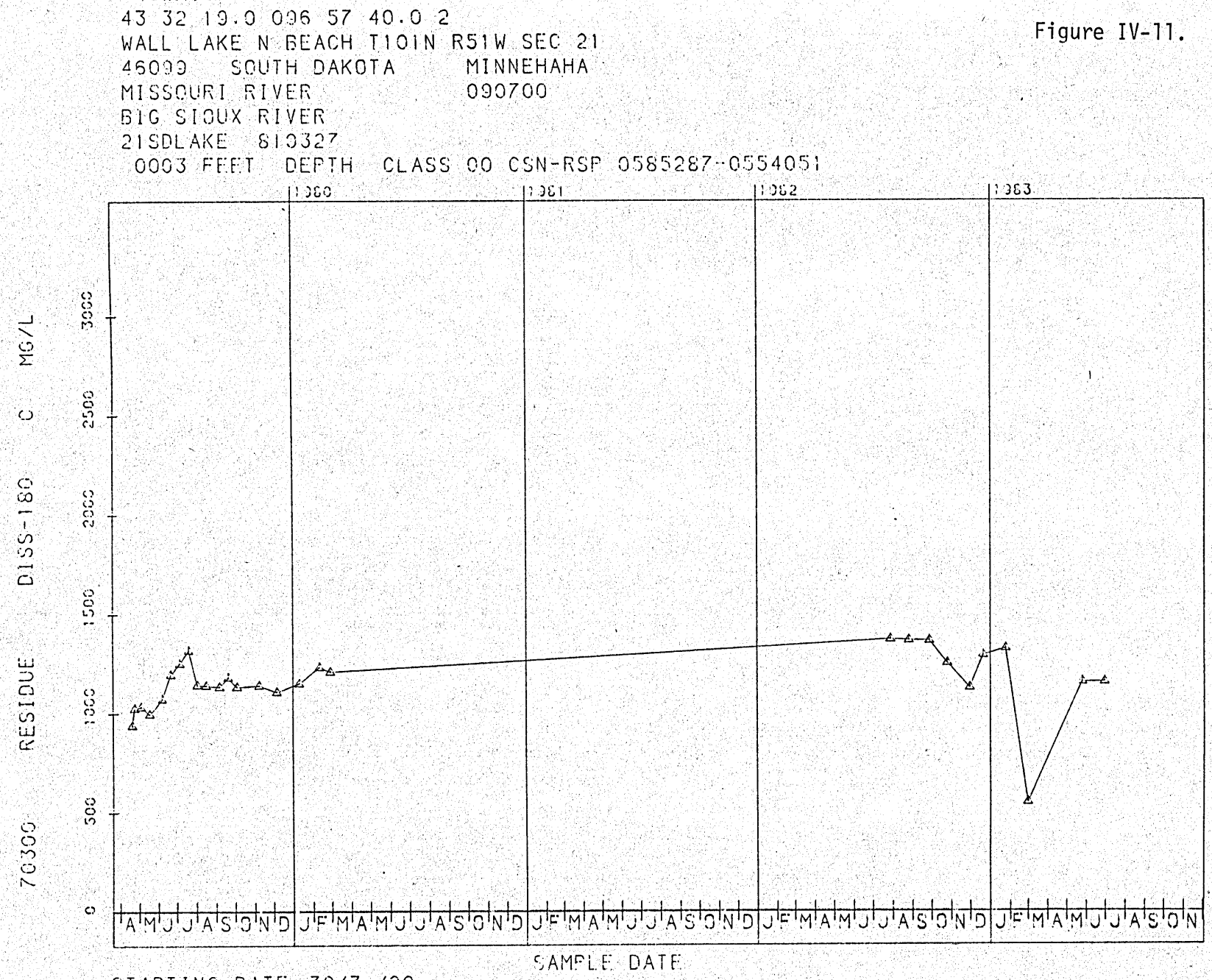


Figure IV-11.


46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585287-0554051
1980
1981
1982
1983
70300 RESIDUE DISS-180 C MG/L
3000
2500
2000
1500
1000
500
0
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N
SAMPLE DATE
STARTING DATE 79/3 /20

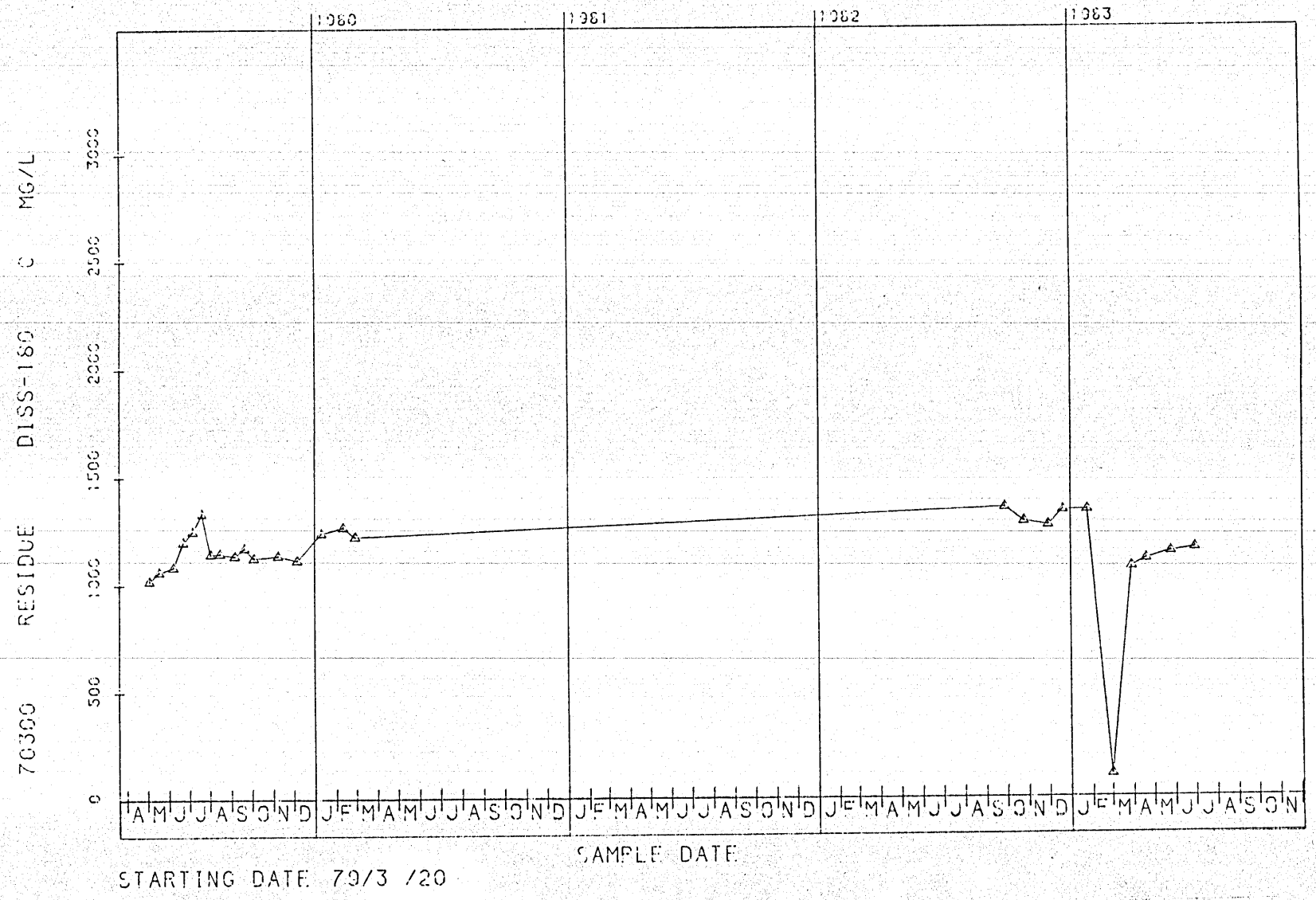
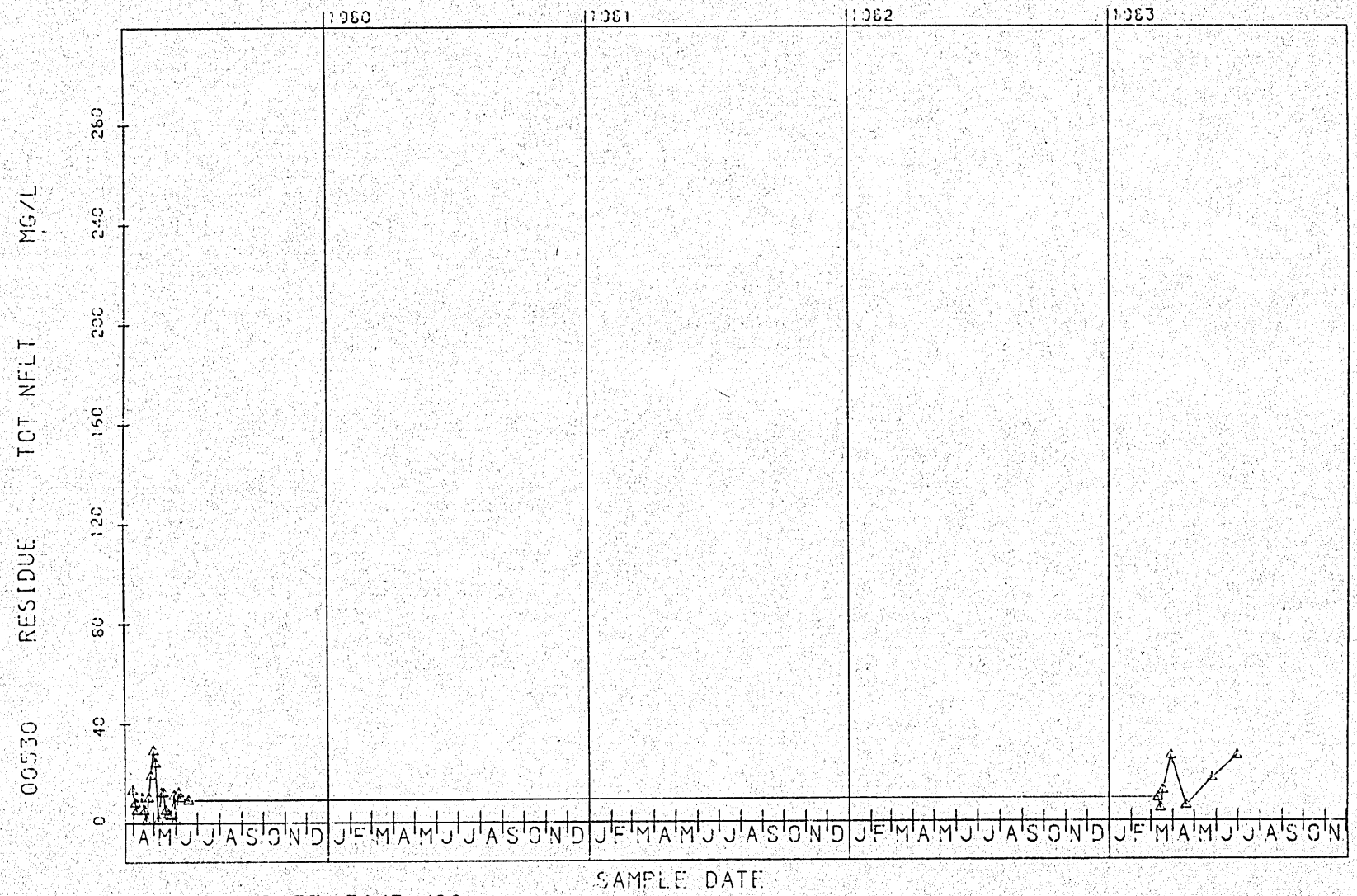

46WA06
43 3i 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE &10327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585288-0554052
1980
1981
1982
1983
70300 RESIDUE DISS-180 C MG/L
0
500
1000
1500
2000
2500
3000
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N
SAMPLE DATE
STARTING DATE 79/3 /20

Figure IV-12.

46WA01
43 31 44.0 096 57 10.0 2
WALL LAKE OUTLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593324-0621719

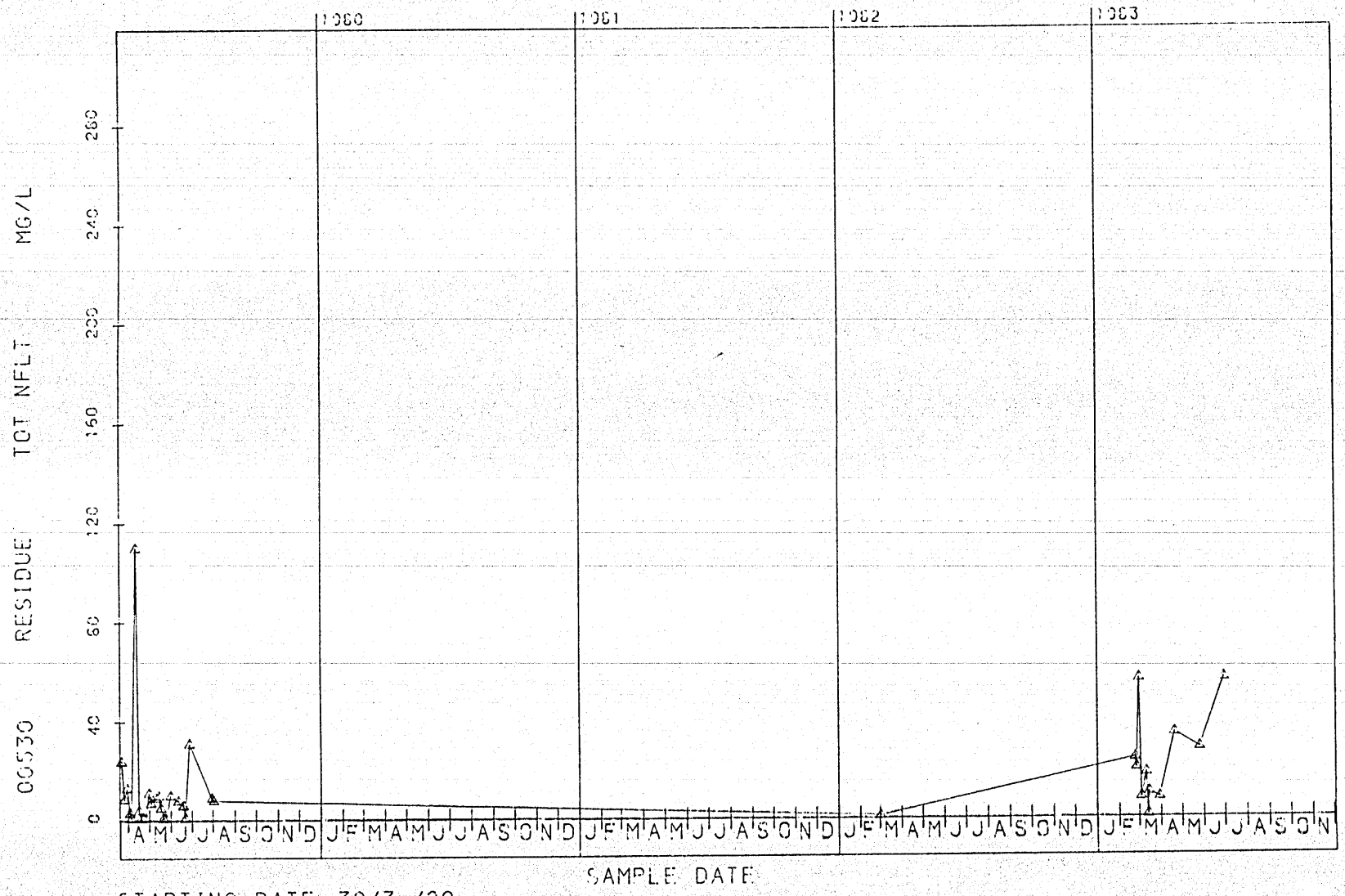
Figure IV-13.



STARTING DATE 79/3 /20

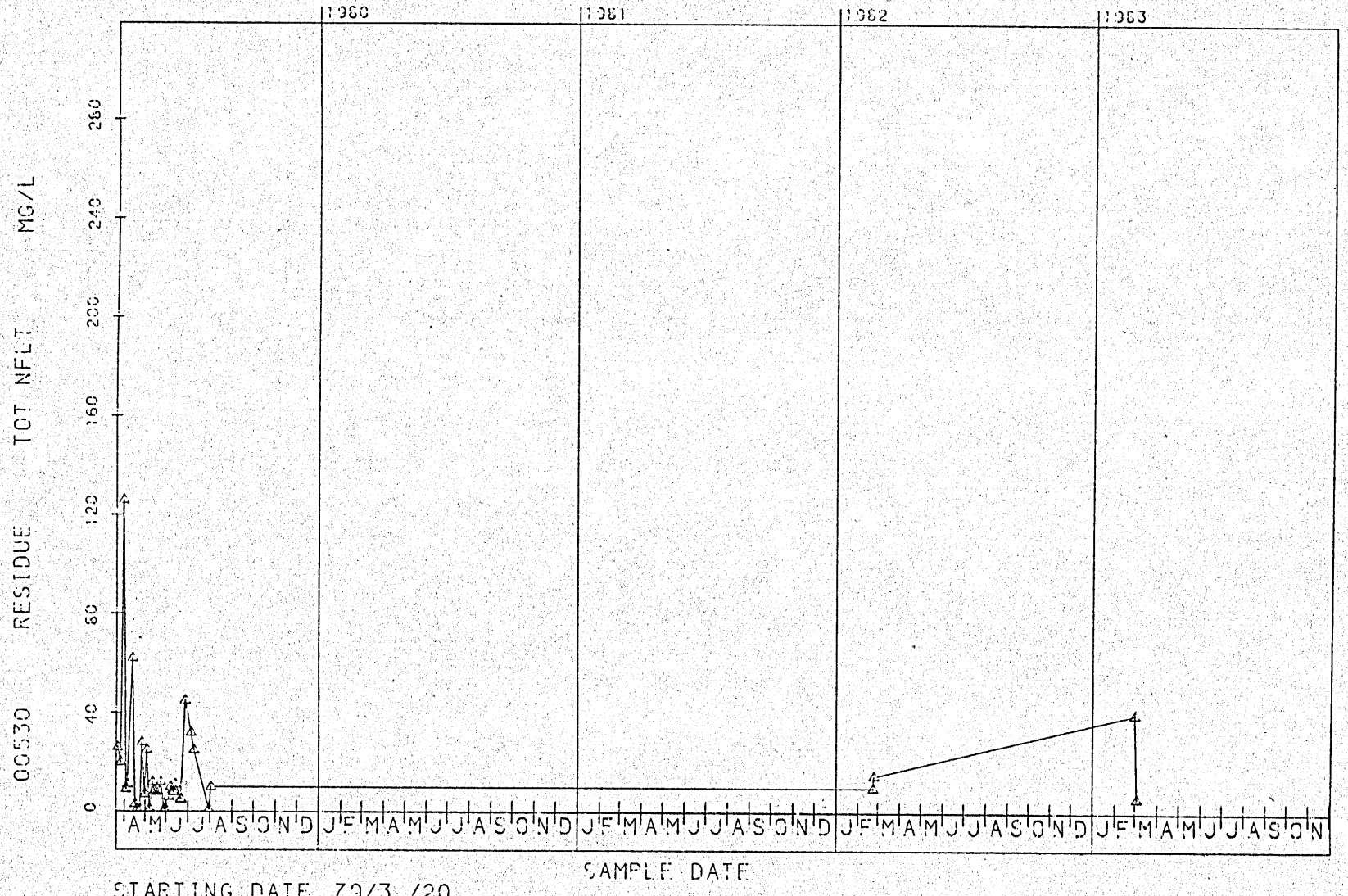
46WA02
43 3i 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593325-0621720

Figure IV-14.



46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593326-0621721

Figure IV-15.



46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0503327 0621722

Figure IV-16.

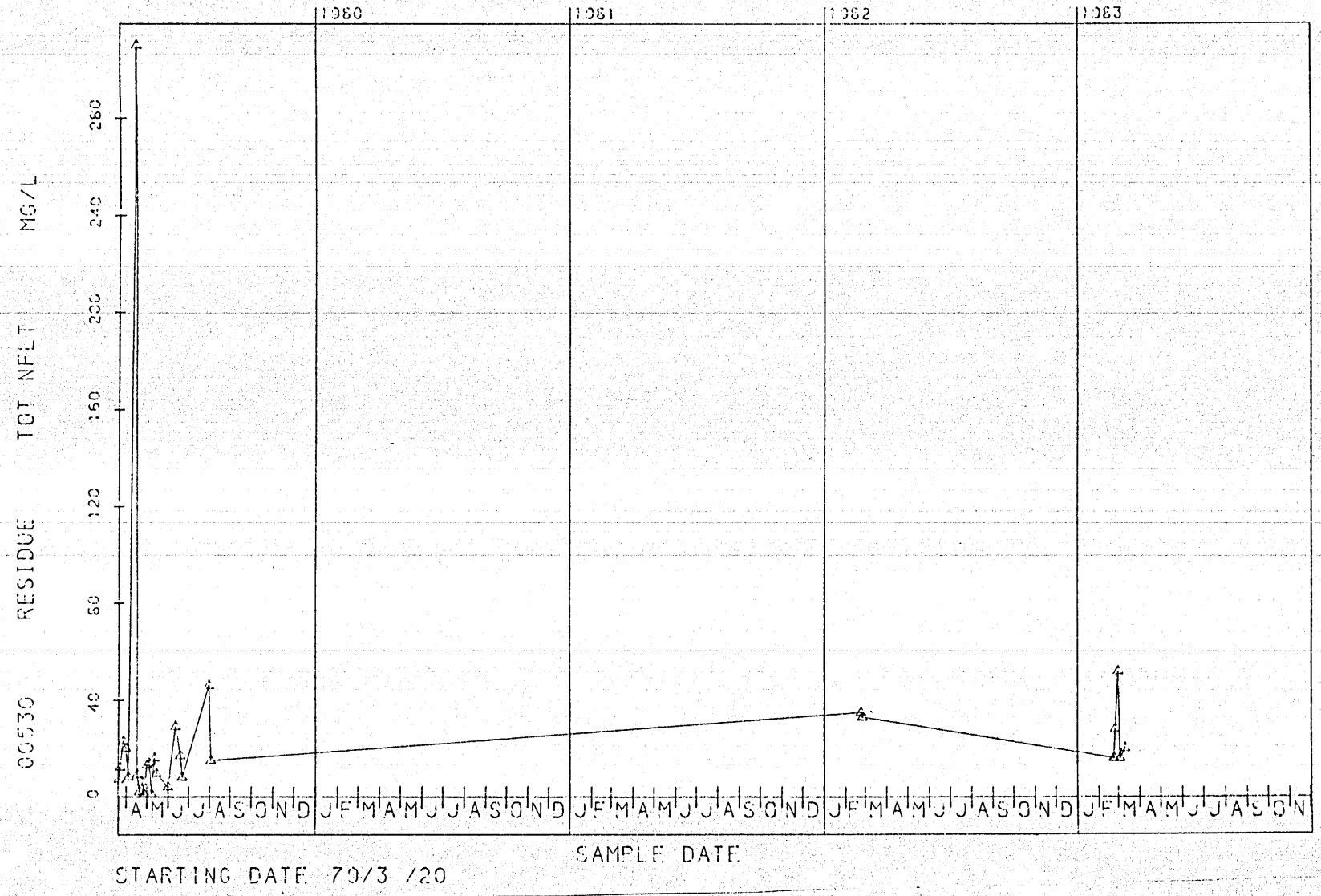
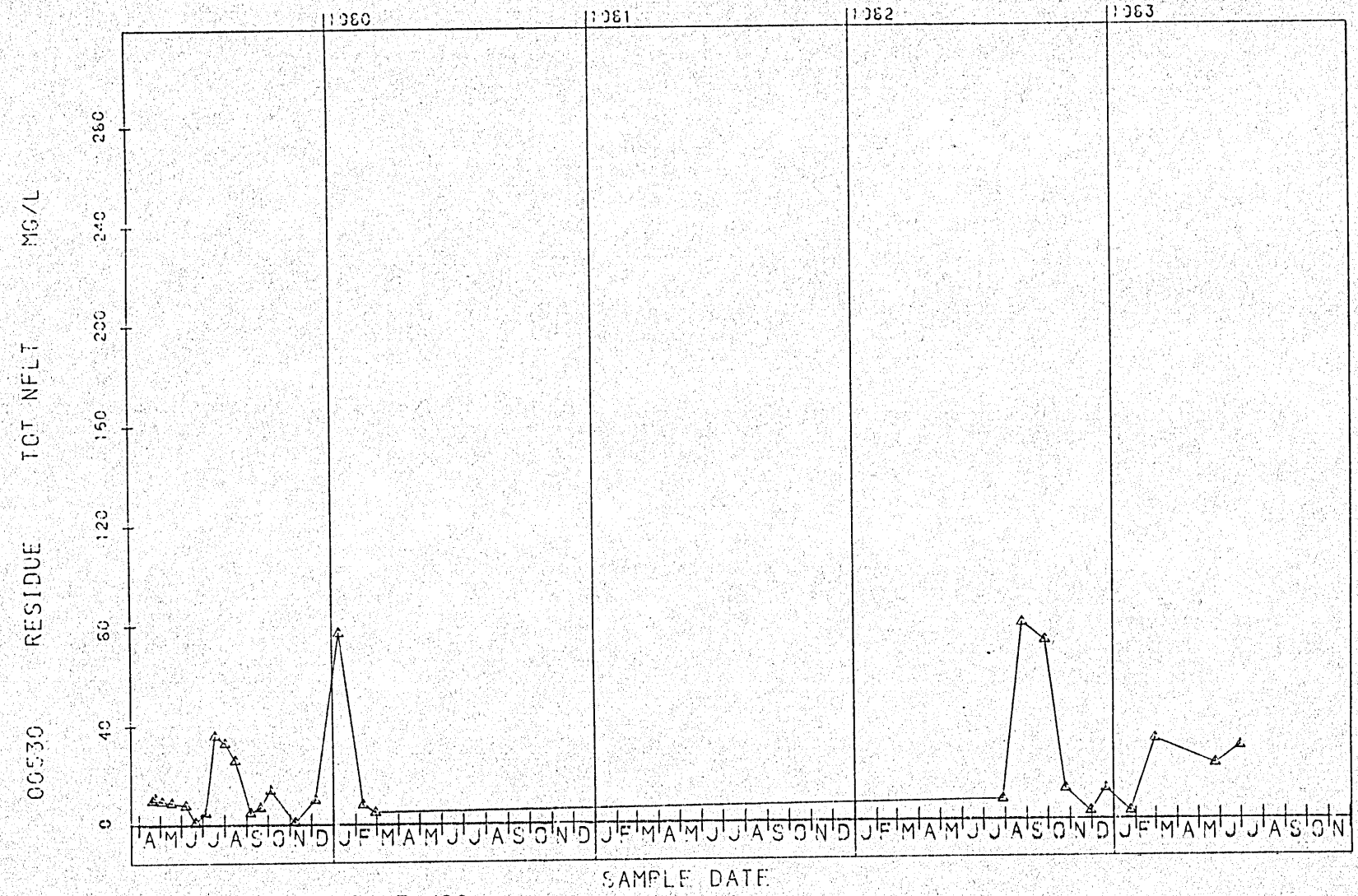


Figure IV-17.

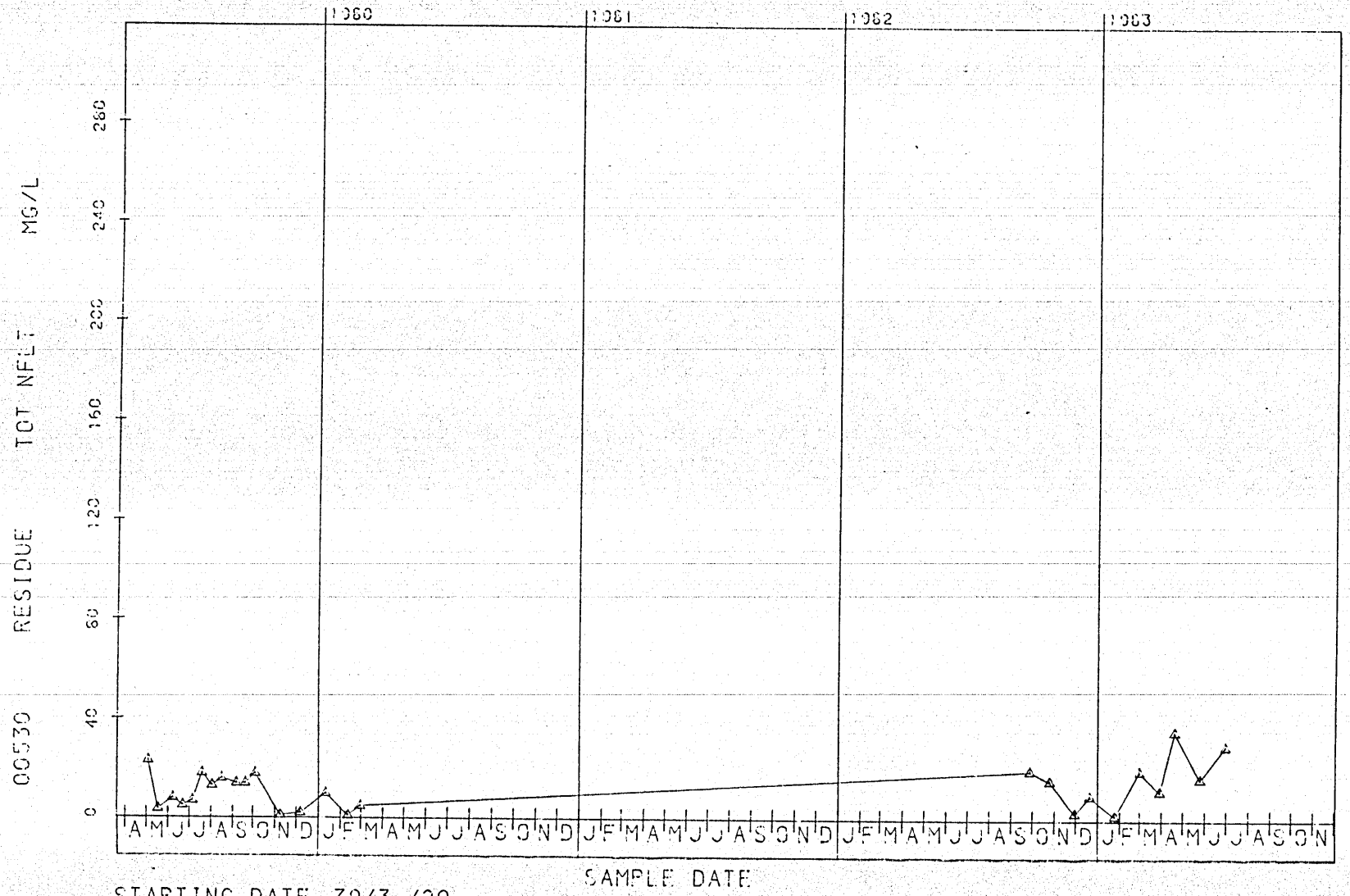
46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585287 0554051



STARTING DATE 79/3 /20

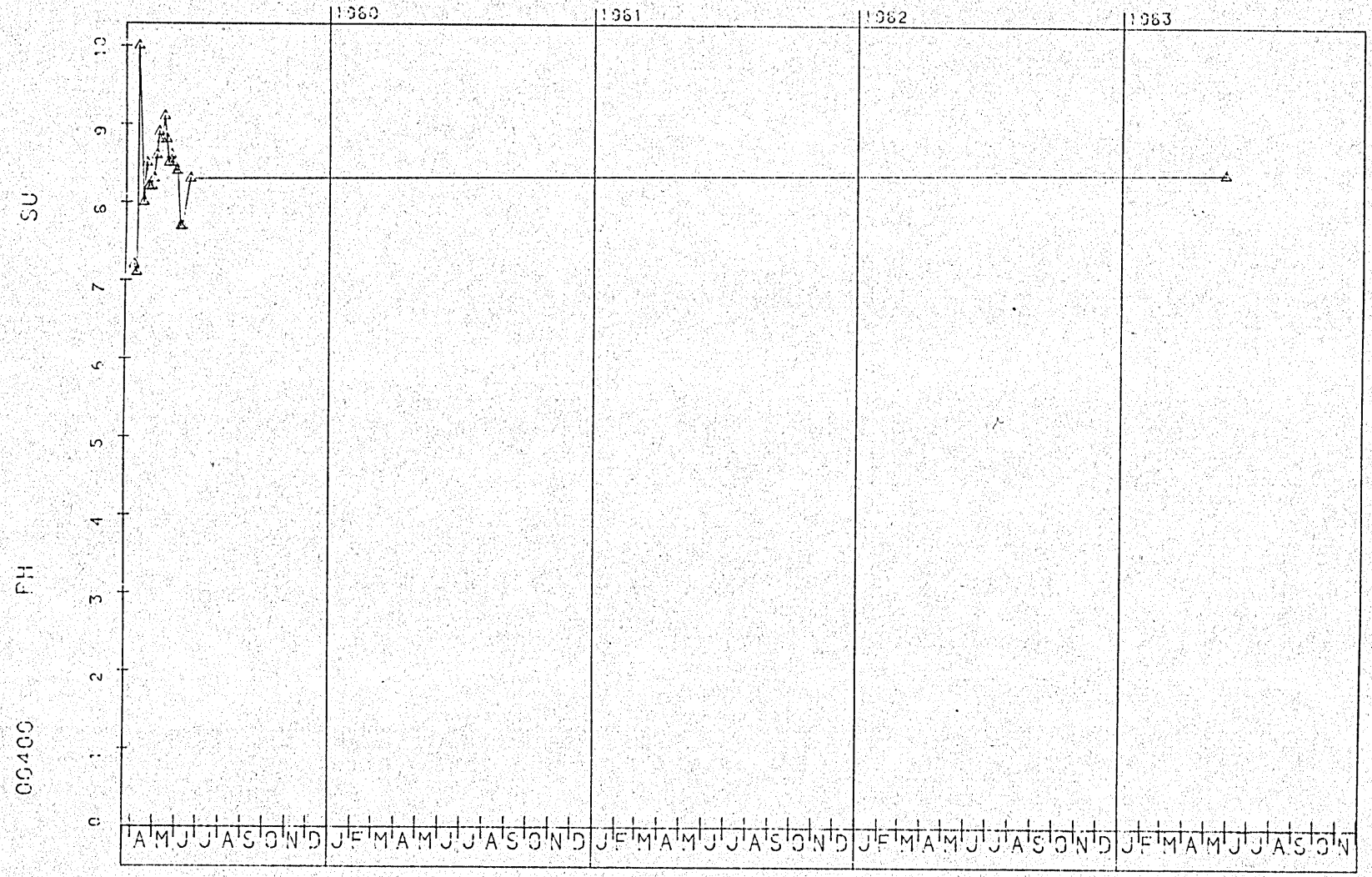
46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585288-0554052

Figure IV-18.



STORET
46WA01
43 31 44.0 096 57 10.0 2
WALL LAKE OUTLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593324-0621710

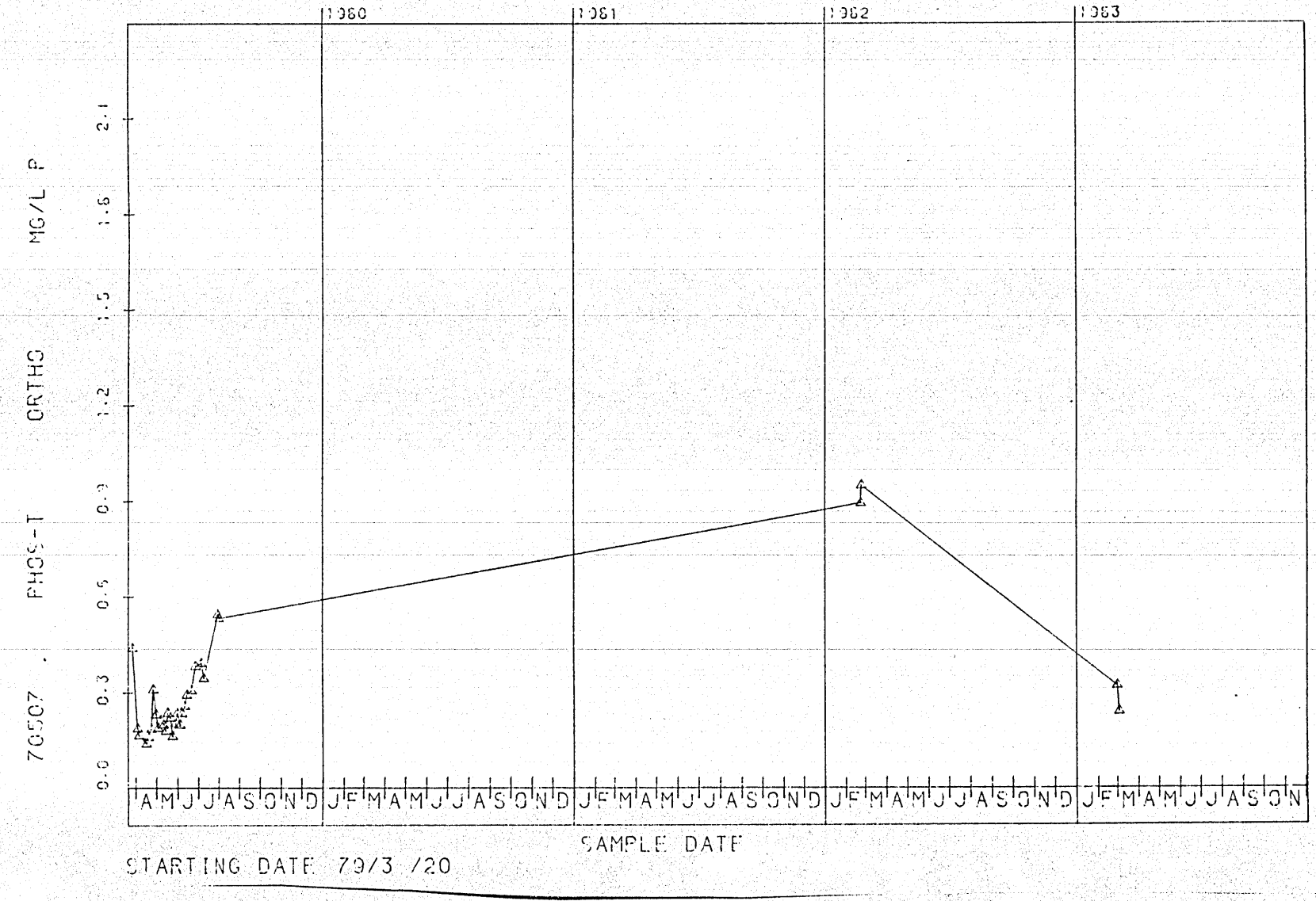
Figure IV-19.



STARTING DATE 70/3 /20

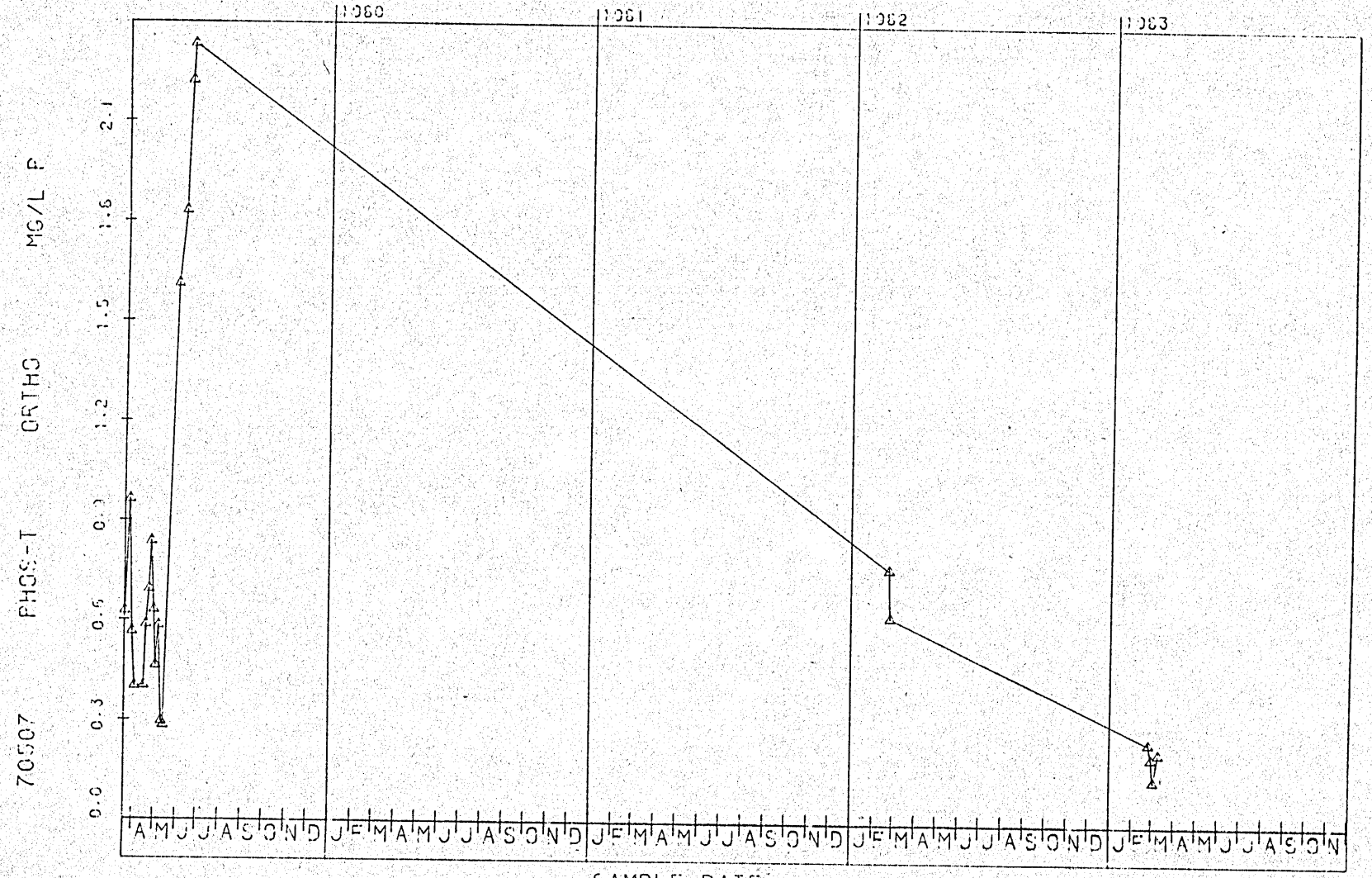
46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593326-0621721

Figure IV-27.



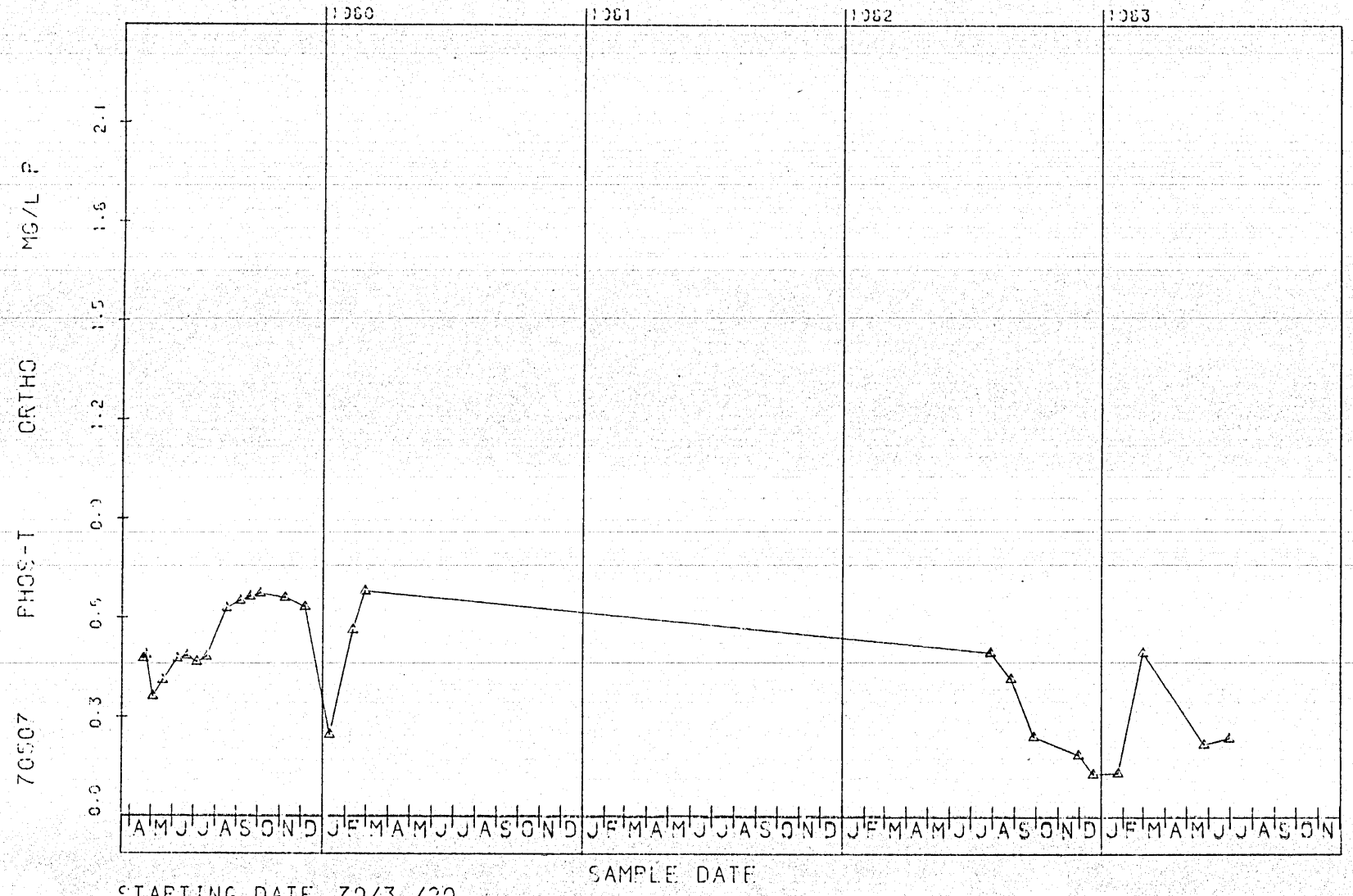
46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593327-0621722

Figure IV-28.



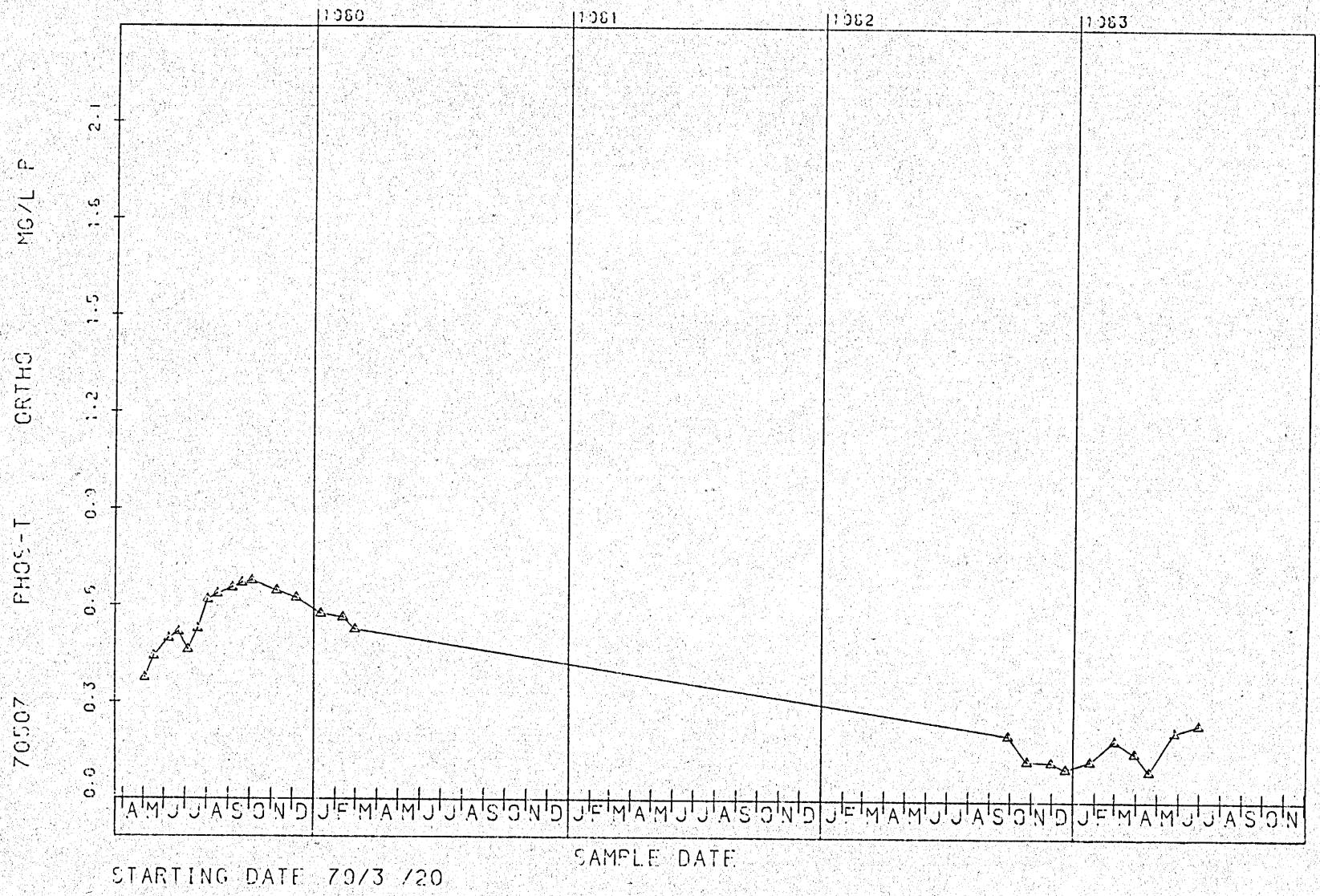
46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585287-0554051

Figure IV-29.



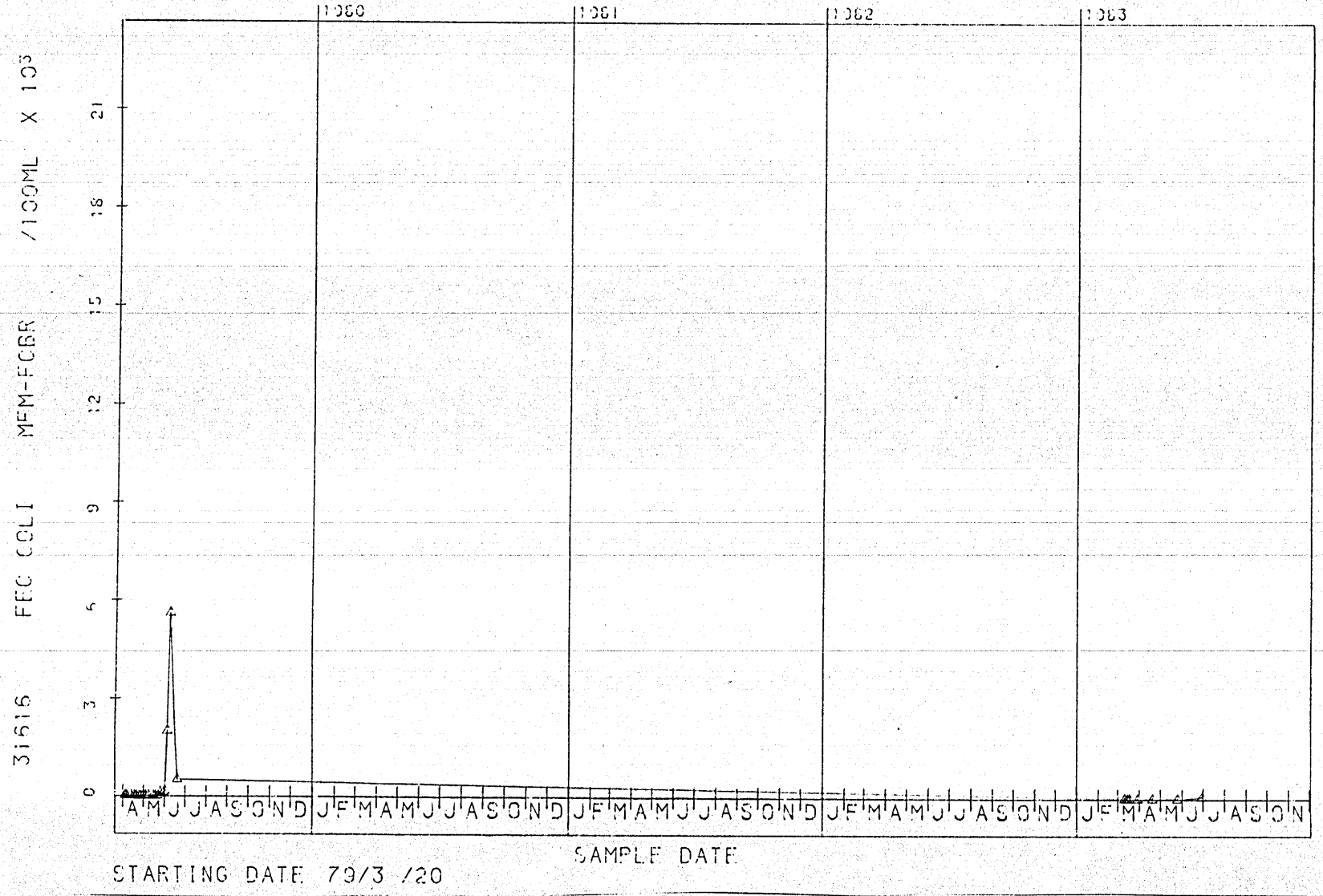
46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585288-0554052

Figure IV-30.



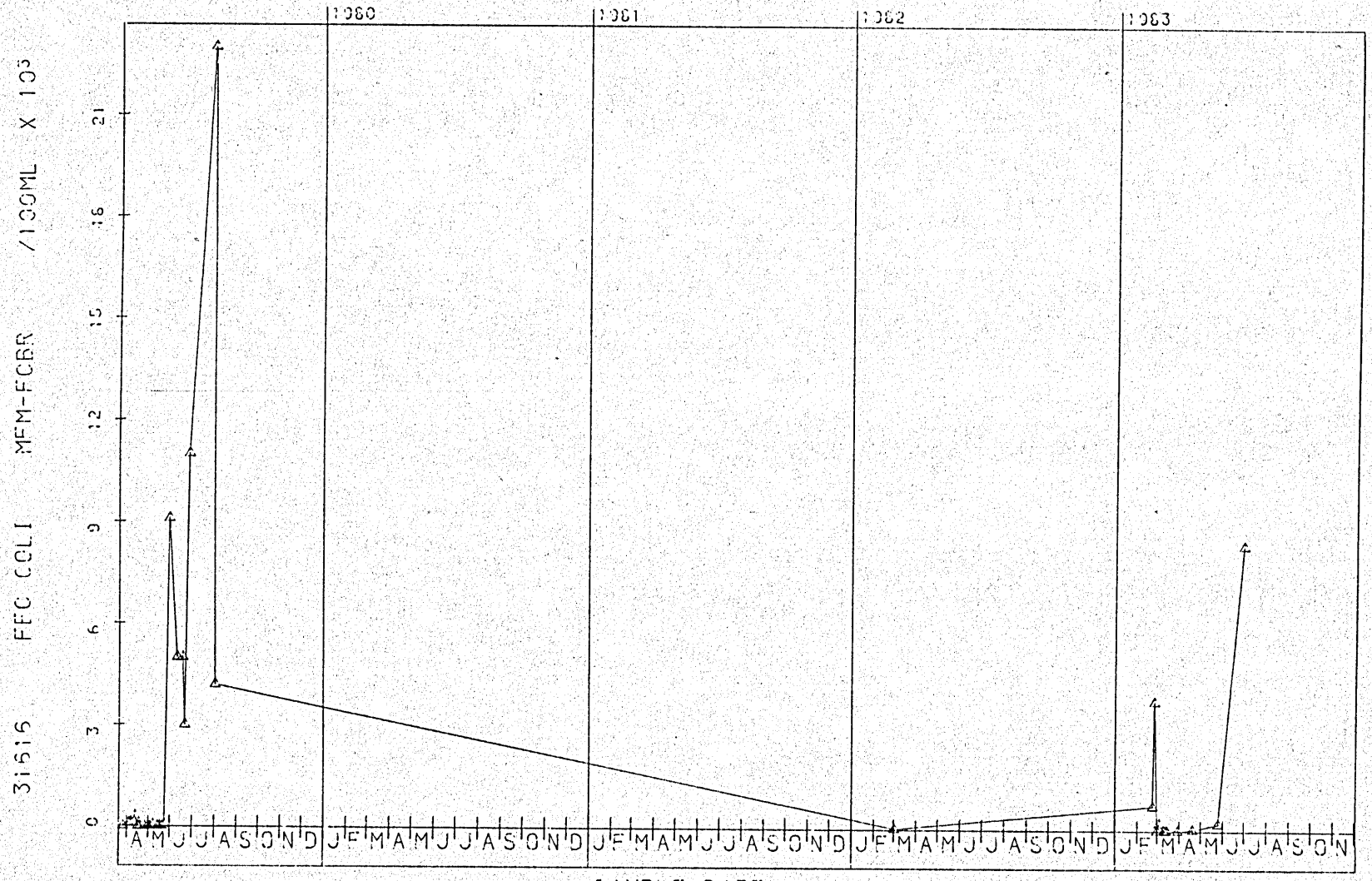
46WA01
43 31 44.0 096 57 10.0 2
WALL LAKE OUTLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593324-0621719

Figure IV-31.



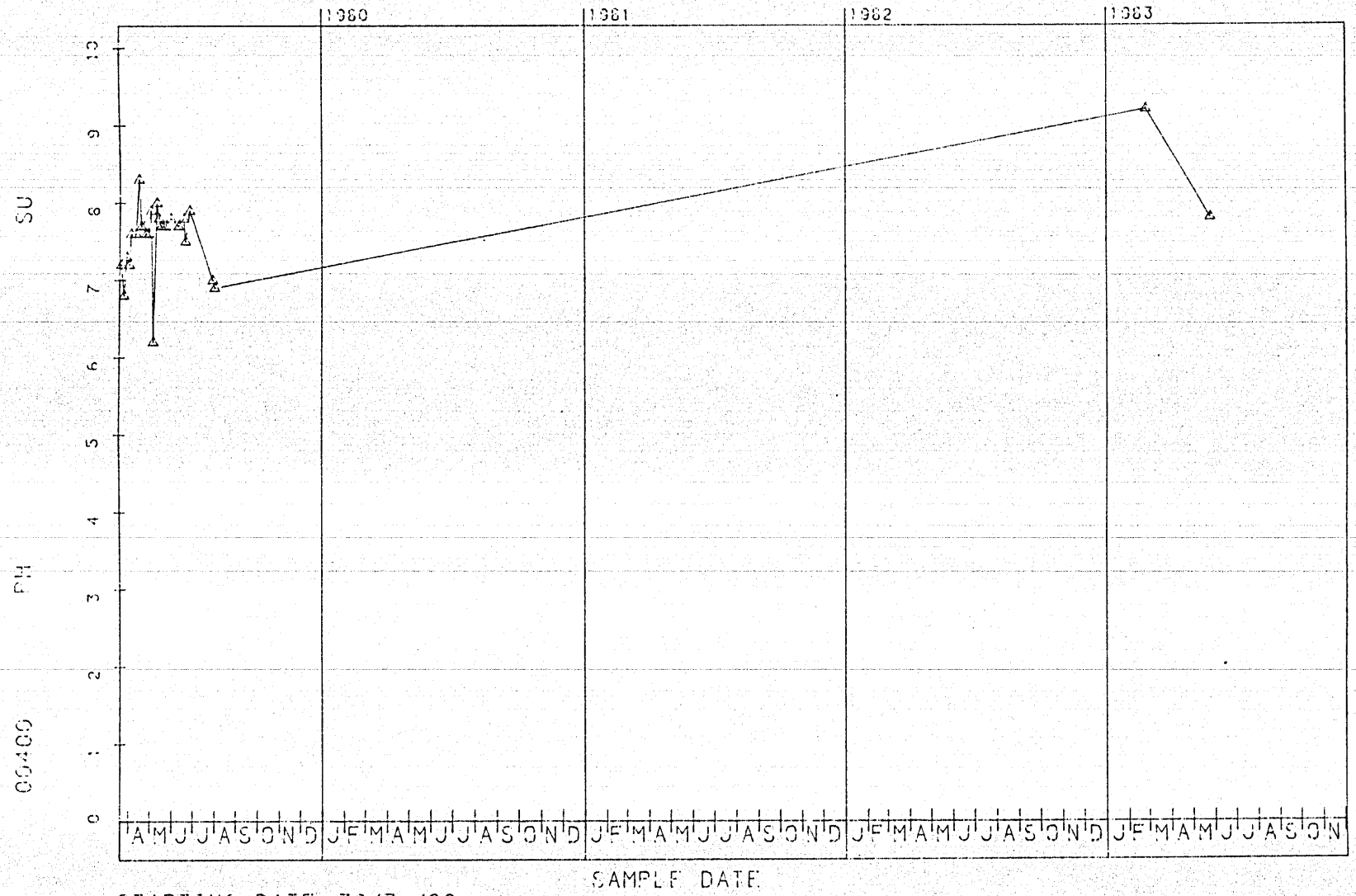
46WA02
43 31 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0503325-0621720

Figure IV-32.



46WA02
43 31 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593325-0621720

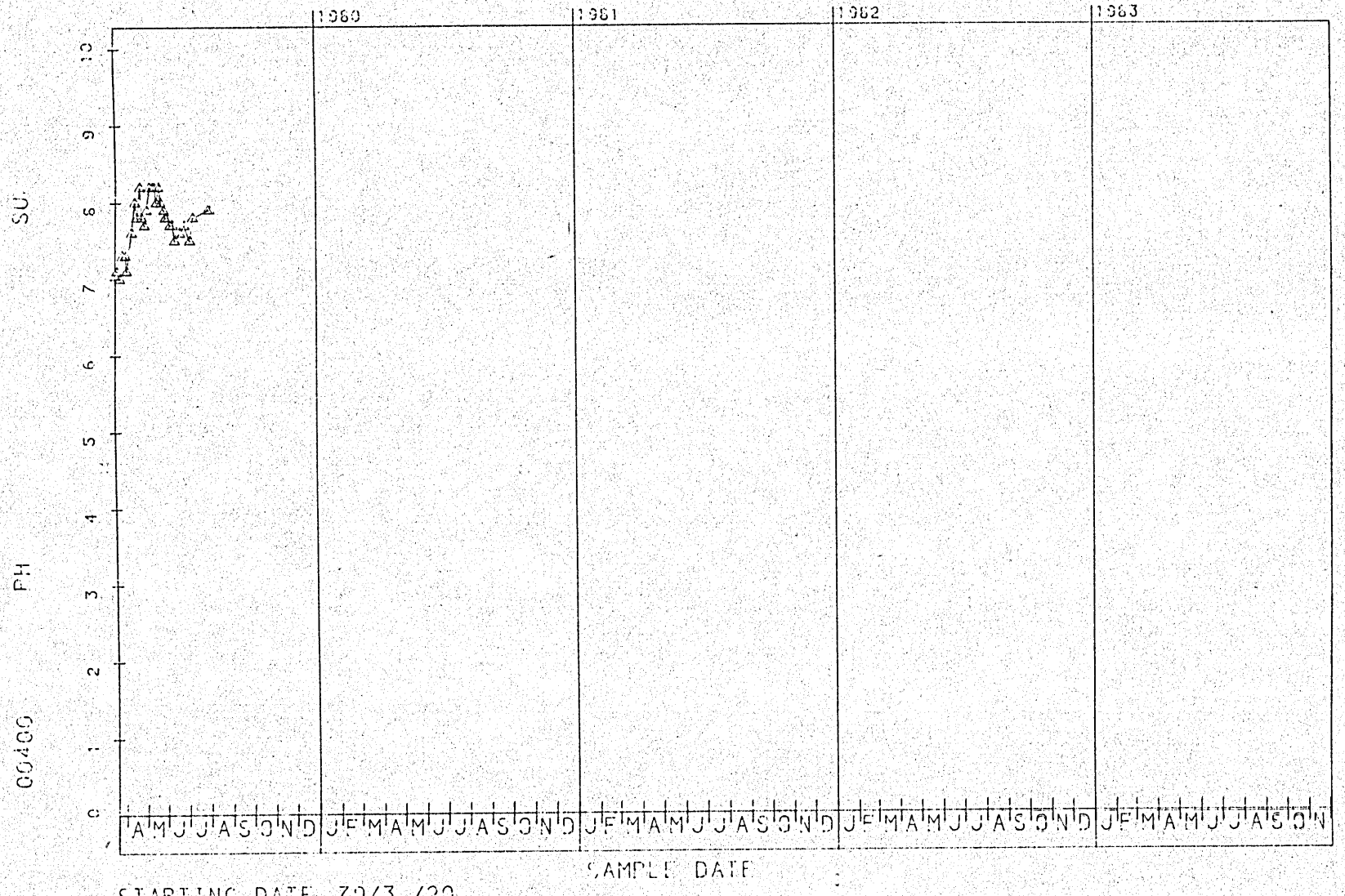
Figure IV-20.



STARTING DATE 79/3 /20

STORET
46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593326-0621721

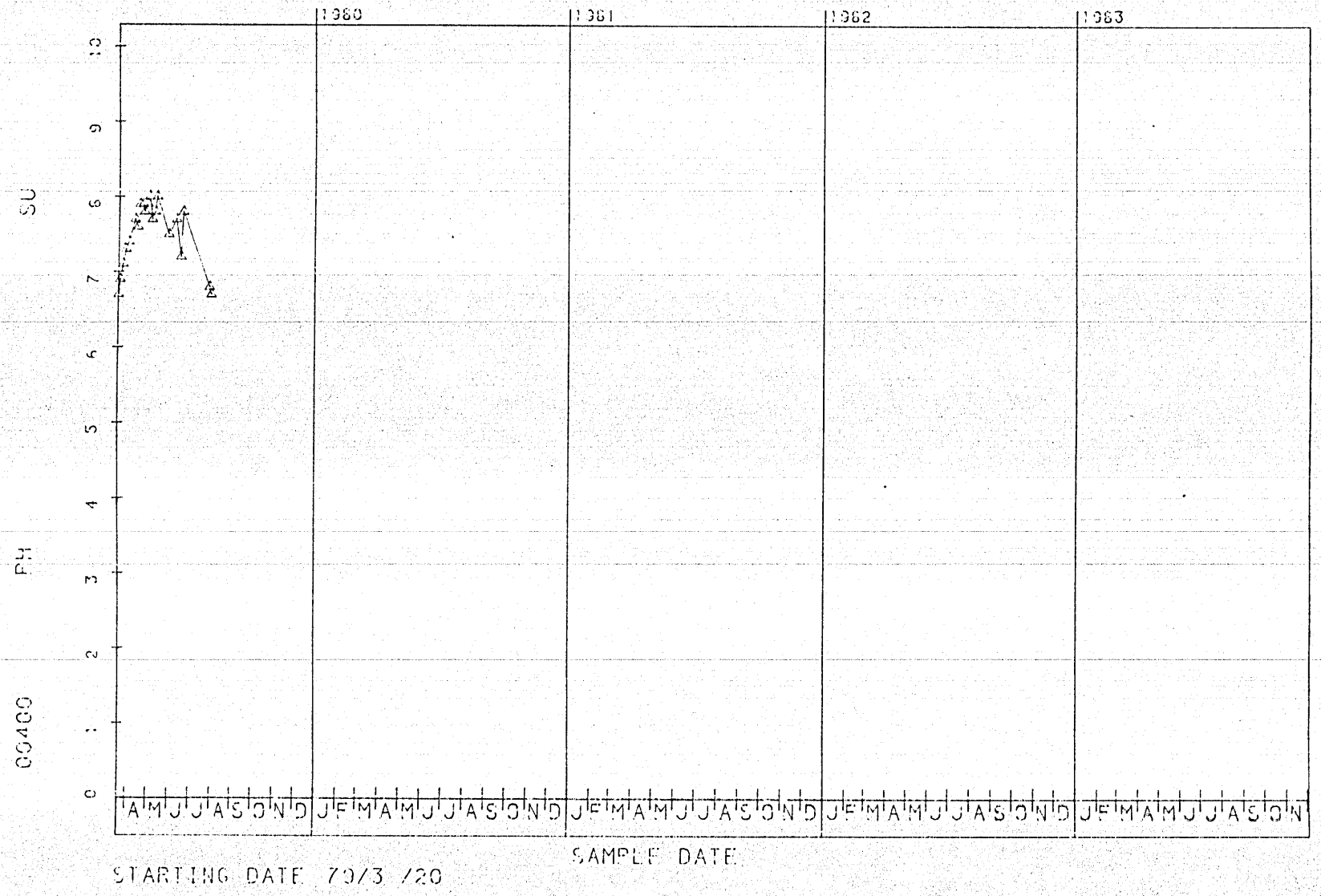
Figure IV-21.



STARTING DATE 79/3 /20

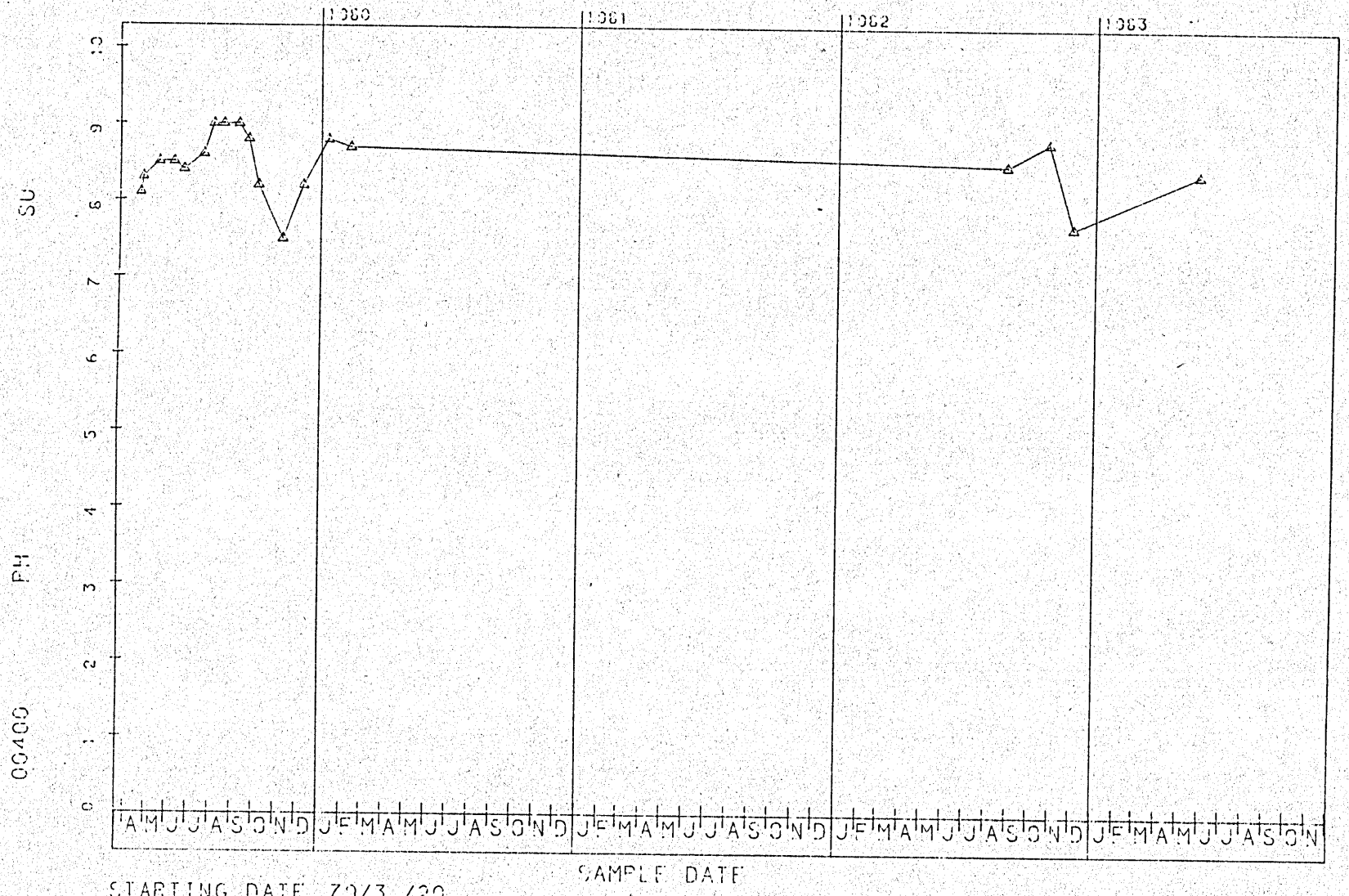
46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593327 0621722

Figure IV-22.



46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585287 0554051

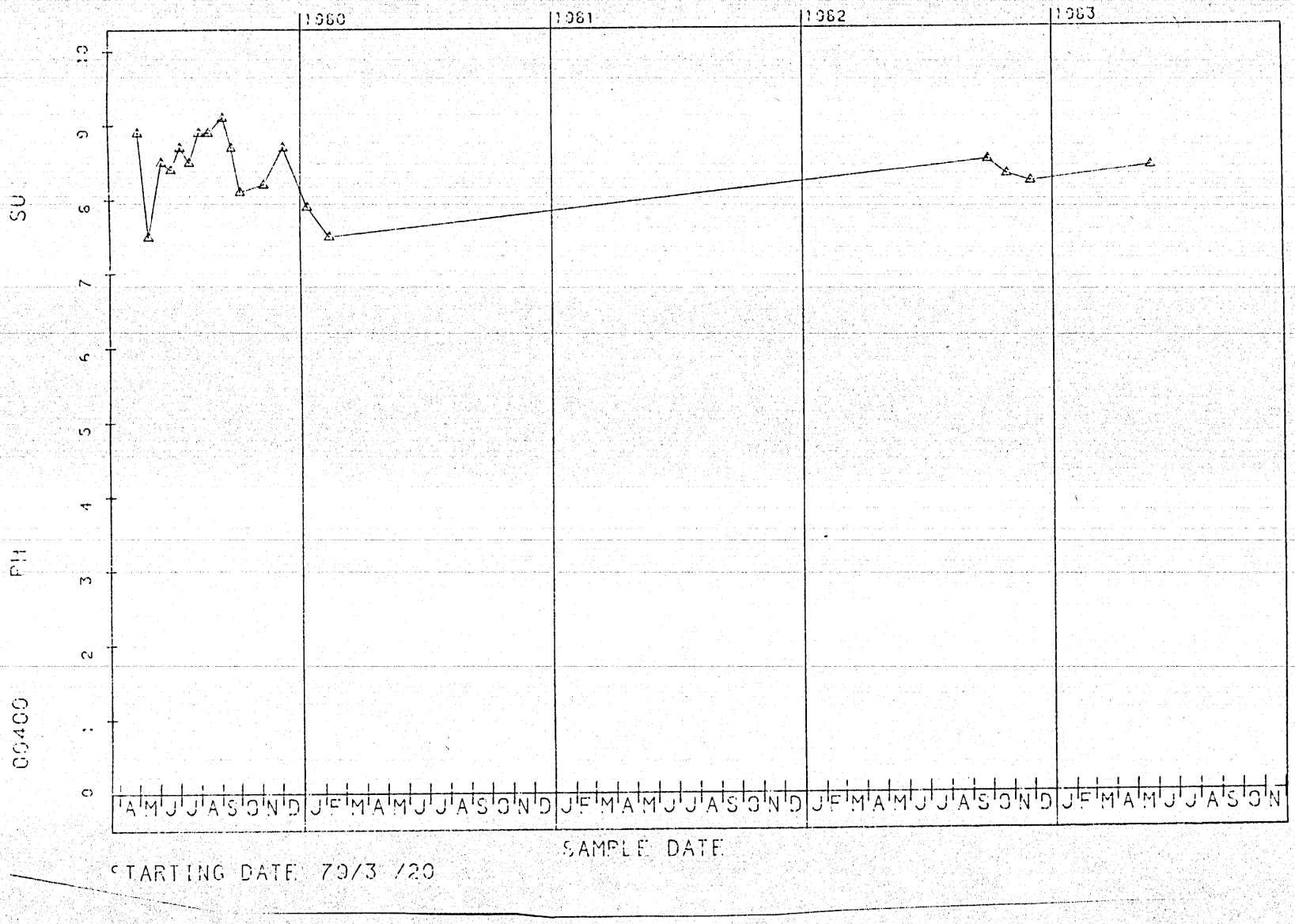
Figure IV-23.



STARTING DATE 7973 720

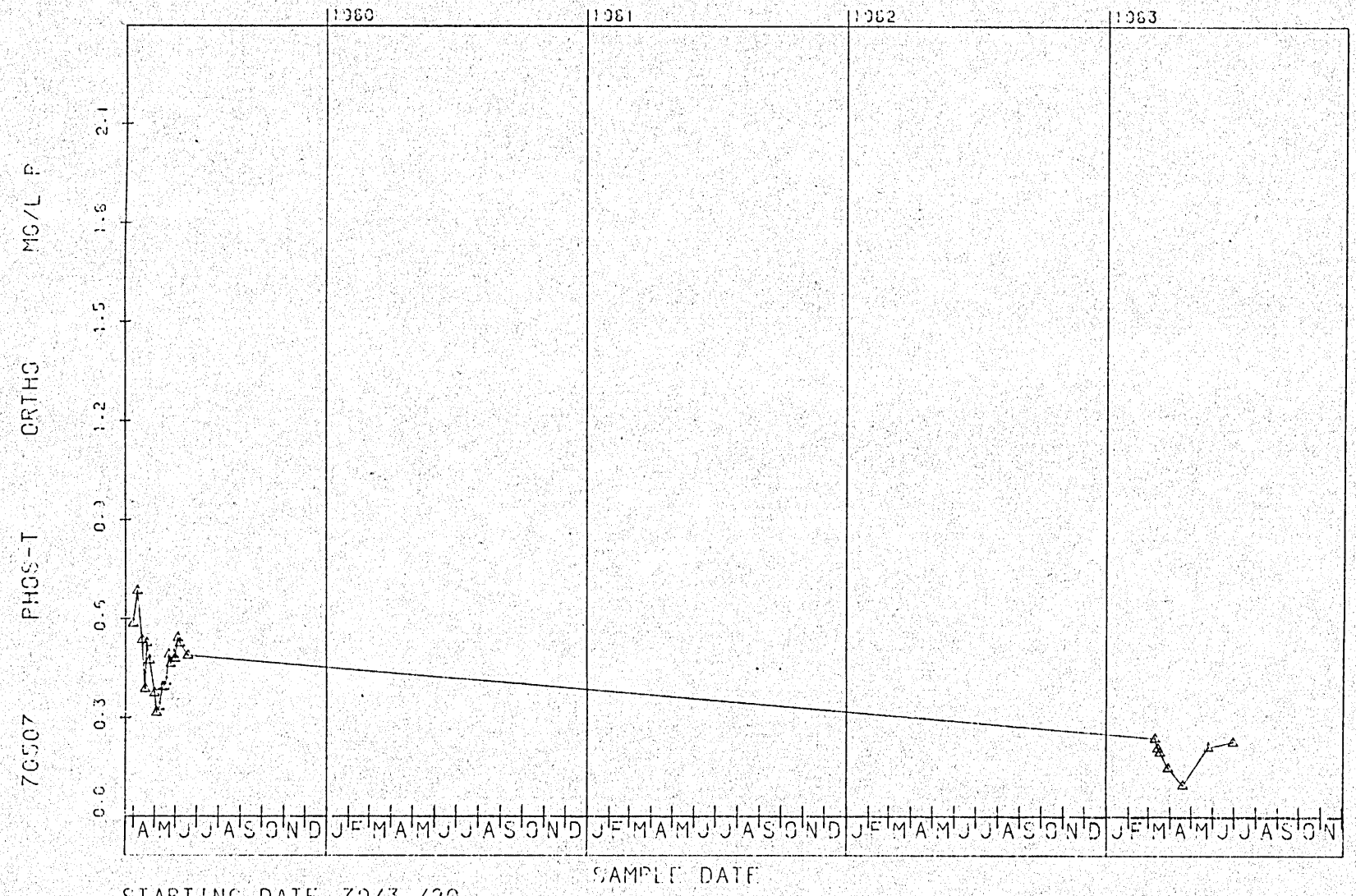
46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585288-0554052

Figure IV-24.



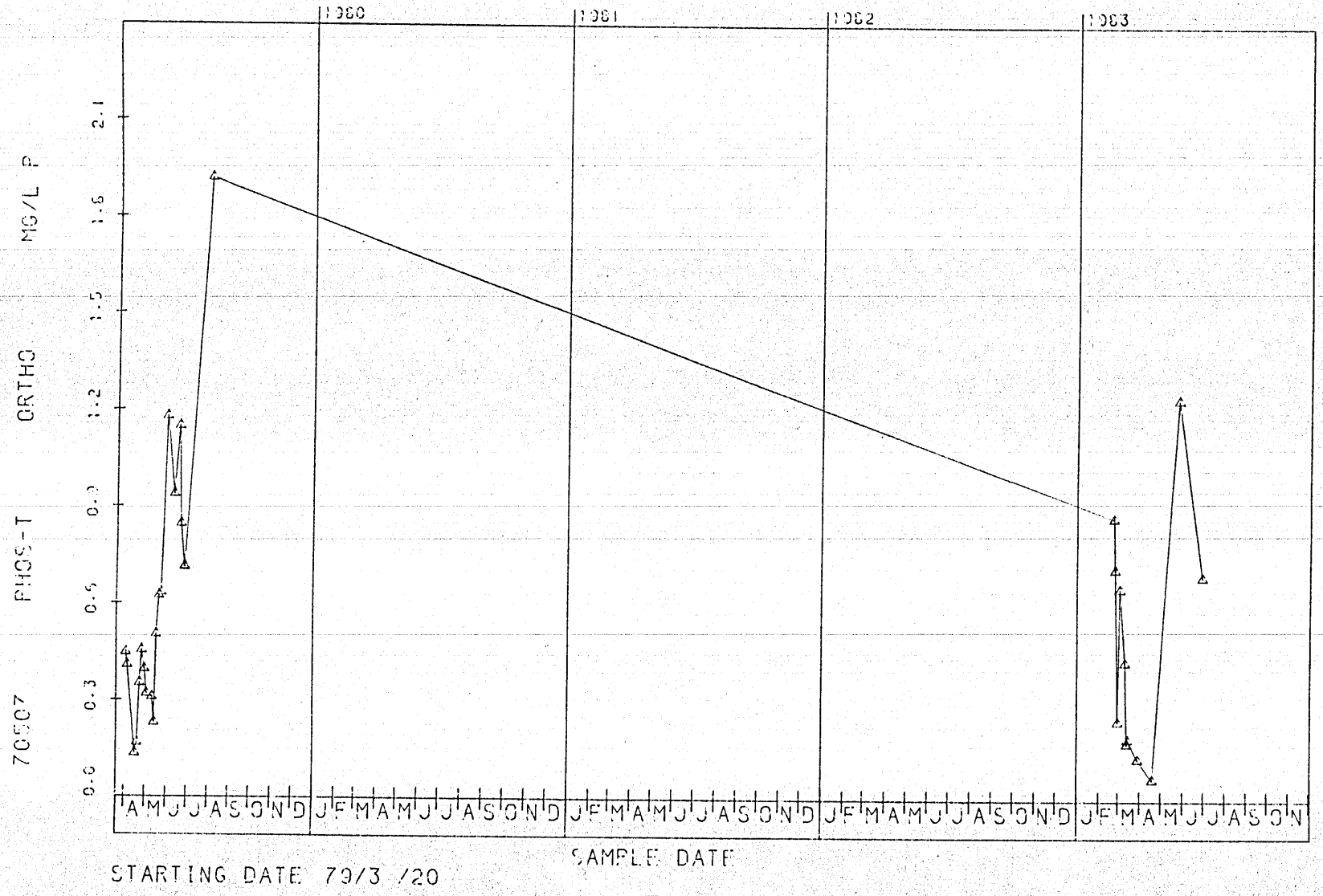
46WA01
43 3i 44.0 096 57 10.0 2
WALL LAKE OUTLET T10IN R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0503324-0621719

Figure IV-25.



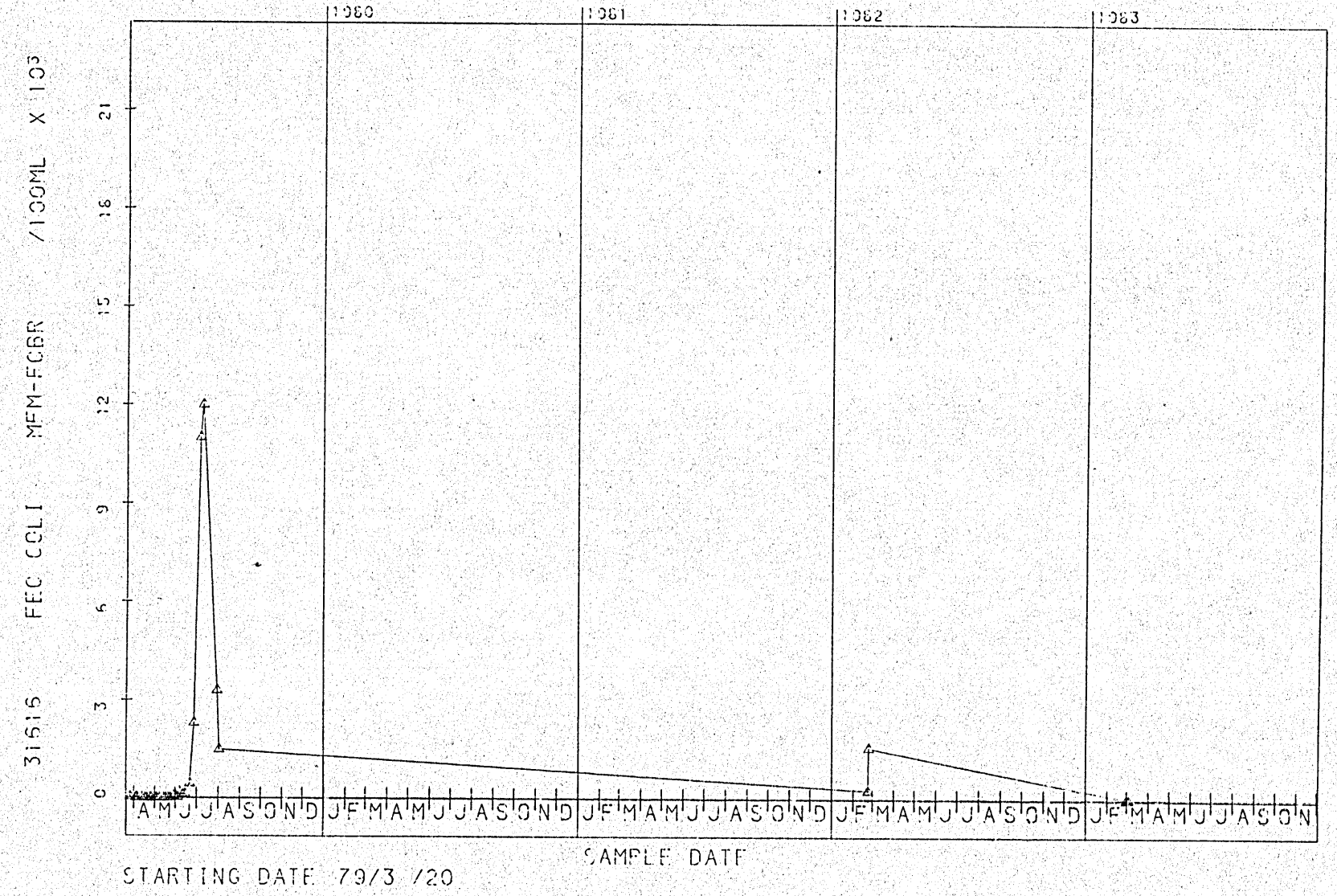
46WA02
43 3i 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593325-0621720

Figure IV-26.



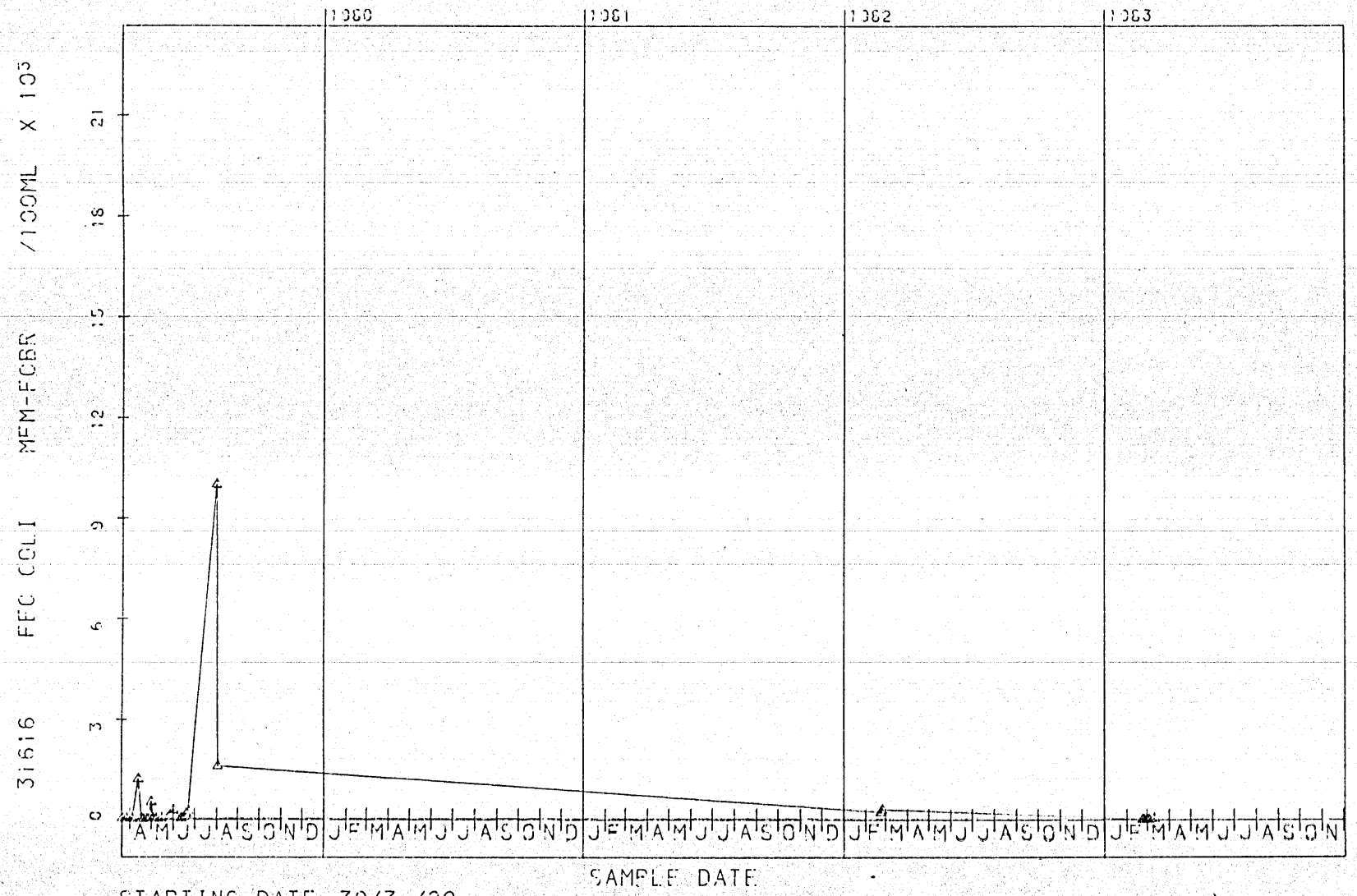
46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593326-0621721

Figure IV-33.



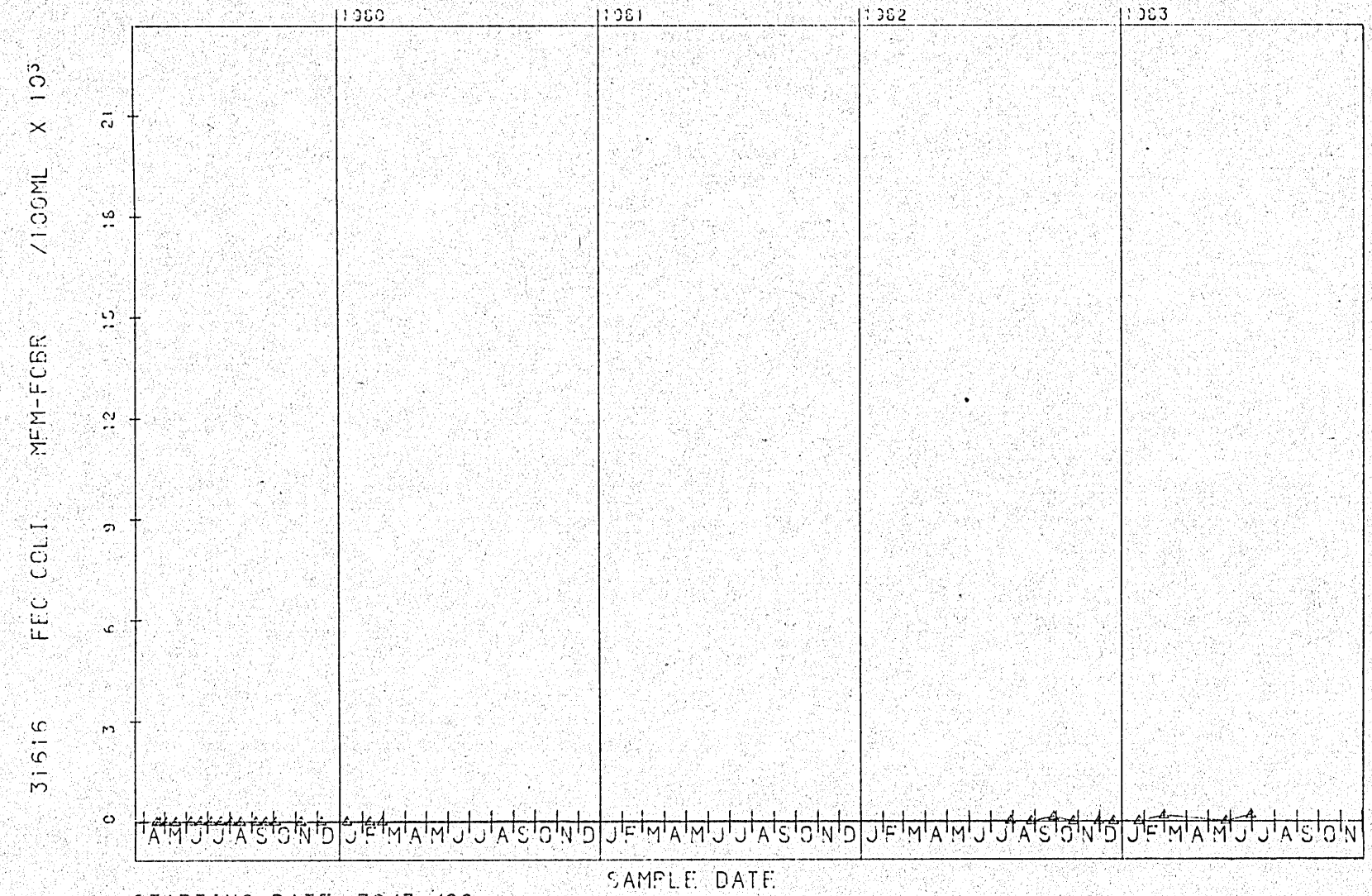
46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593327-0621722

Figure IV-34.



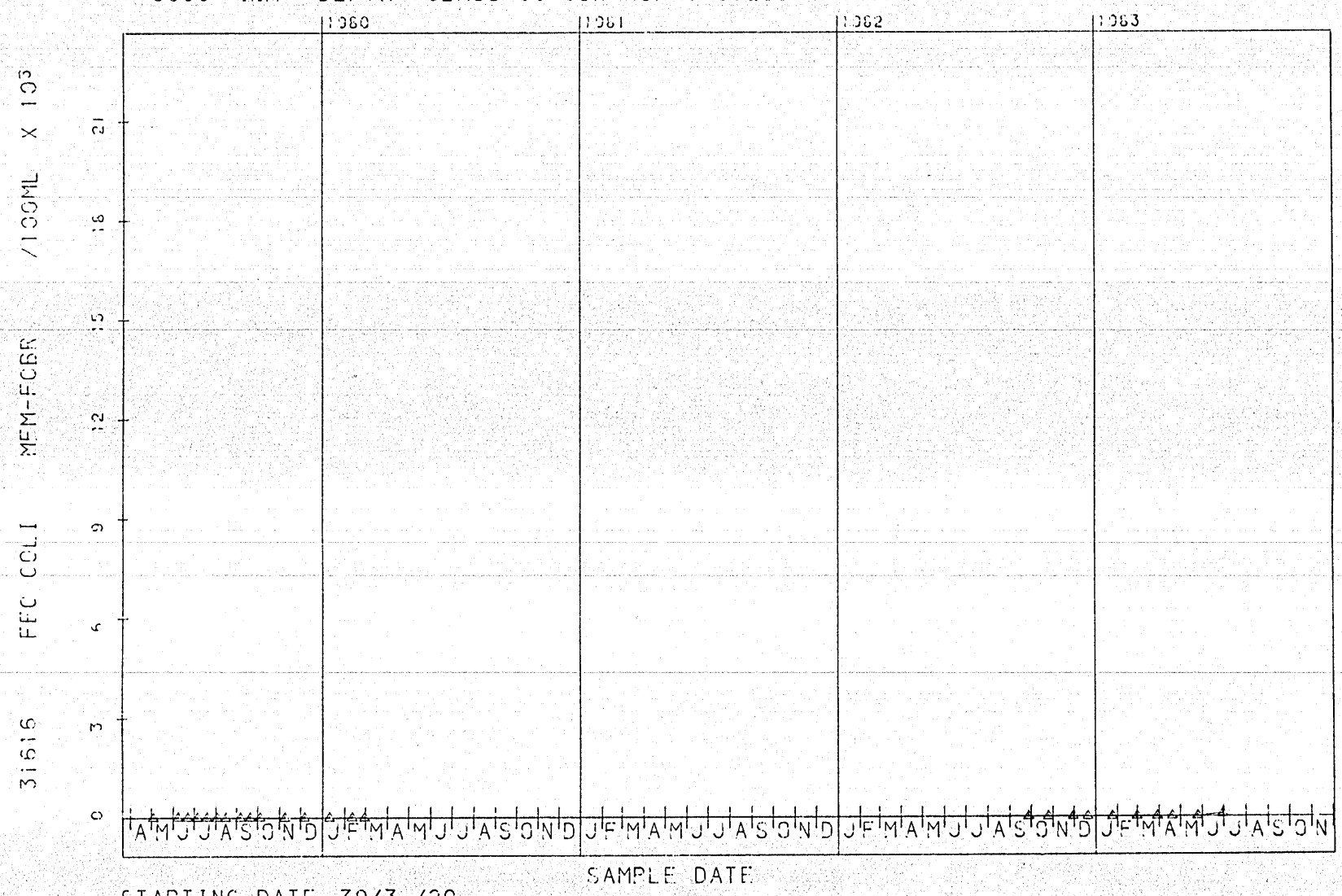
46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585287-0554051

Figure IV-35.


31616 FEC COLI MFM-FCBR /100ML X 10³
0
3
6
9
12
15
18
21
1980
1981
1982
1983
AMJJASONDJFMAMJJASONDJFMAMJJASONDJFMA

46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585288-0554052

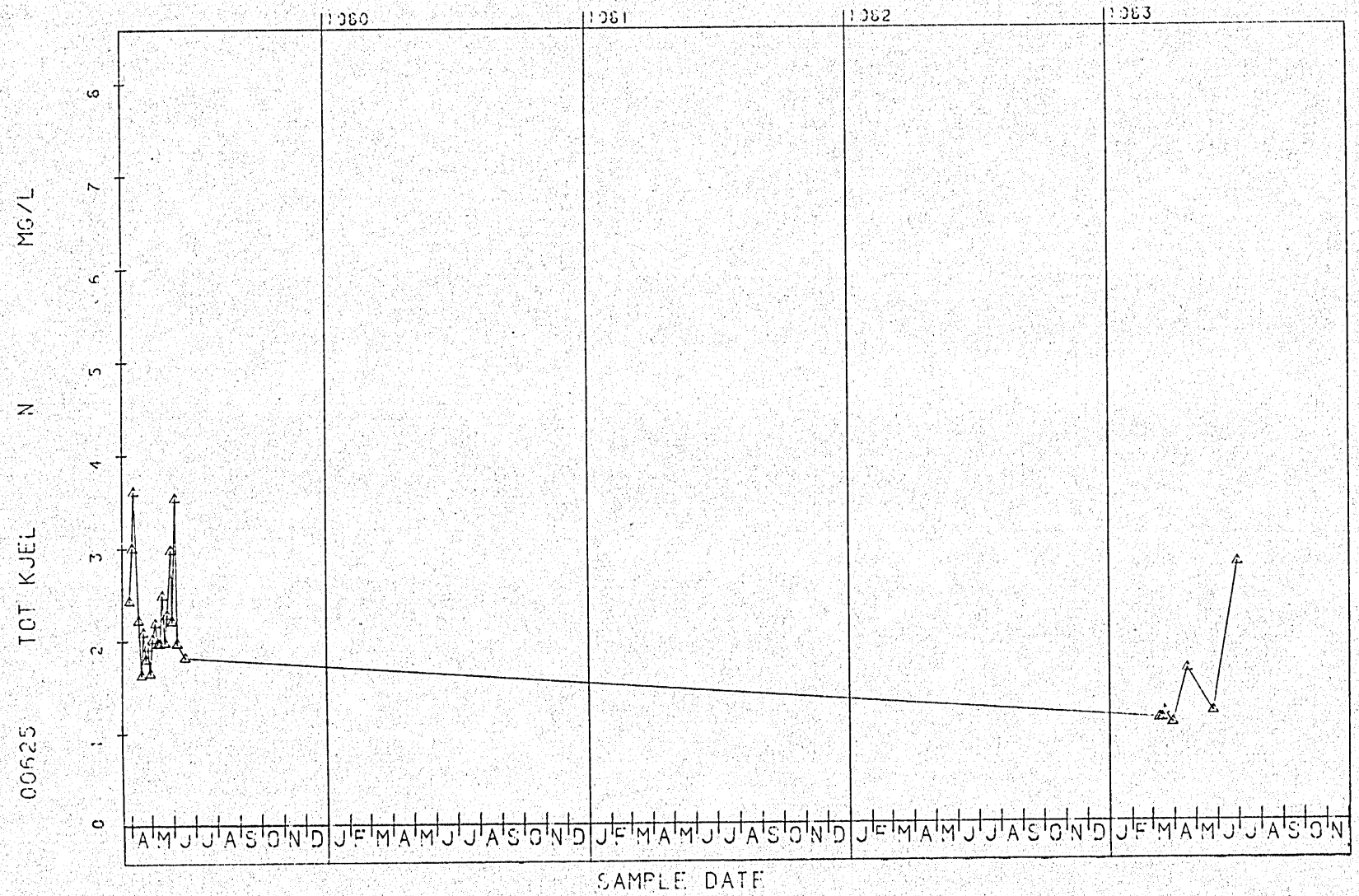
Figure IV-36.



STARTING DATE 79/3 /20

46WA01
43 31 44.0 096 57 10.0 2
WALL LAKE OUTLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593324-0621719

Figure IV-37.



STARTING DATE 79/3 /20

Figure IV-38.

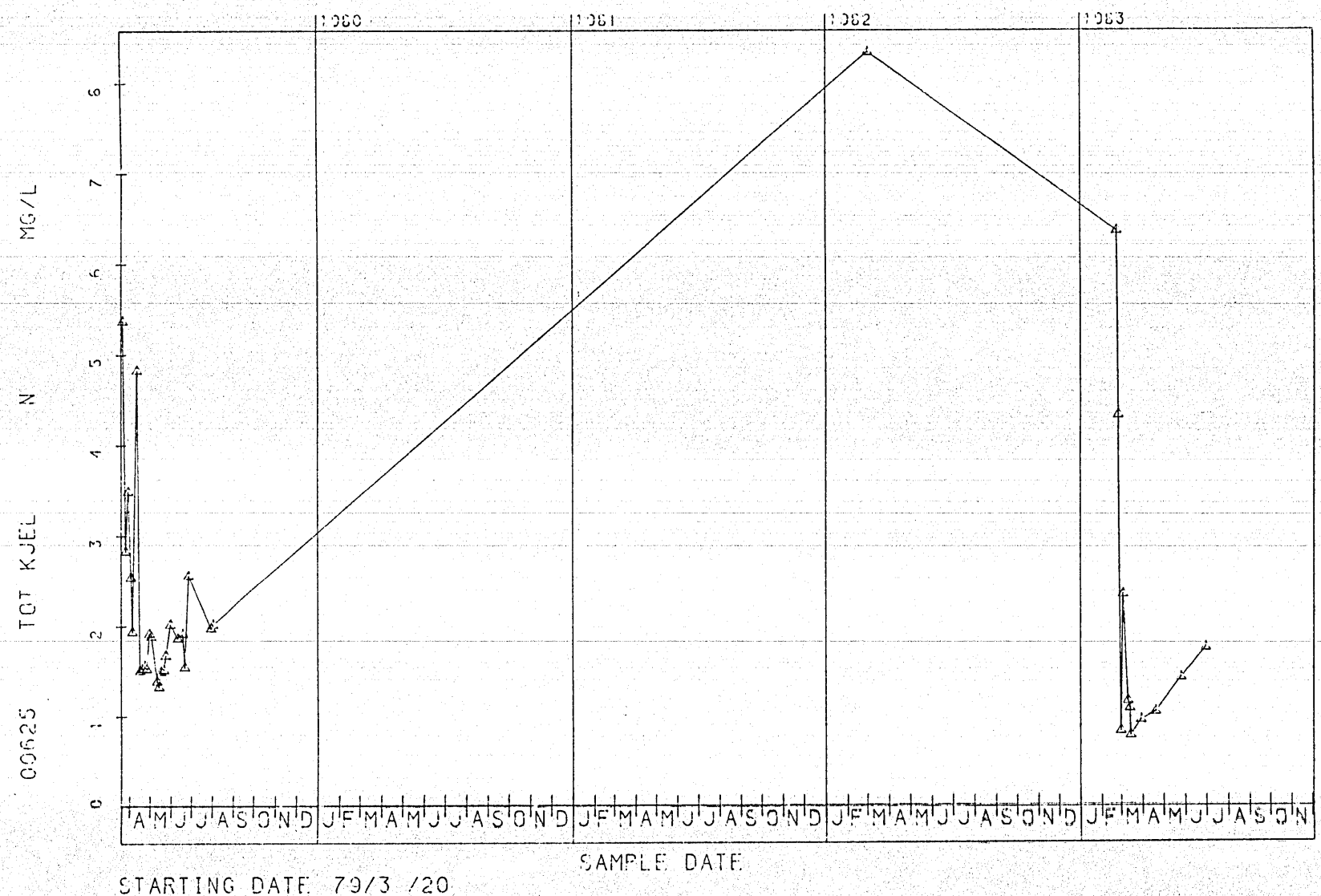
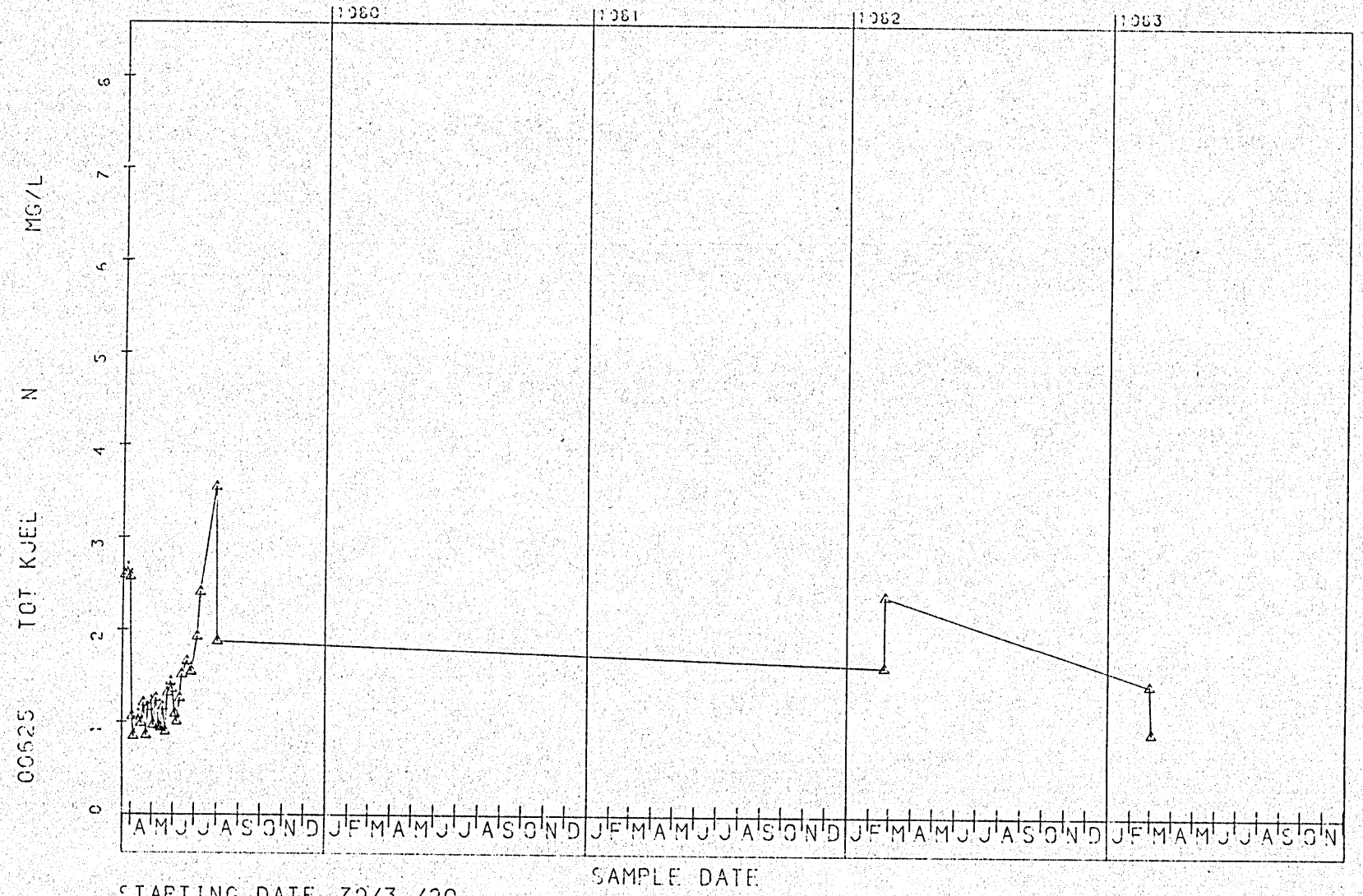

46WA02
43 3i 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46009 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSF 0593325-0621720
00625 TOT KJEL N MG/L
1980
1981
1982
1983
SAMPLE DATE
STARTING DATE 79/3 /20

Figure IV-39.

46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T10IN R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593326-0621721



STARTING DATE 79/3 /20

46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593327-0621722

Figure IV-40.

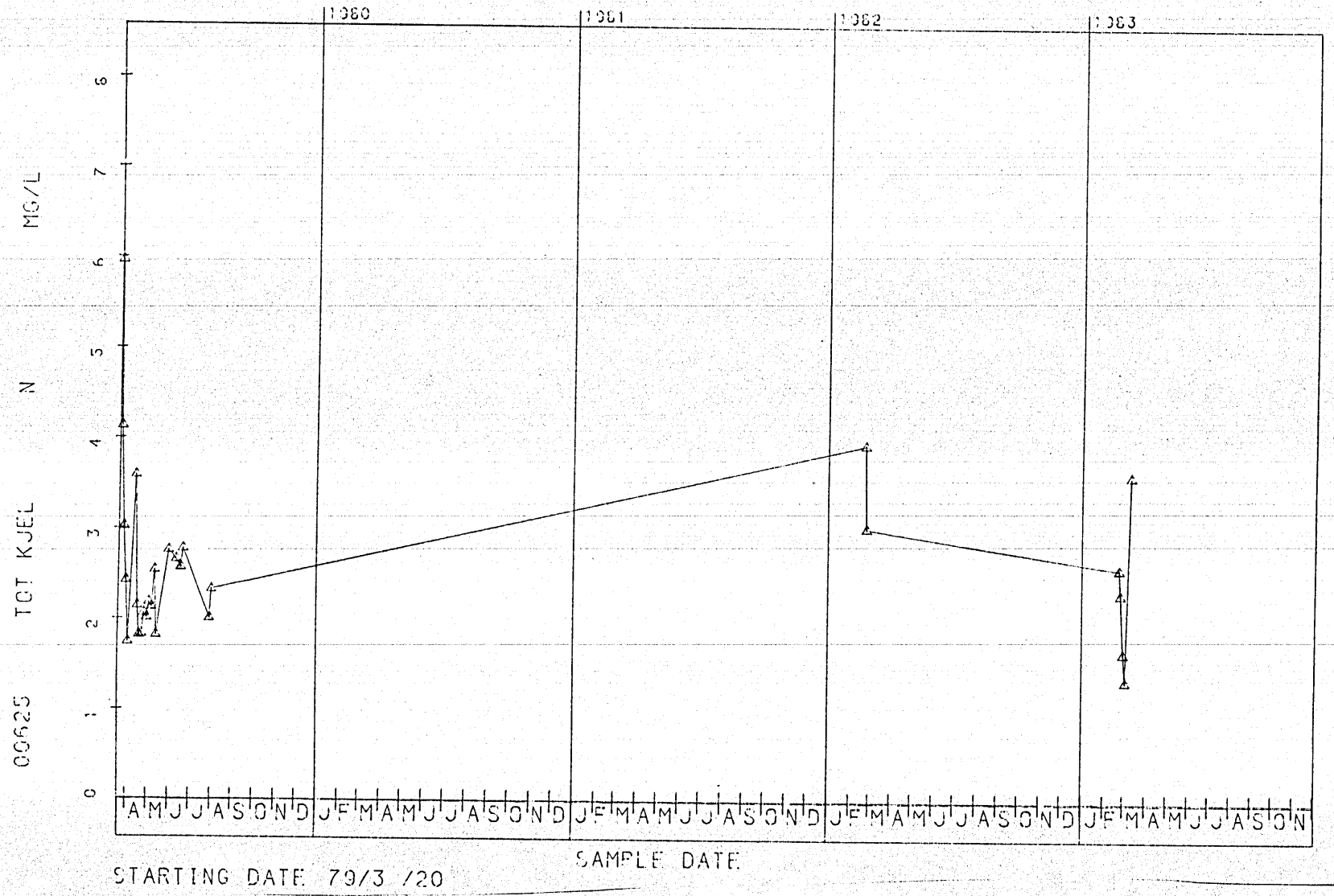
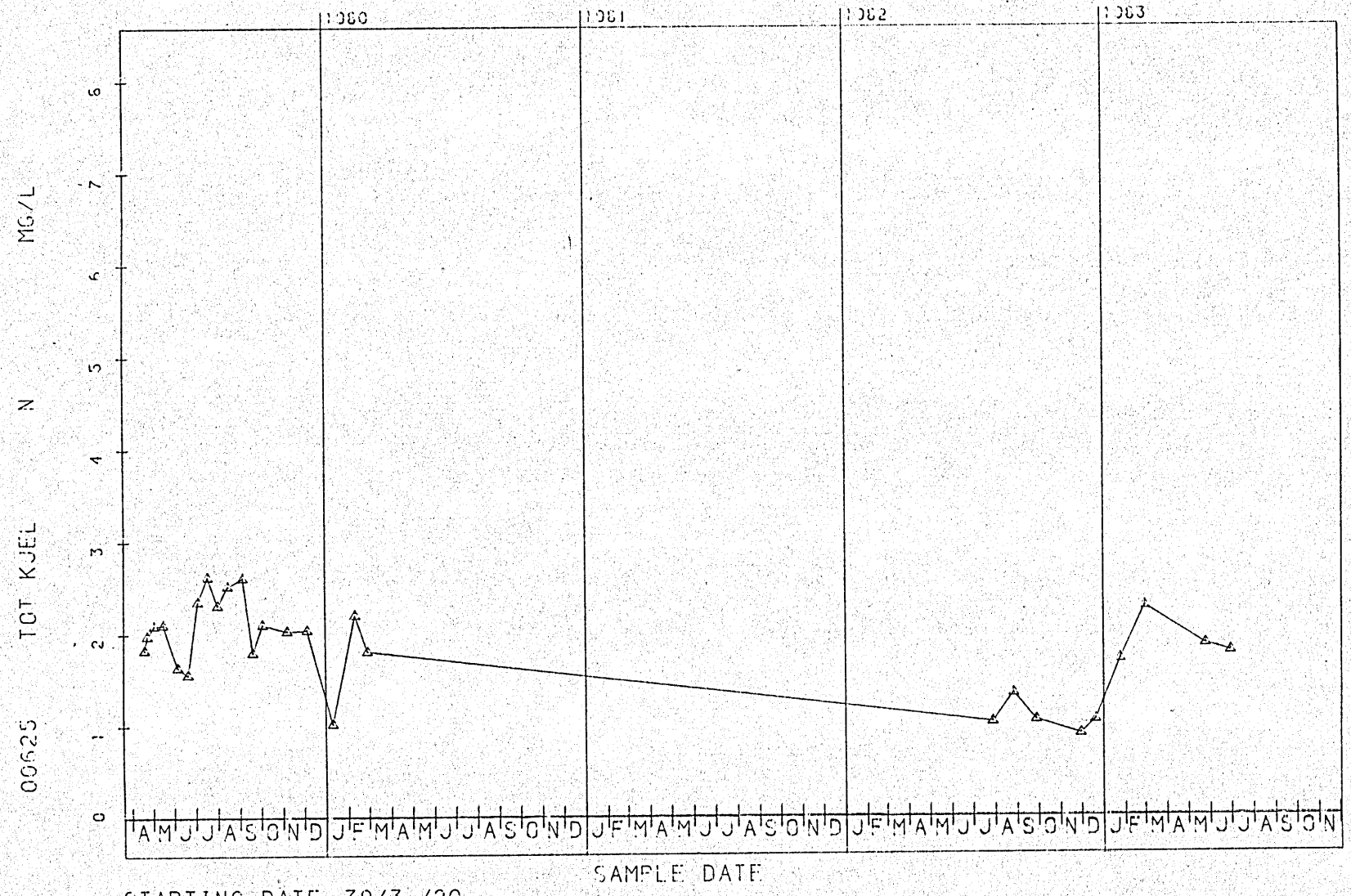
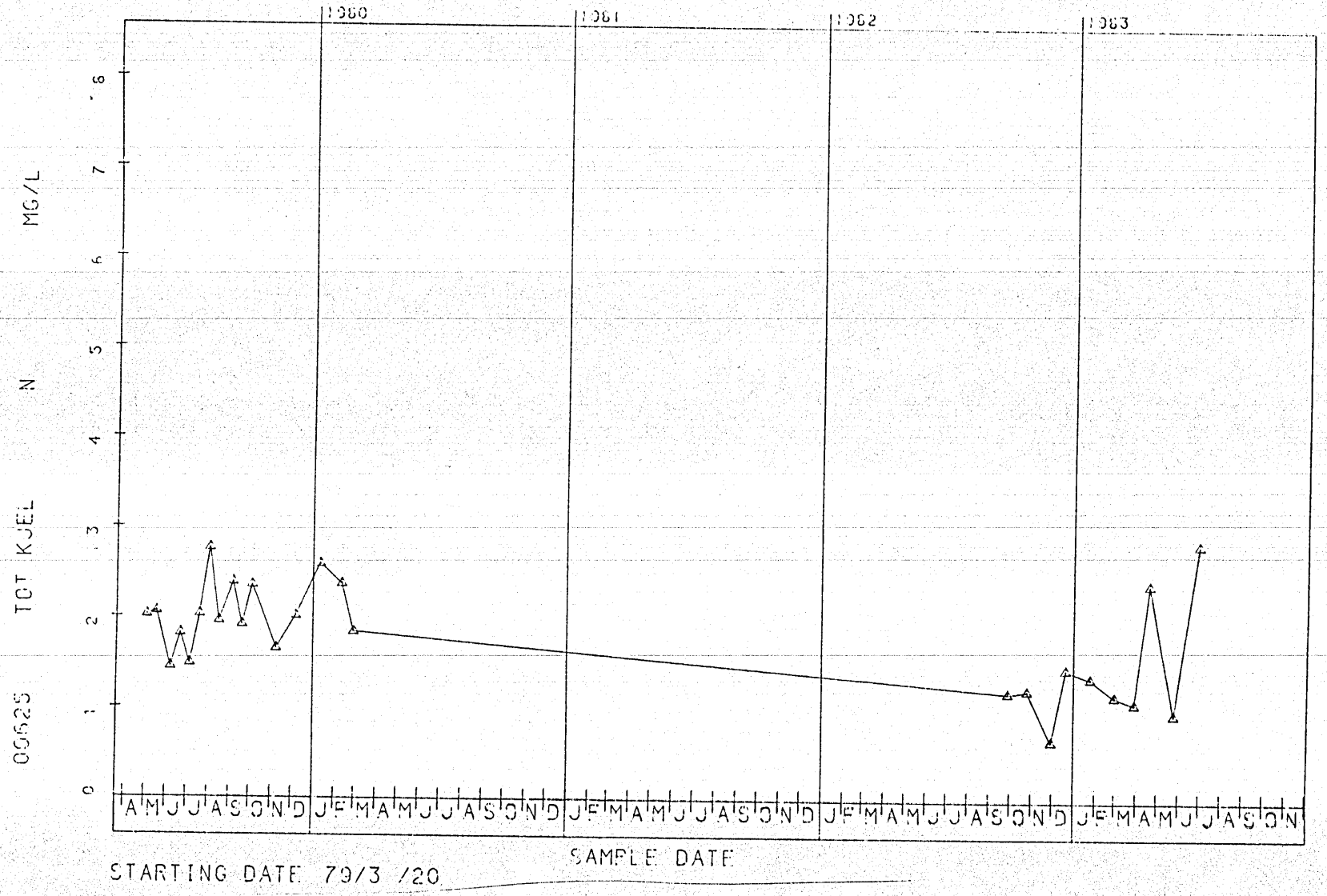


Figure IV-41.


46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585287 0554051
1980
1981
1982
1983
00625 TOT KJEL N MG/L
0
1
2
3
4
5
6
7
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N
SAMPLE DATE
STARTING DATE 79/3 /20

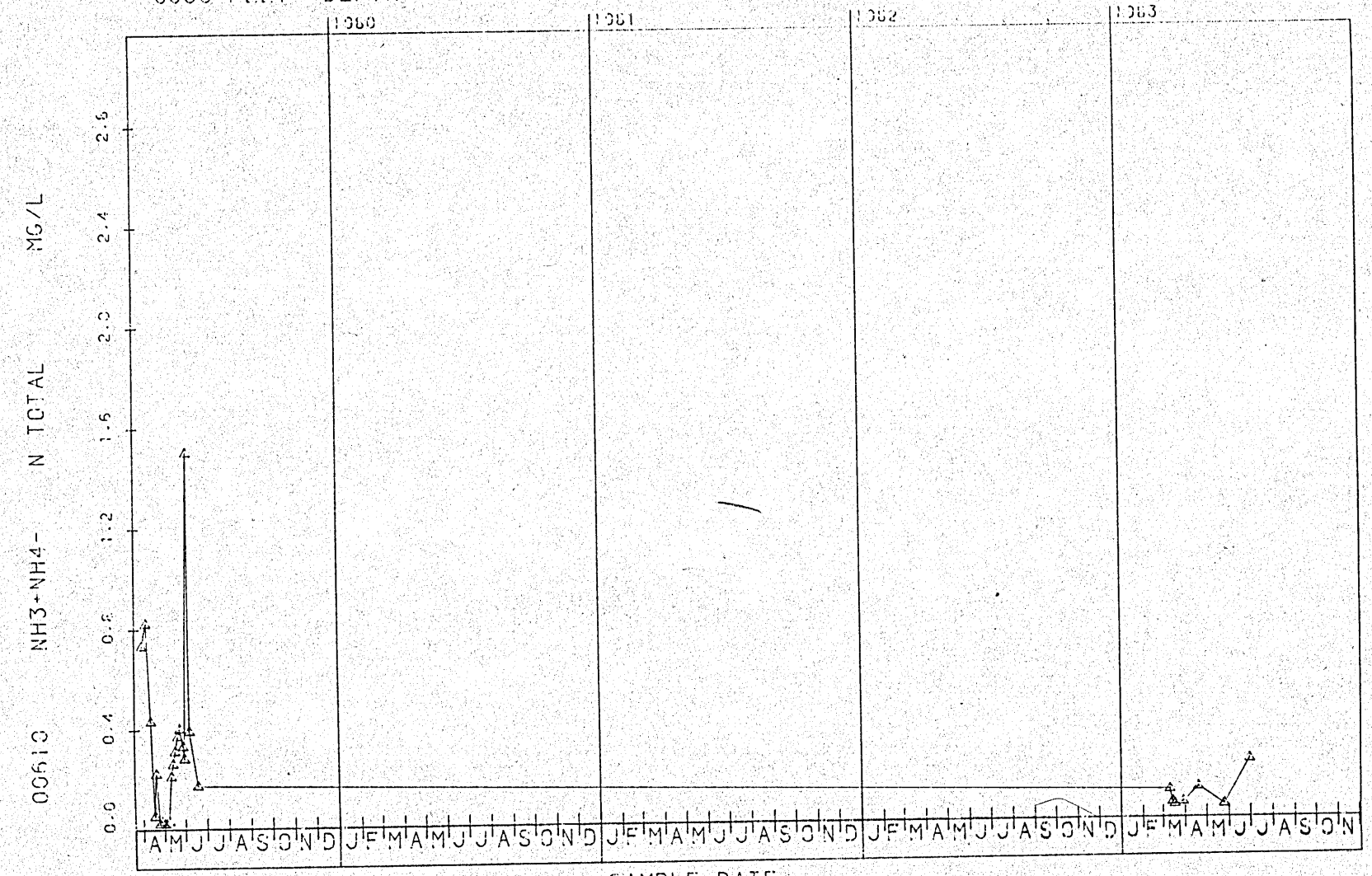
46WA06
43 3i 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585288-0554052

Figure IV-42.



STORET
46WA01
43 31 44.0 096 57 10.0 2
WALL LAKE OUTLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593324-0621710

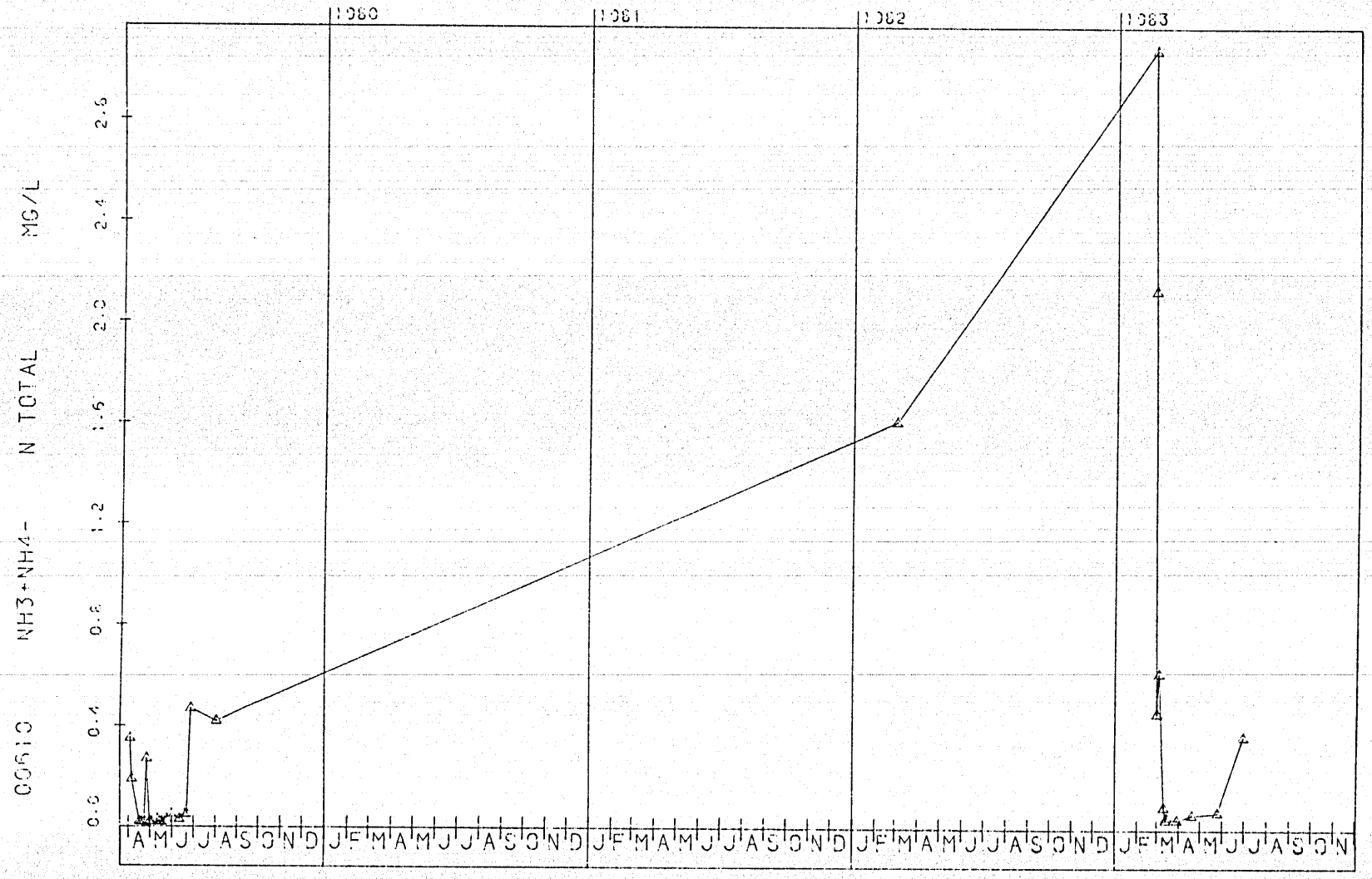
Figure IV-43.



STARTING DATE 79/3 /20

STORET
46WA02
43 31 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593325-0621720

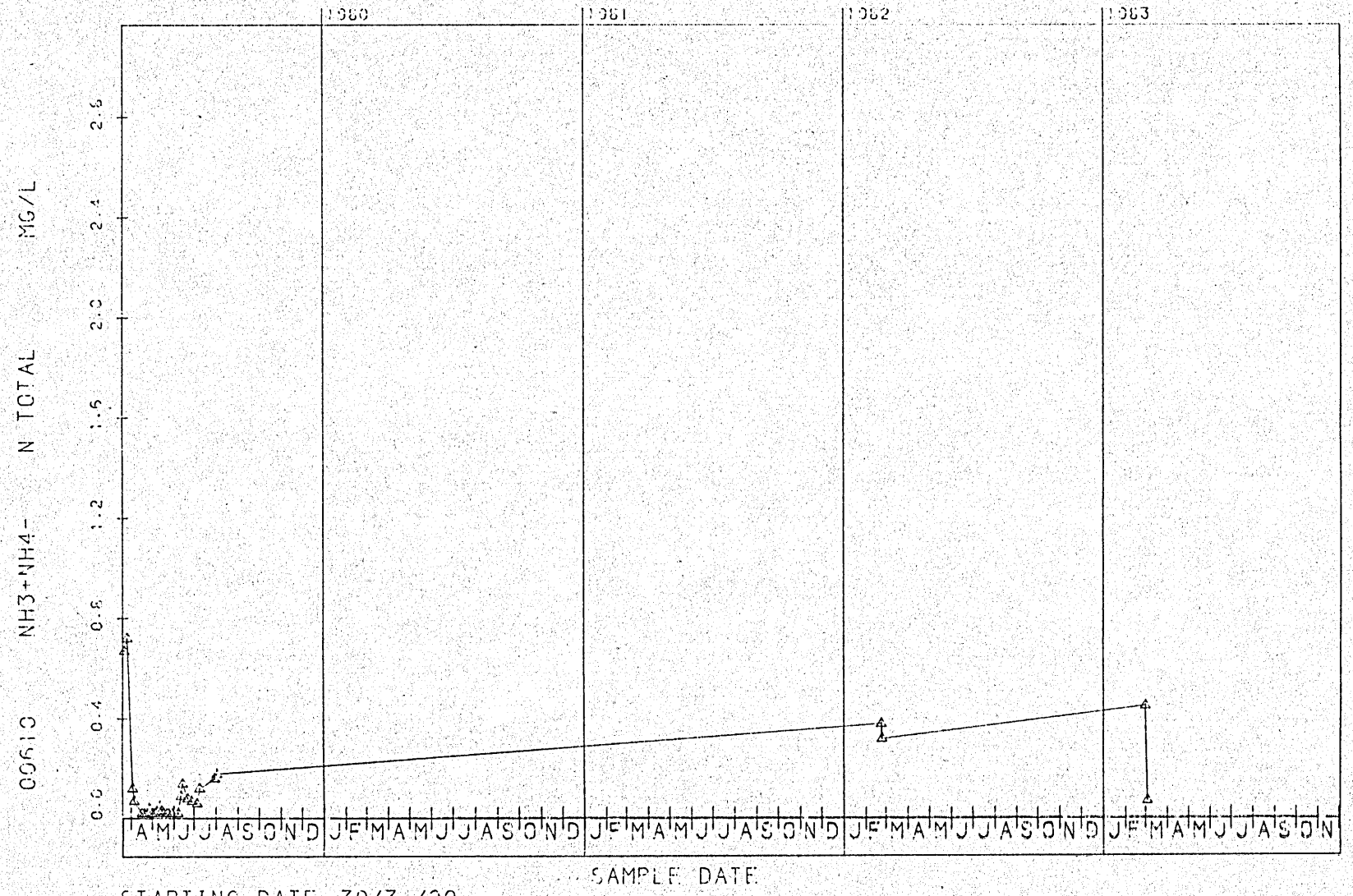
Figure IV-44.



STARTING DATE 7973 720

46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0503326-0621721

Figure IV-45.



STARTING DATE 79/3 /20

Figure IV-46.

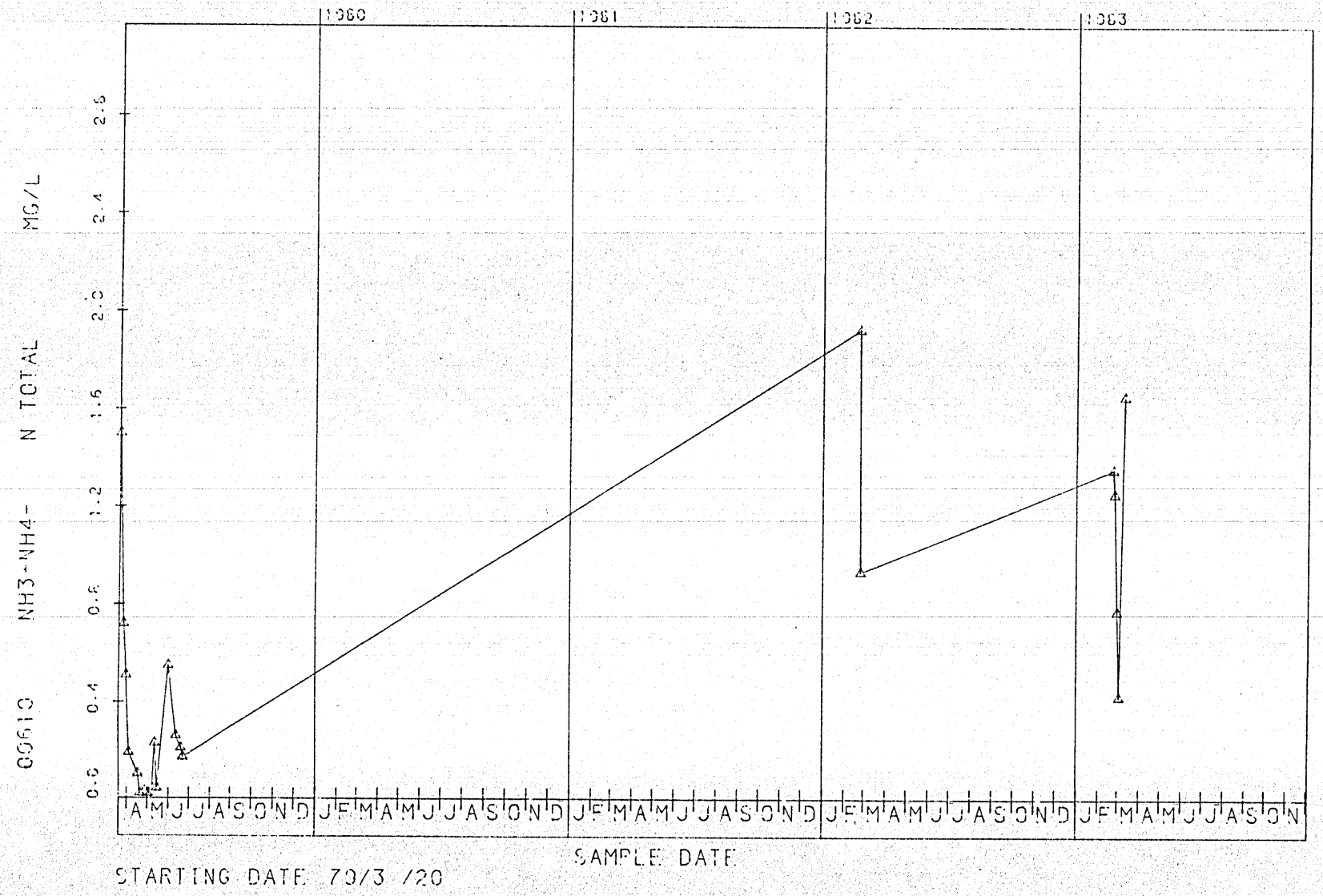

STORET
46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0503327-0621722
00610 NH3-NH4- N TOTAL MG/L
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
1980
1981
1982
1983
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N
SAMPLE DATE
STARTING DATE 79/3 /20

Figure IV-47.

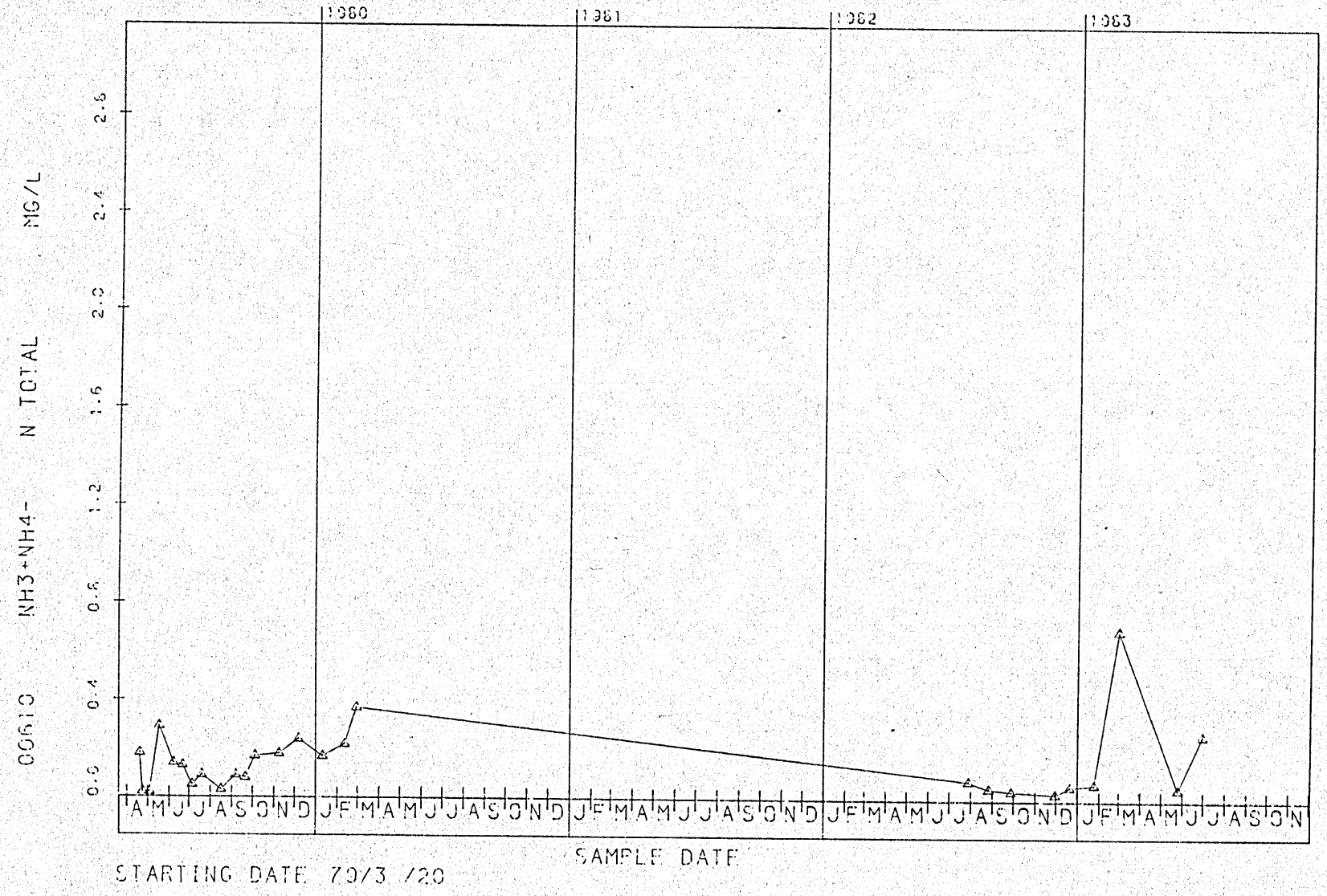
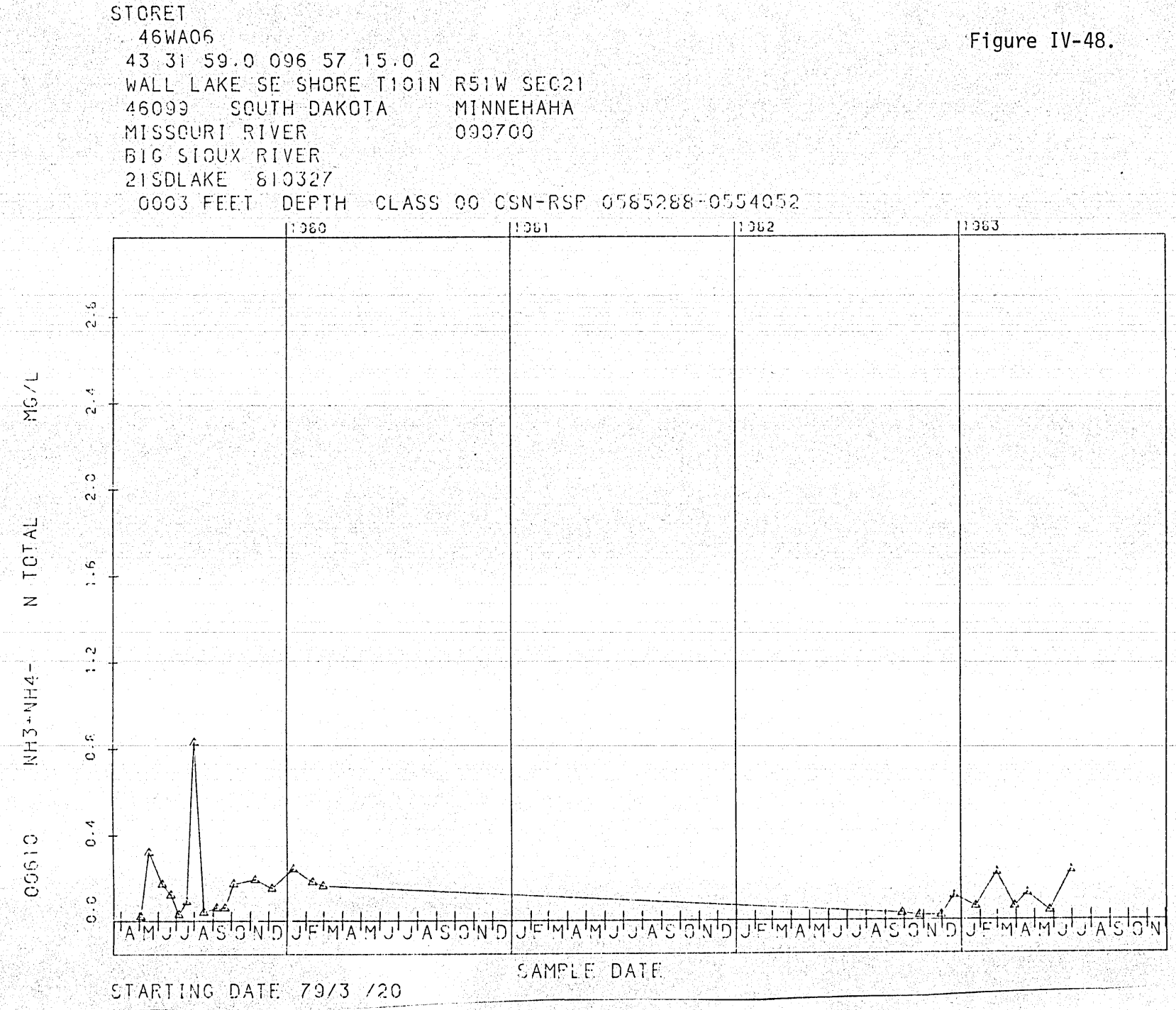
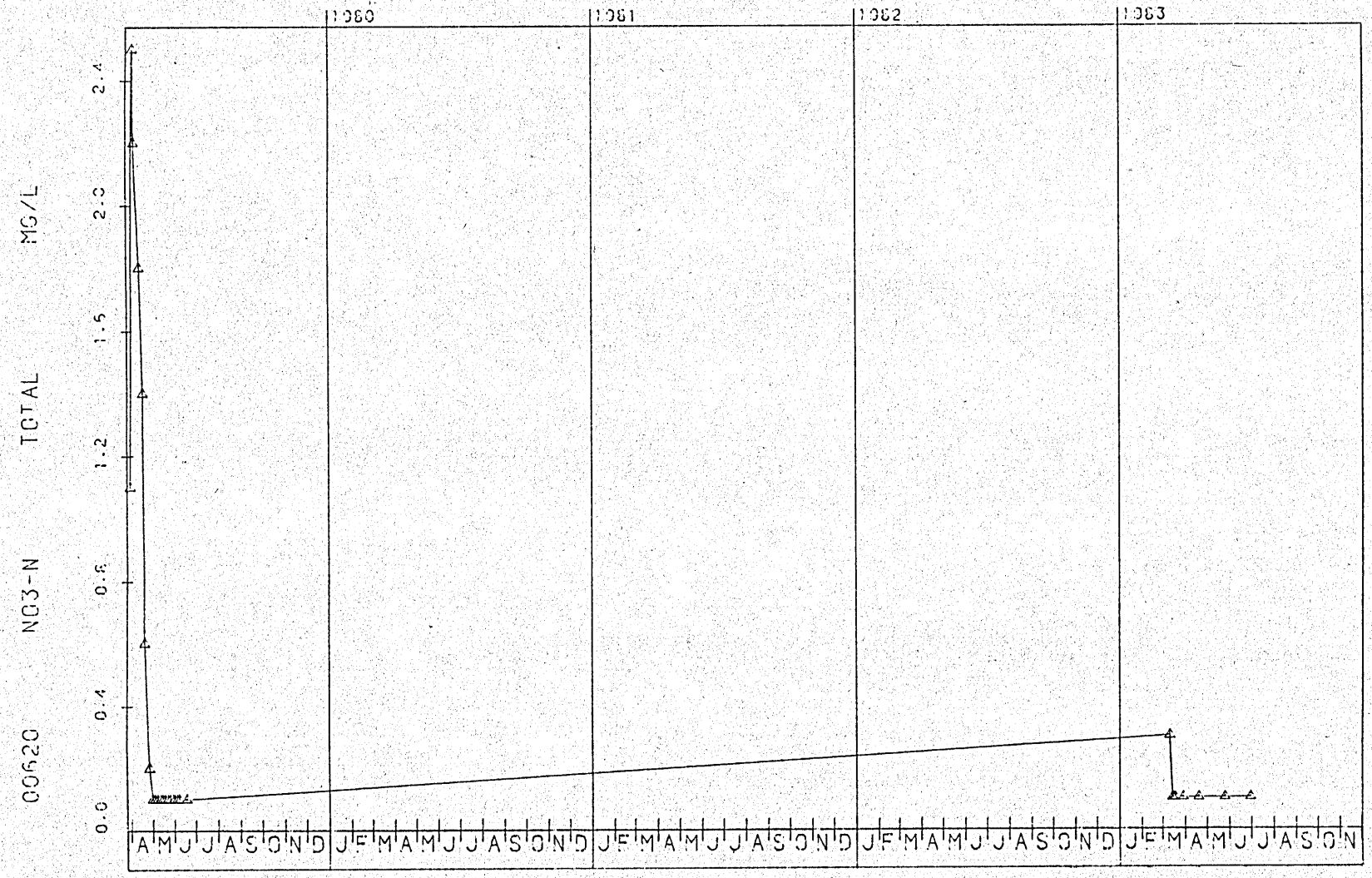

46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585287-0554051
00613 NH3+NH4- N TOTAL MG/L
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
1980
1981
1982
1983
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N
SAMPLE DATE
STARTING DATE 79/3 /20

Figure IV-48.


STORET
46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585288-0554052
1980
1981
1982
1983
00610 NH3+NH4- N TOTAL MG/L
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N
SAMPLE DATE
STARTING DATE 79/3 /20

46WA01
43 31 44.0 096 57 10.0 2
WALL LAKE OUTLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593324-0621719

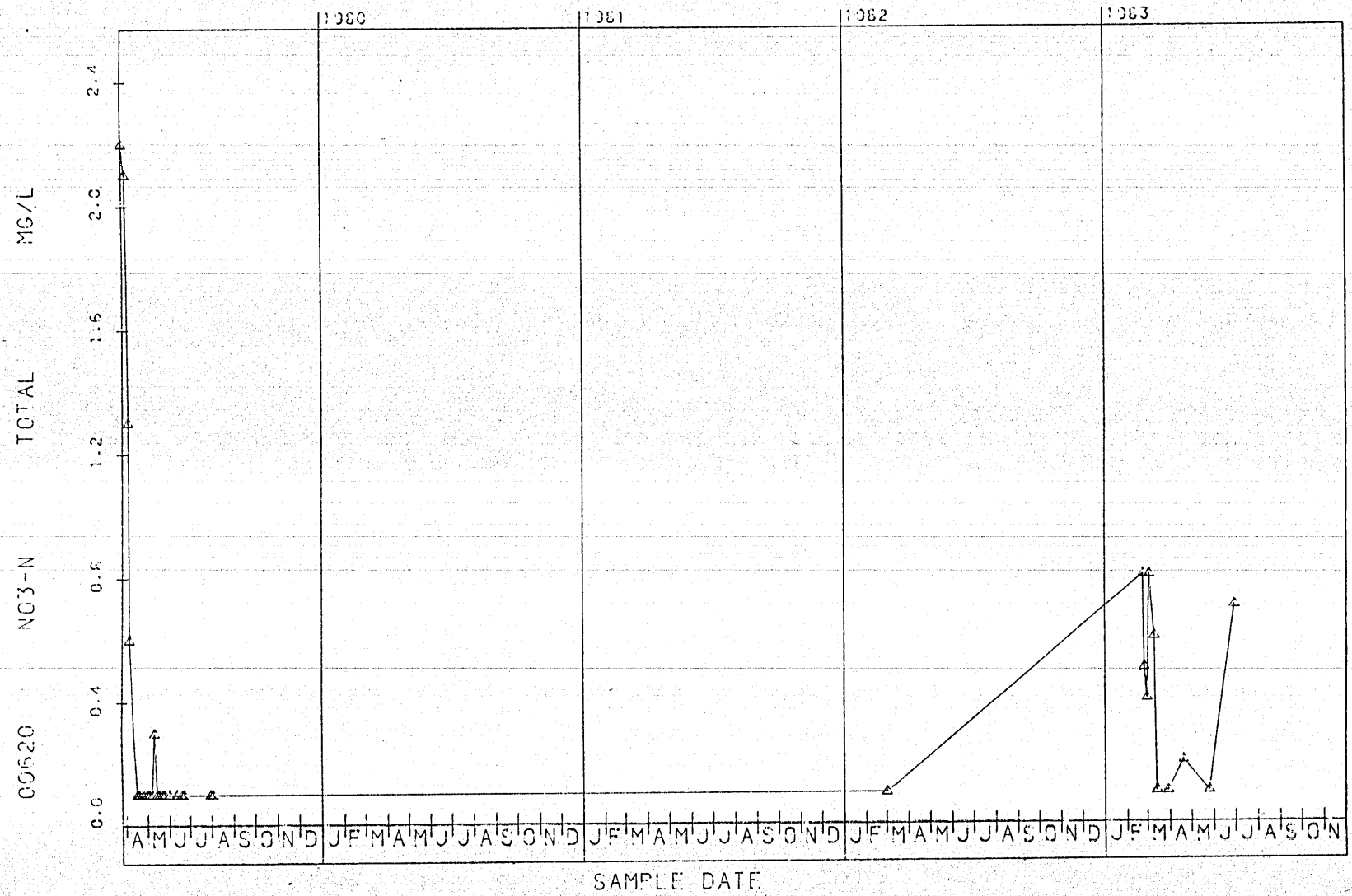
Figure IV-49.



STARTING DATE 79/3 /26

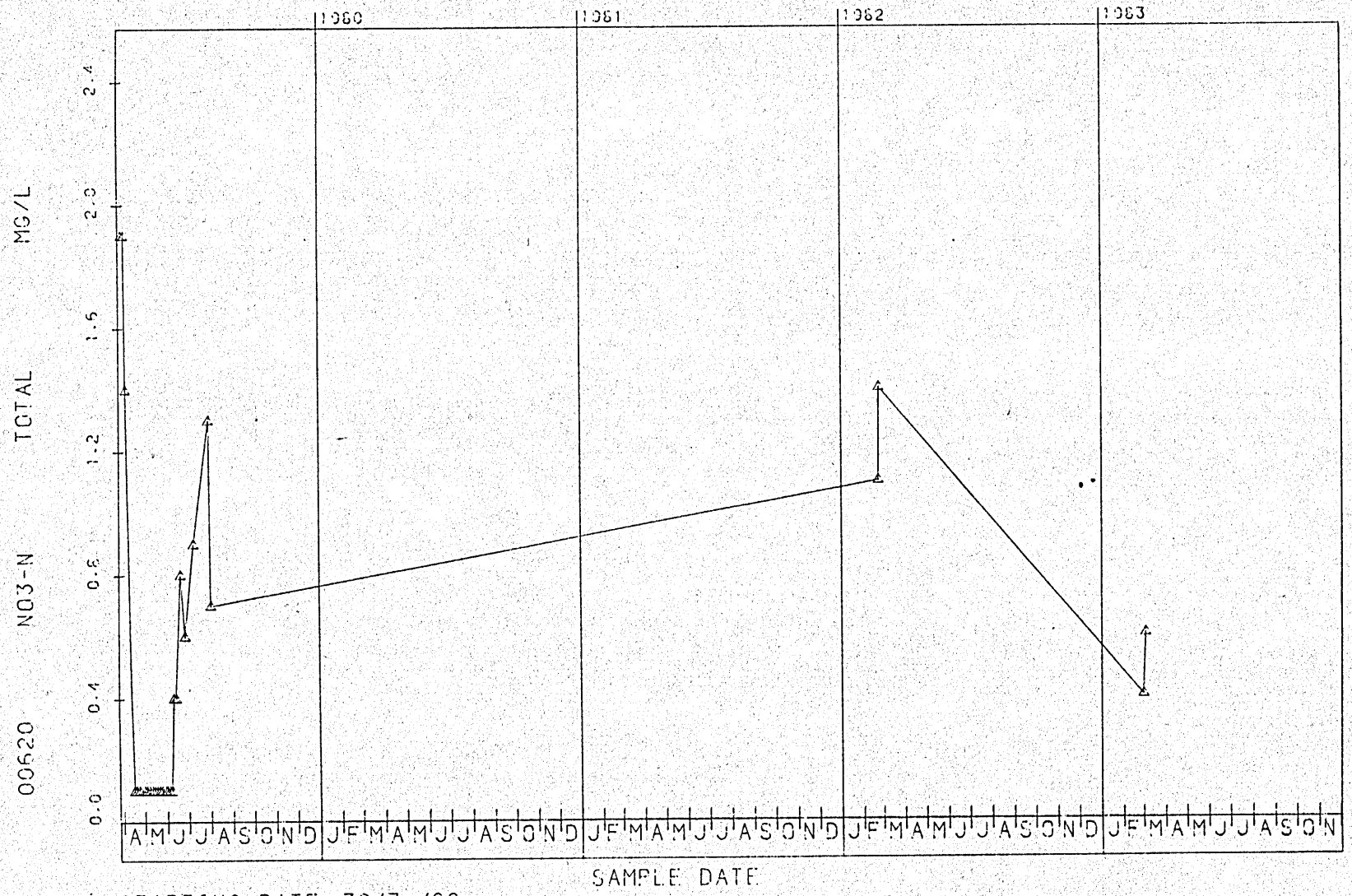
46WA02
43 3i 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593325-0621720

Figure IV-50.



46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593326-0621721

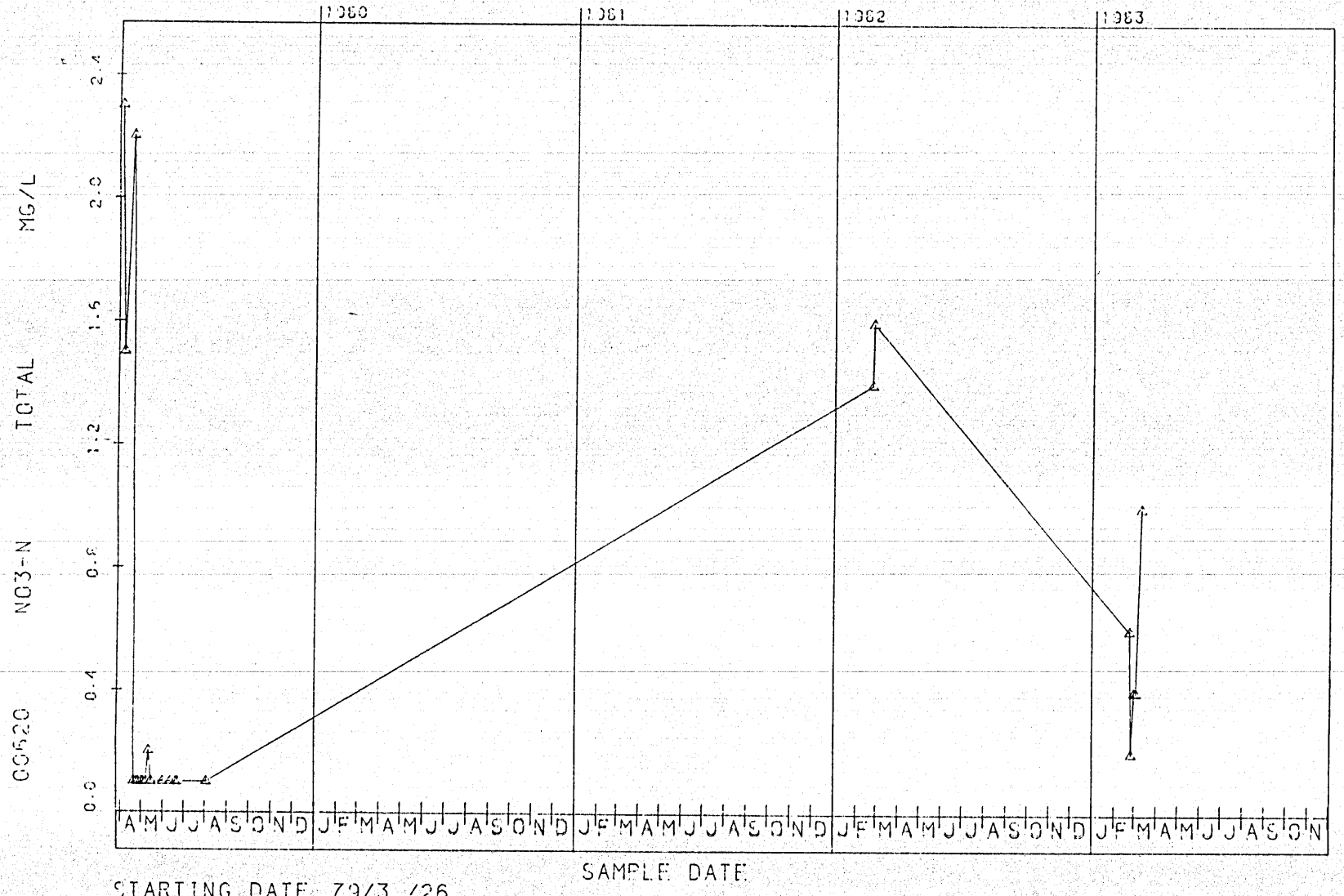
Figure IV-51.



STARTING DATE 79/3 /26

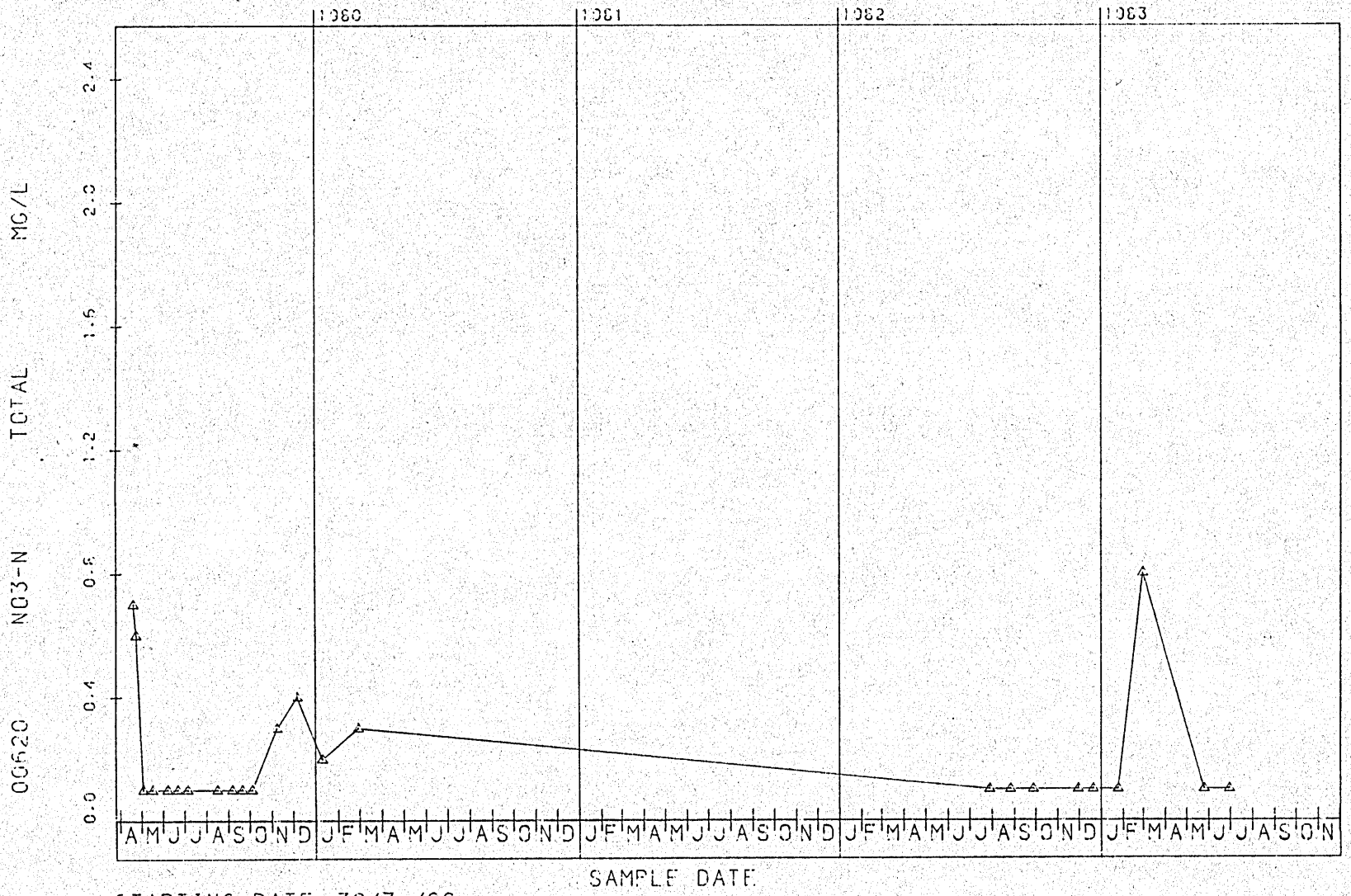
46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593327-0621722

Figure IV-52.



46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585287-0554051

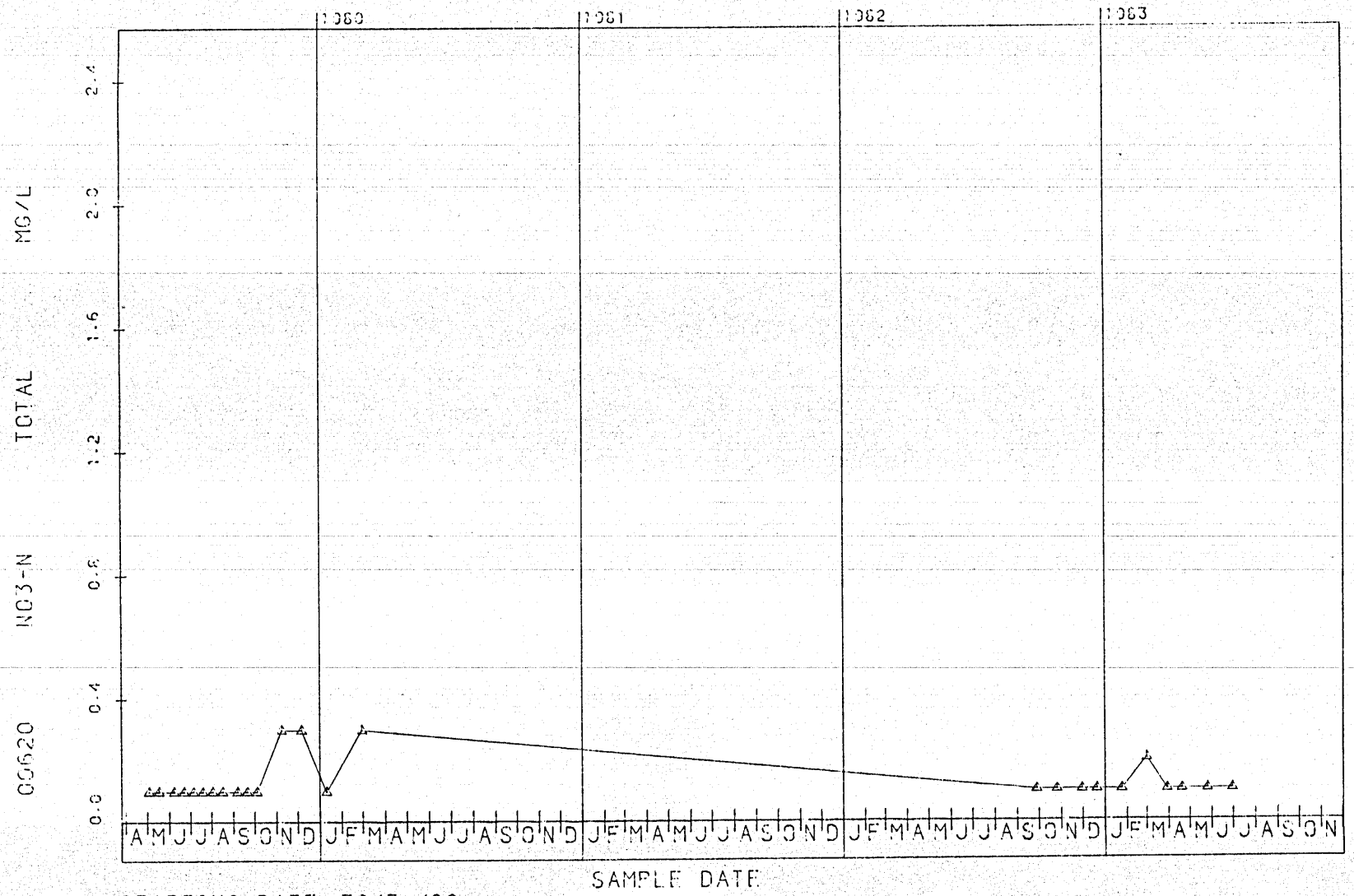
Figure IV-53.



STARTING DATE 79/3 /26

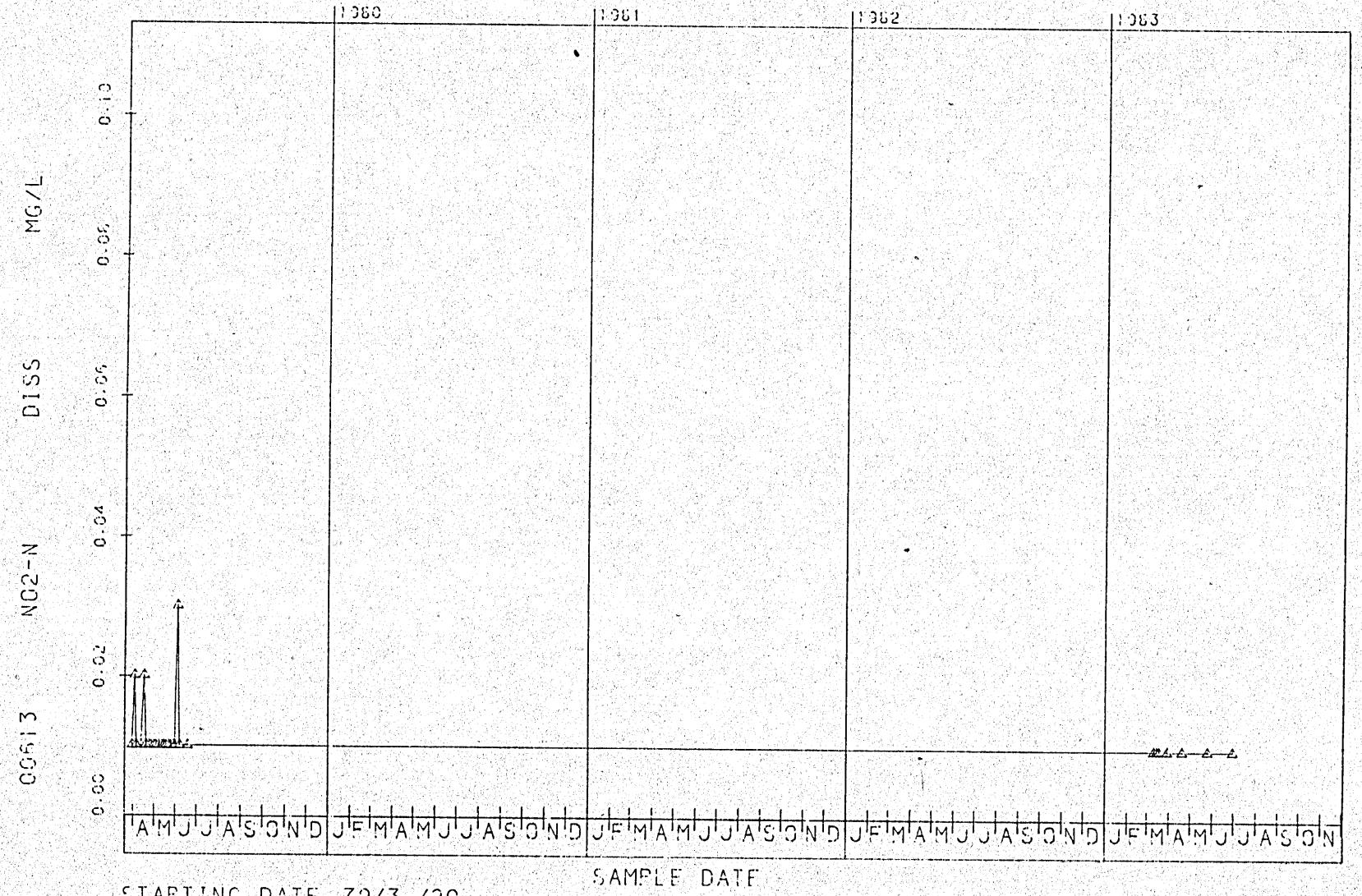
46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585288-0554052

Figure IV-54.



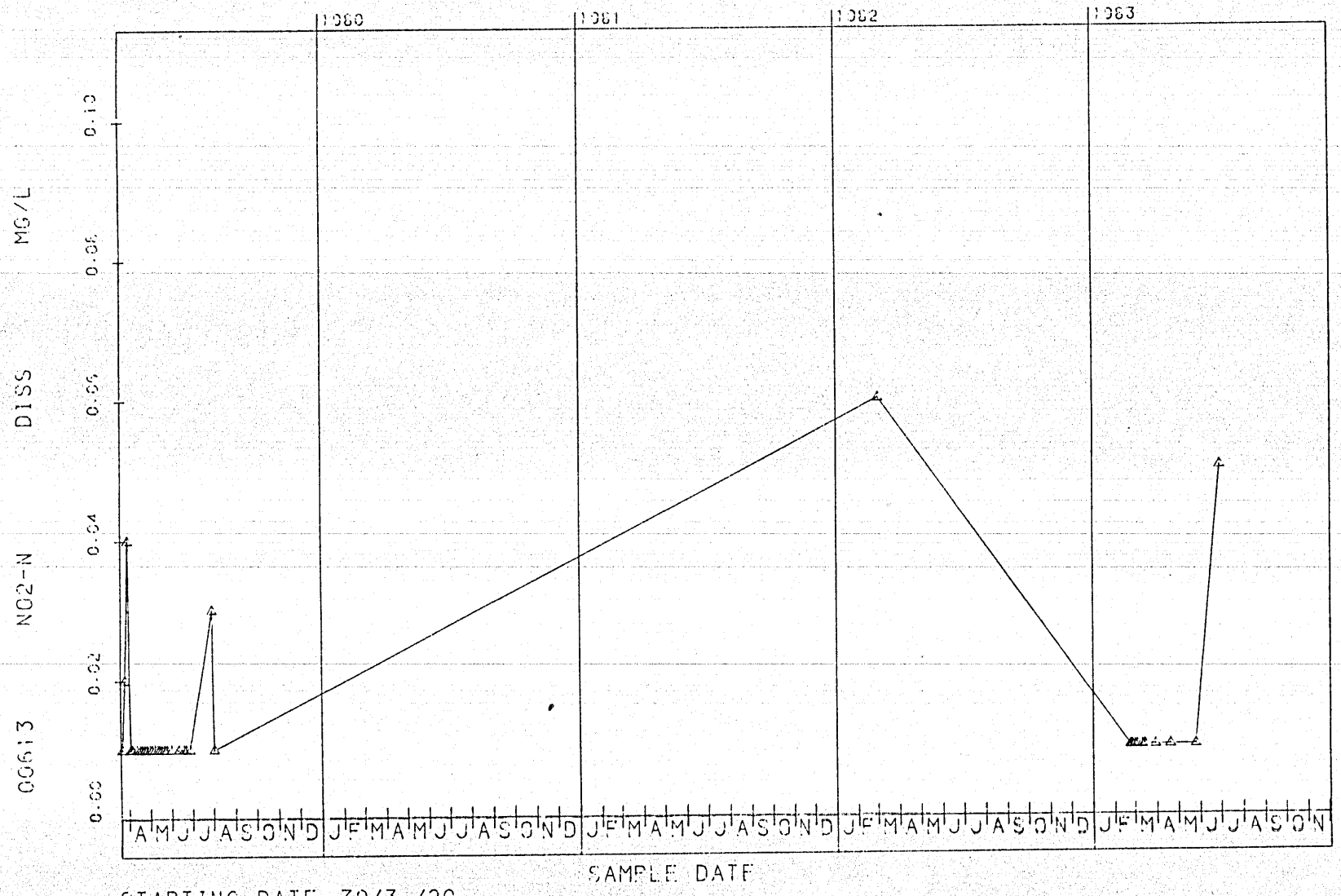
46WA01
43 31 44.0 096 57 10.0 2
WALL LAKE OUTLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593324-0621719

Figure IV-55.



46WA02
43 3i 57.0 096 58 11.0 2
WALL LAKE WEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593325-0621720

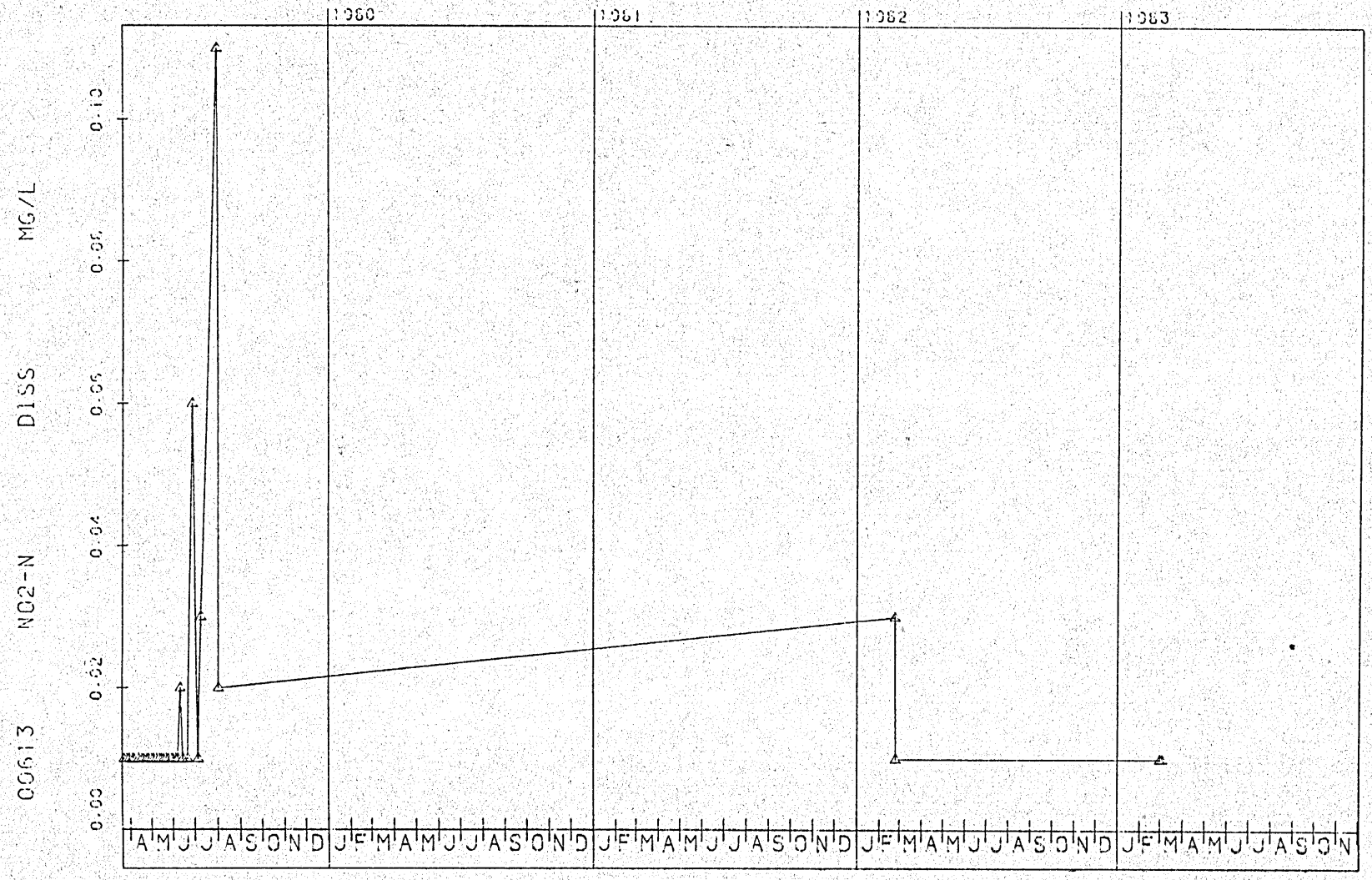
Figure IV-56.



STARTING DATE 79/3 /20

46WA03
43 32 20.0 096 57 54.0 2
WALL LAKE NORTHWEST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593326-0621721

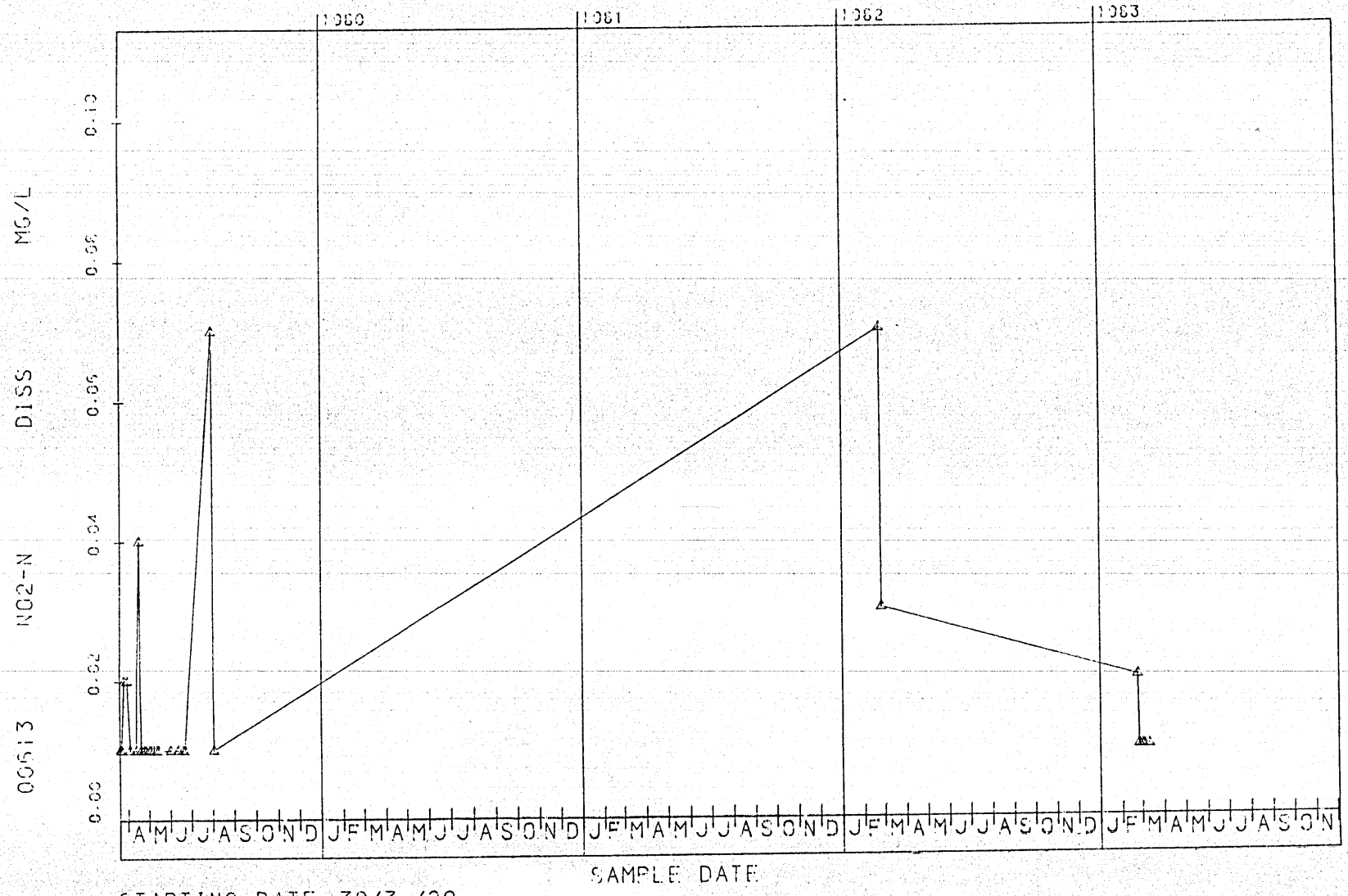
Figure IV-57.



STARTING DATE 79/3 /20

46WA04
43 32 23.0 096 57 32.0 2
WALL LAKE NORTHEAST INLET T101N R51W SECTION 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810523
0000 FEET DEPTH CLASS 00 CSN-RSP 0593327 0621722

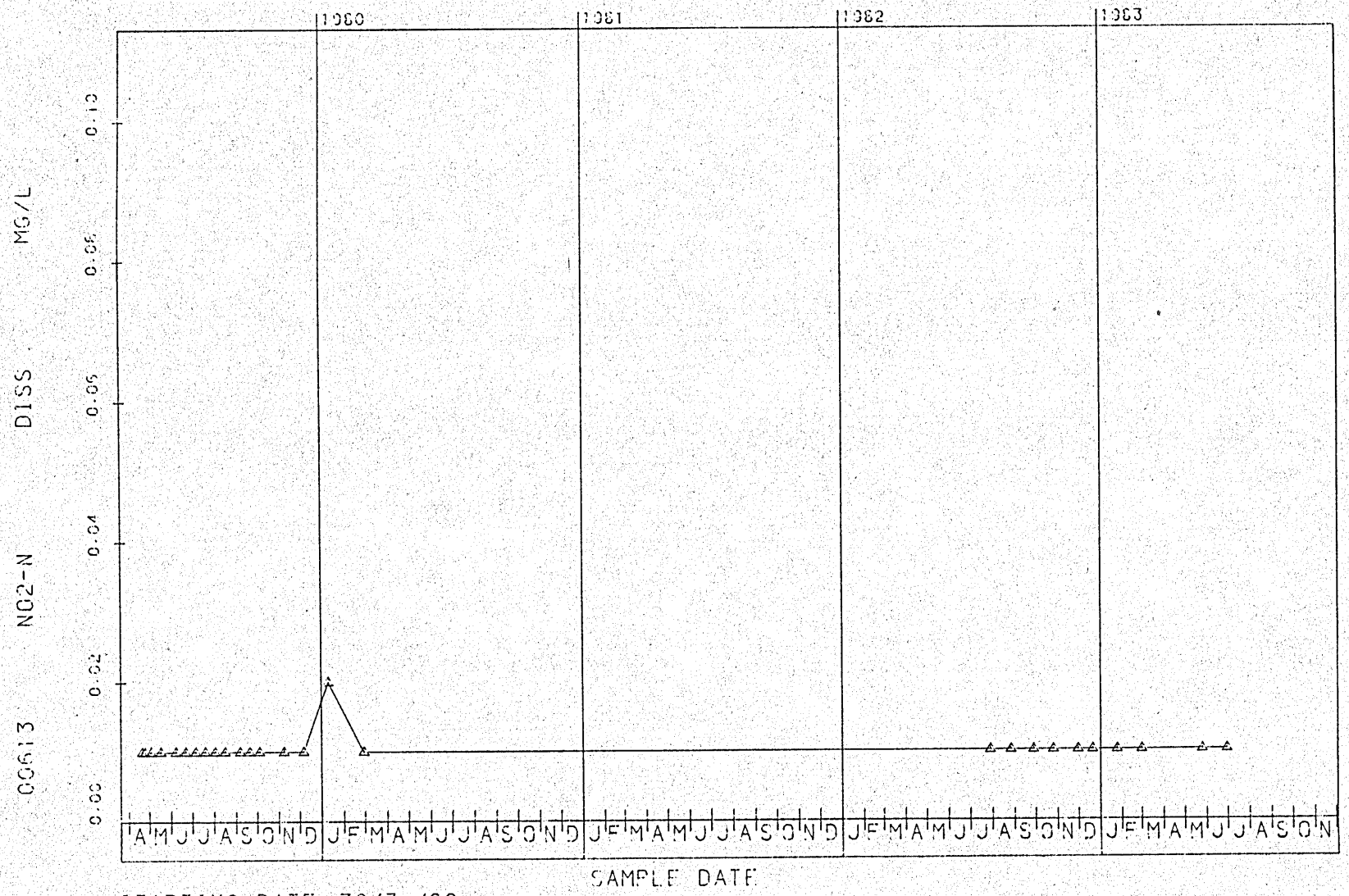
Figure IV-58.



STARTING DATE 79/3 /20

46WA05
43 32 19.0 096 57 40.0 2
WALL LAKE N BEACH T101N R51W SEC 21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585287-0554051

Figure IV-59.



46WA06
43 31 59.0 096 57 15.0 2
WALL LAKE SE SHORE T101N R51W SEC21
46099 SOUTH DAKOTA MINNEHAHA
MISSOURI RIVER 090700
BIG SIOUX RIVER
21SDLAKE 810327
0003 FEET DEPTH CLASS 00 CSN-RSP 0585288-0554052

Figure IV-60.

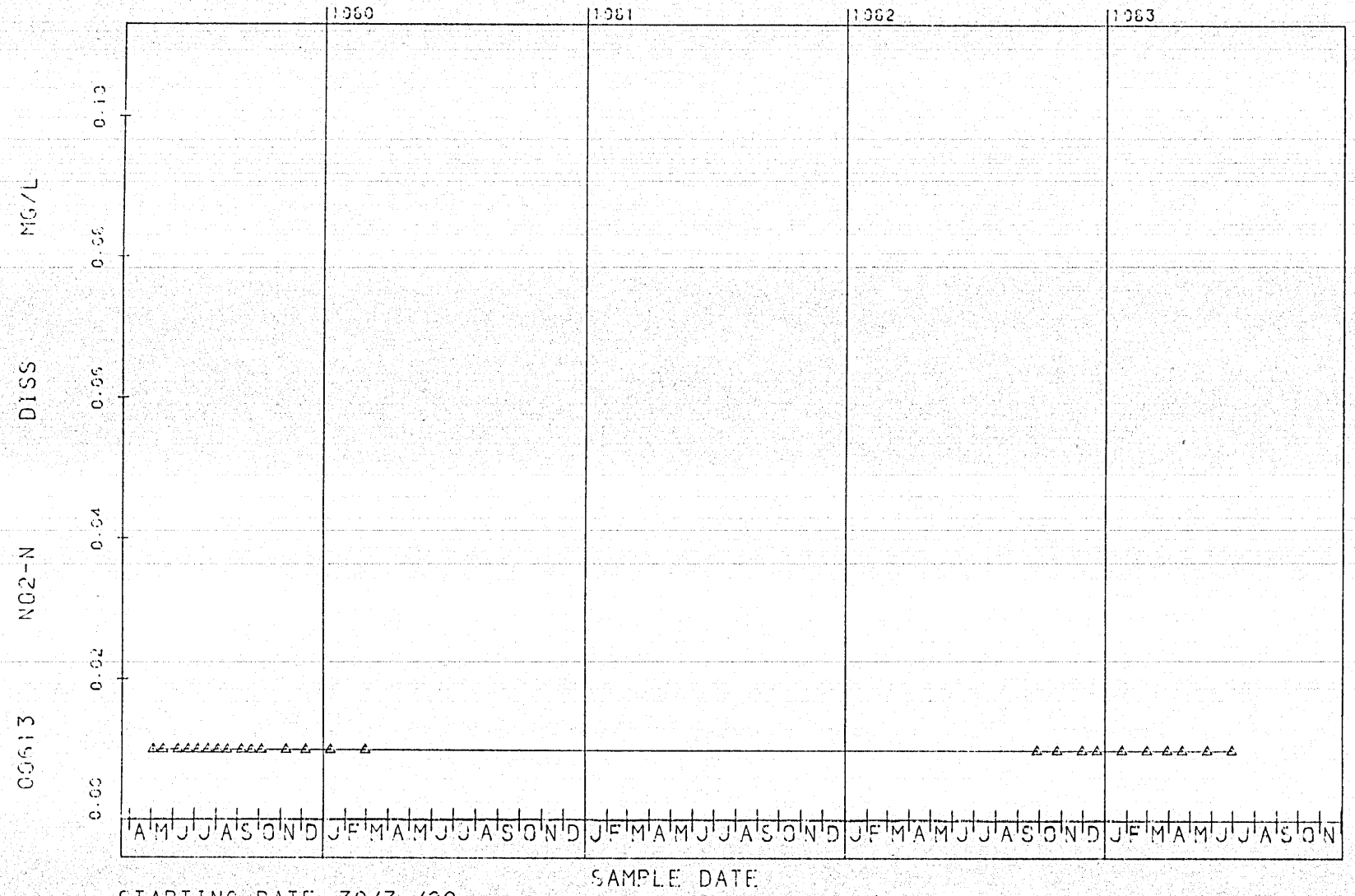


Figure IV-61.

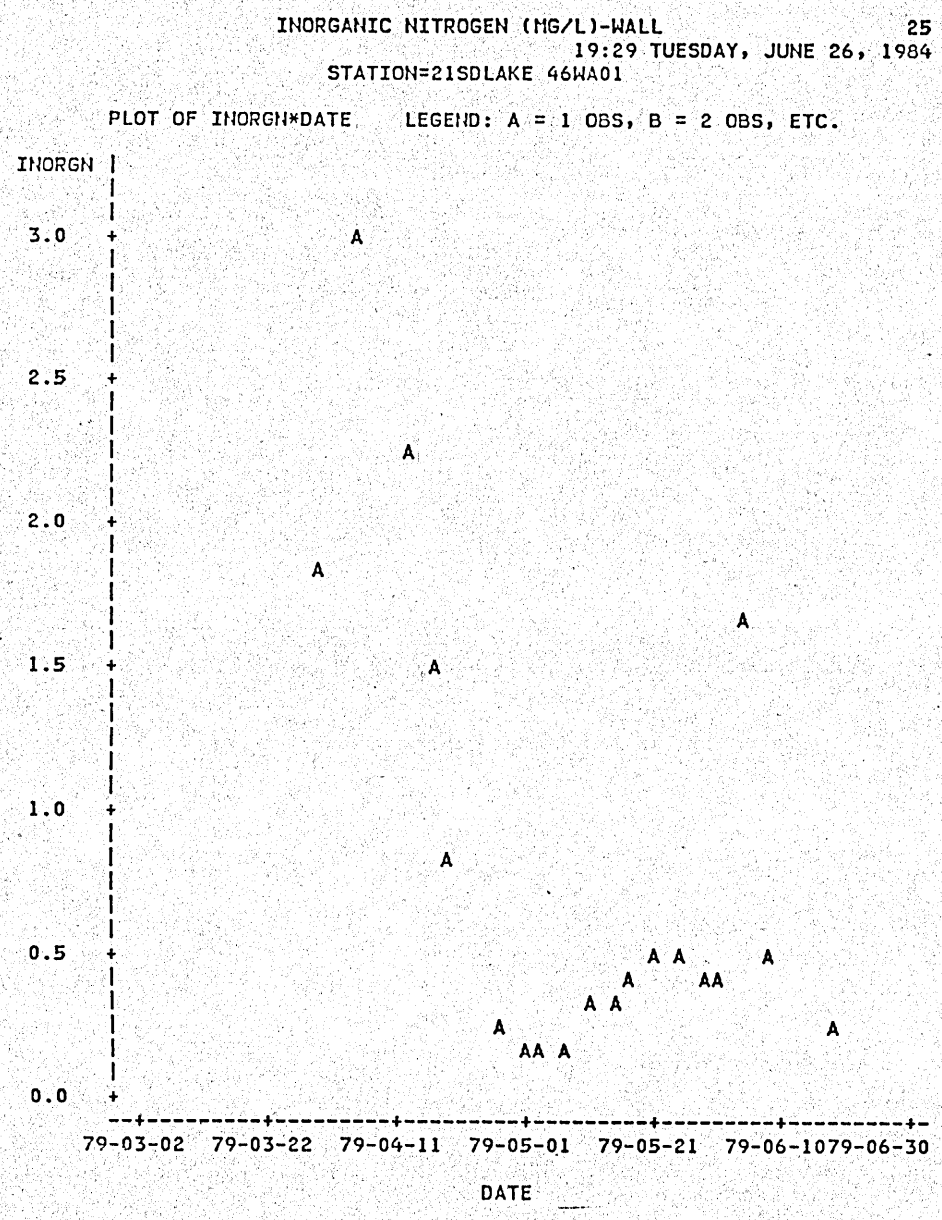

INORGANIC NITROGEN (MG/L)-WALL 25
19:29 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA01
PLOT OF INORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
3.0
2.5
2.0
1.5
1.0
0.5
0.0
79-03-02
79-03-22
79-04-11
79-05-01
79-05-21
79-06-10
79-06-30
DATE

Figure IV-62.

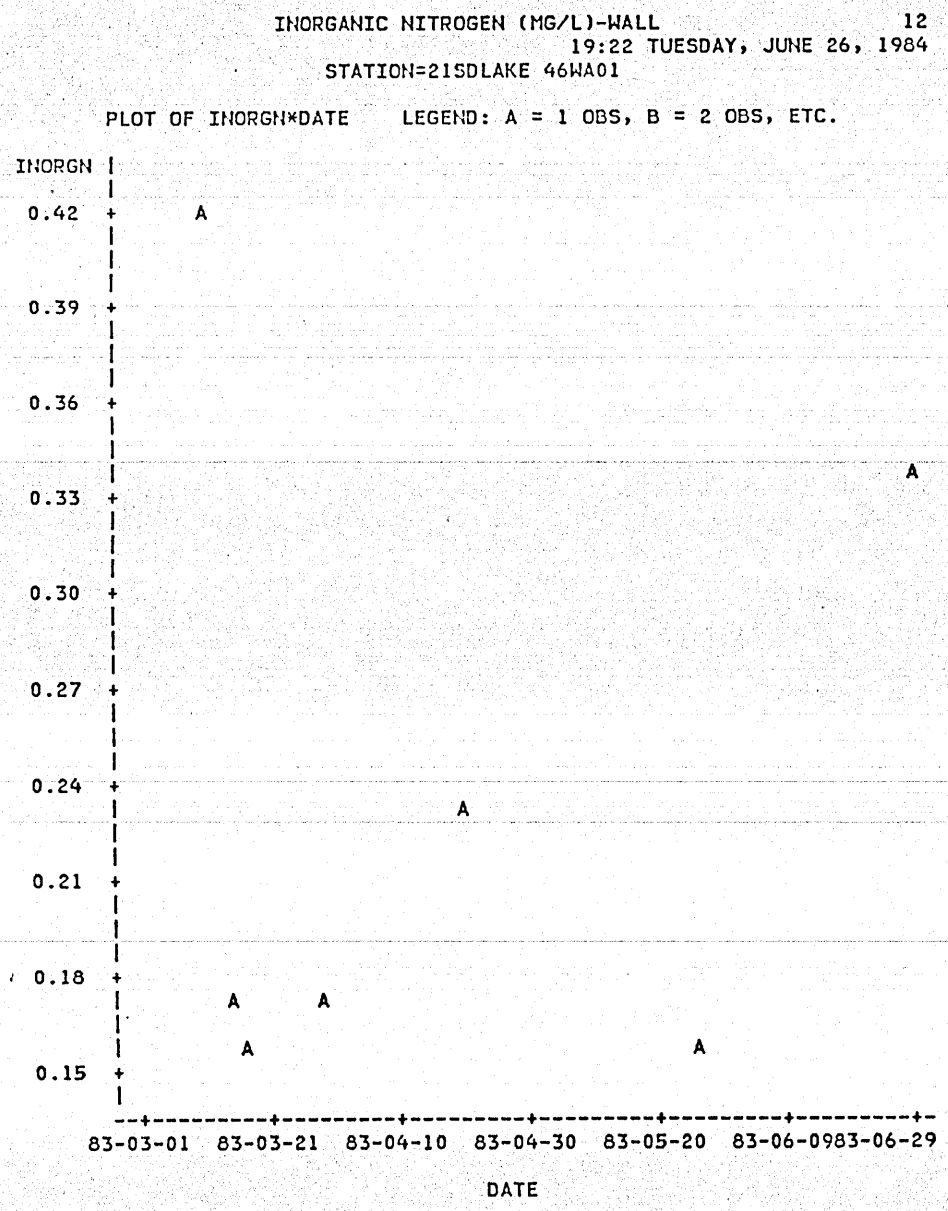

INORGANIC NITROGEN (MG/L)-WALL 12
19:22 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA01
PLOT OF INORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
0.42
0.39
0.36
0.33
0.30
0.27
0.24
0.21
0.18
0.15
83-03-01
83-03-21
83-04-10
83-04-30
83-05-20
83-06-09
83-06-29
DATE

Figure IV-63.

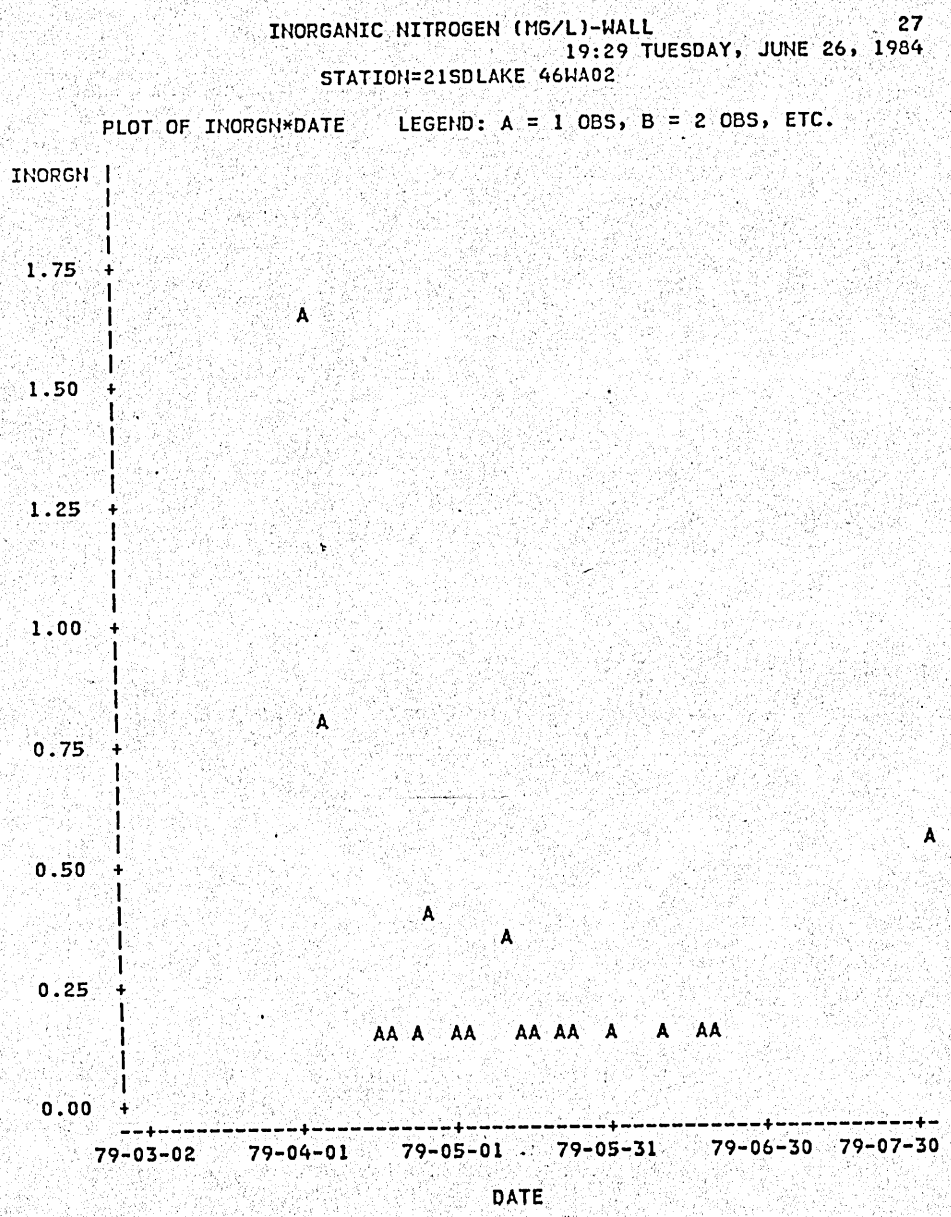

INORGANIC NITROGEN (MG/L)-WALL
27
19:29 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA02
PLOT OF INORGN*DATE
LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
79-03-02
79-04-01
79-05-01
79-05-31
79-06-30
79-07-30
DATE

Figure IV-64.

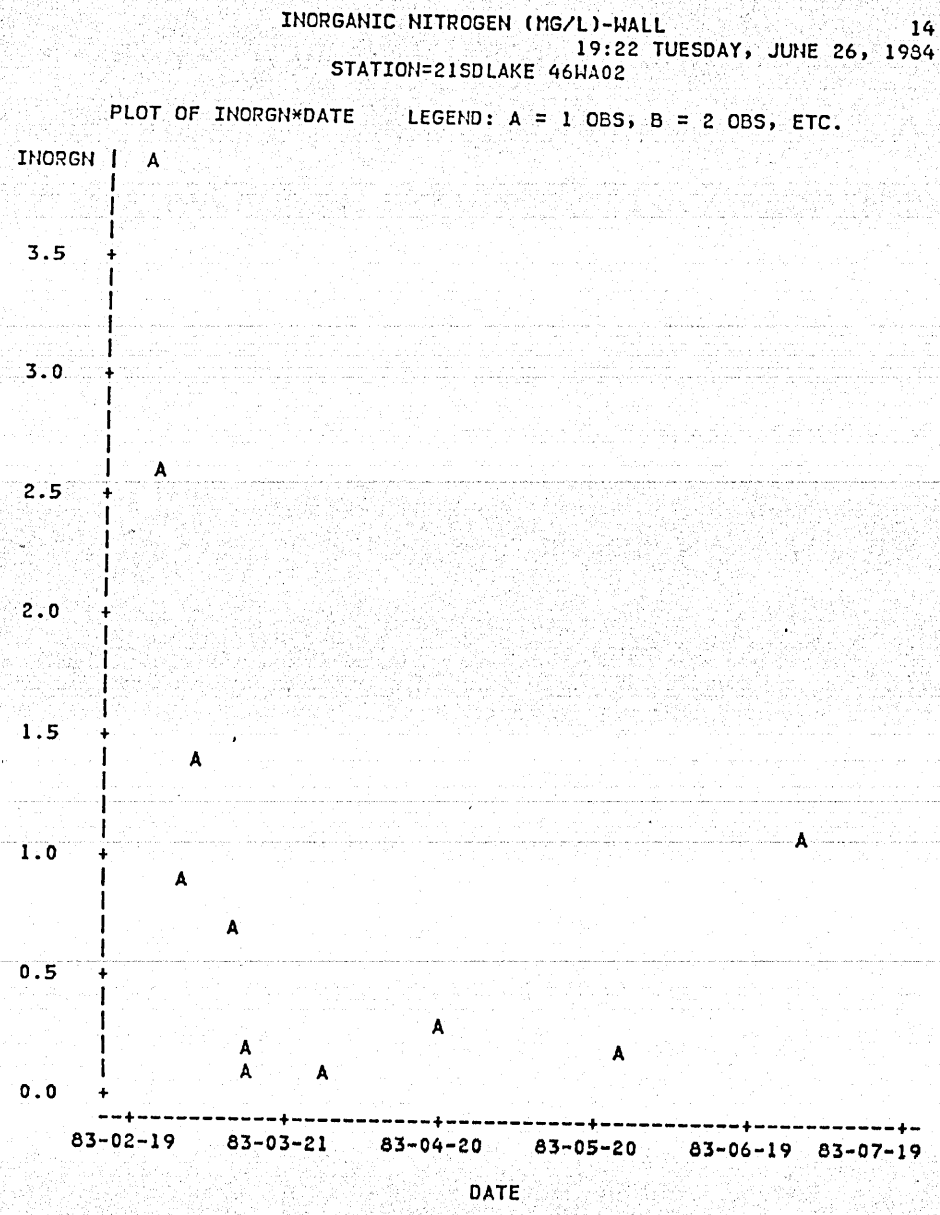

INORGANIC NITROGEN (MG/L)-WALL 14
19:22 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA02
PLOT OF INORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
83-02-19
83-03-21
83-04-20
83-05-20
83-06-19
83-07-19
DATE

Figure IV-65.

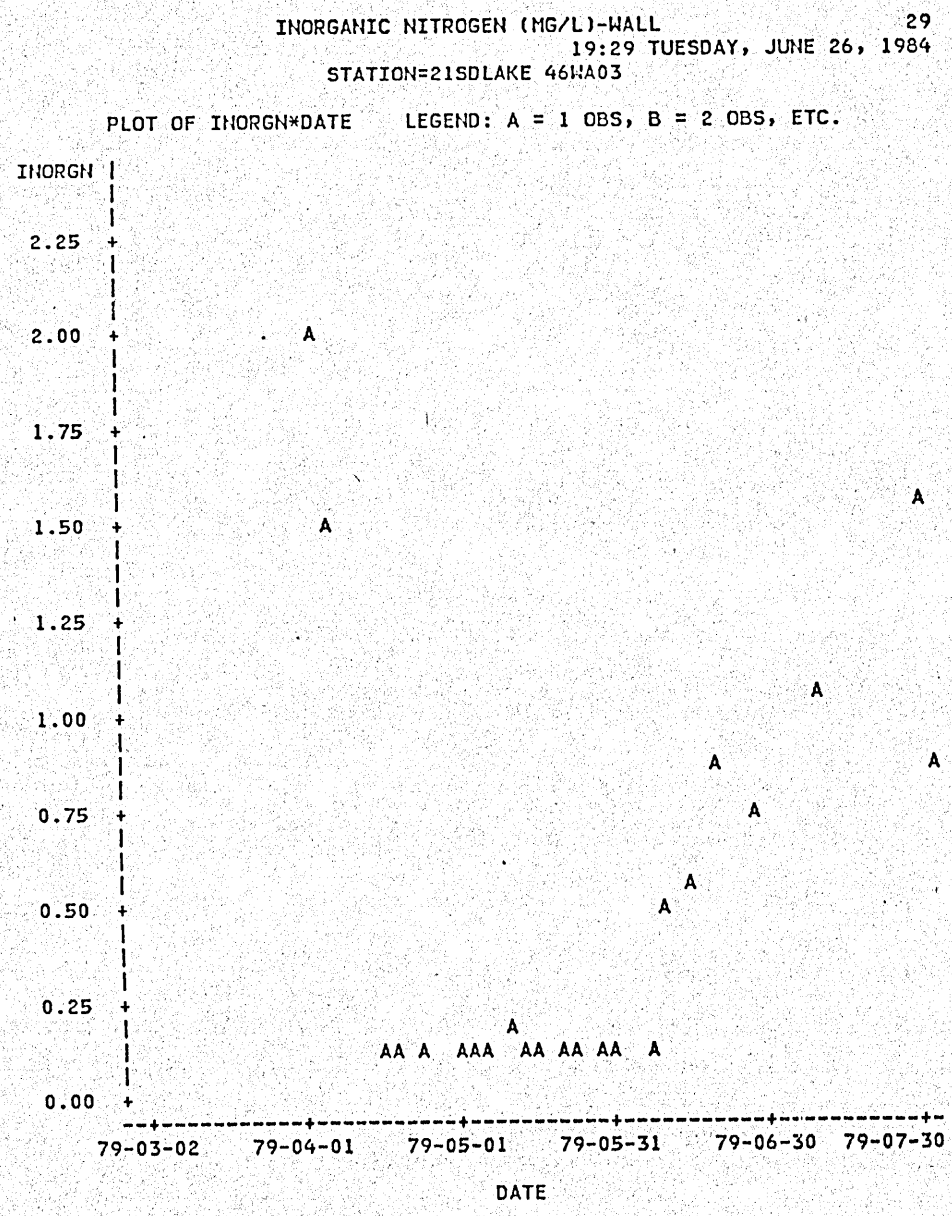

INORGANIC NITROGEN (MG/L)-WALL 29
19:29 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA03
PLOT OF INORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
79-03-02
79-04-01
79-05-01
79-05-31
79-06-30
79-07-30
DATE

Figure IV-66.

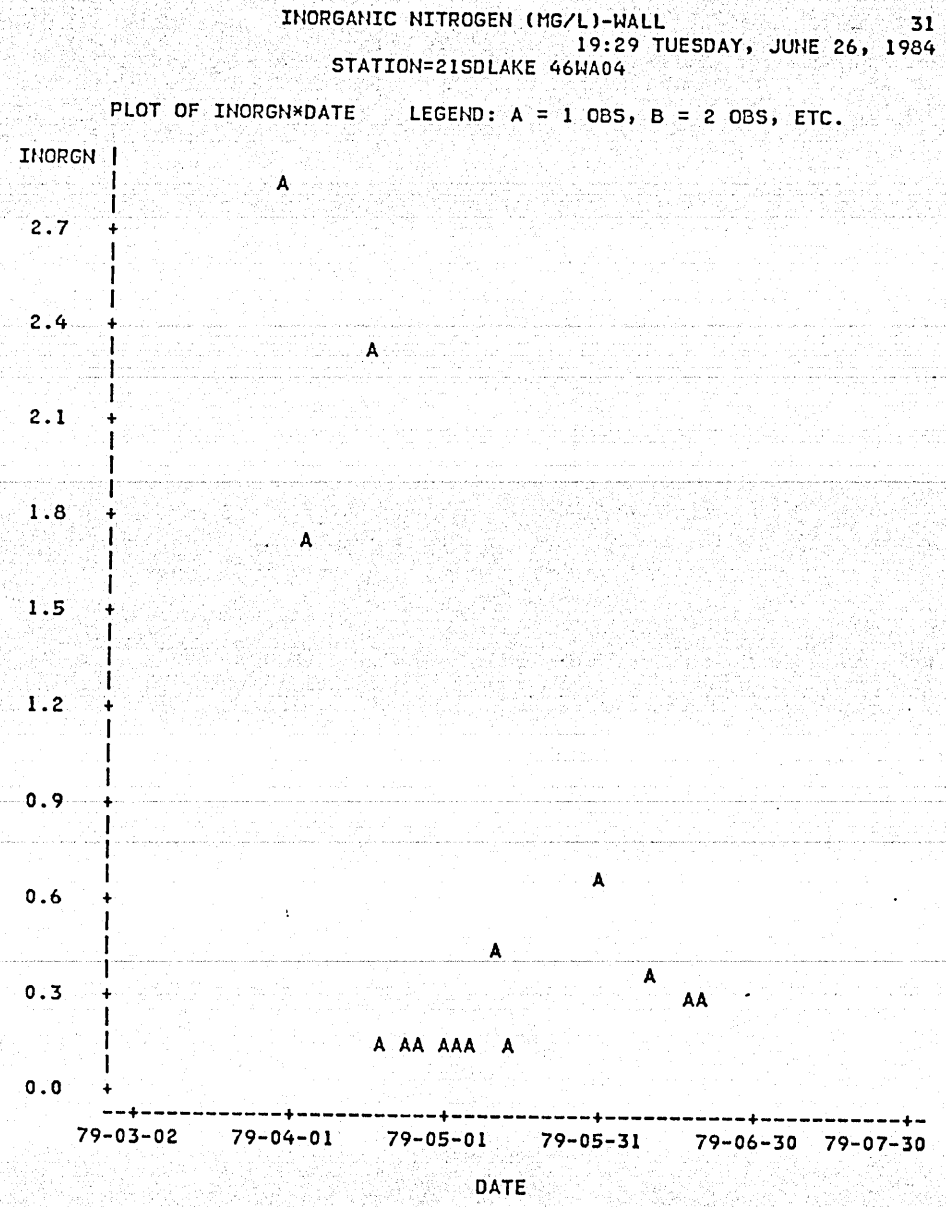

INORGANIC NITROGEN (MG/L)-WALL 31
19:29 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA04
PLOT OF INORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0.0
79-03-02
79-04-01
79-05-01
79-05-31
79-06-30
79-07-30
DATE

Figure IV-67.

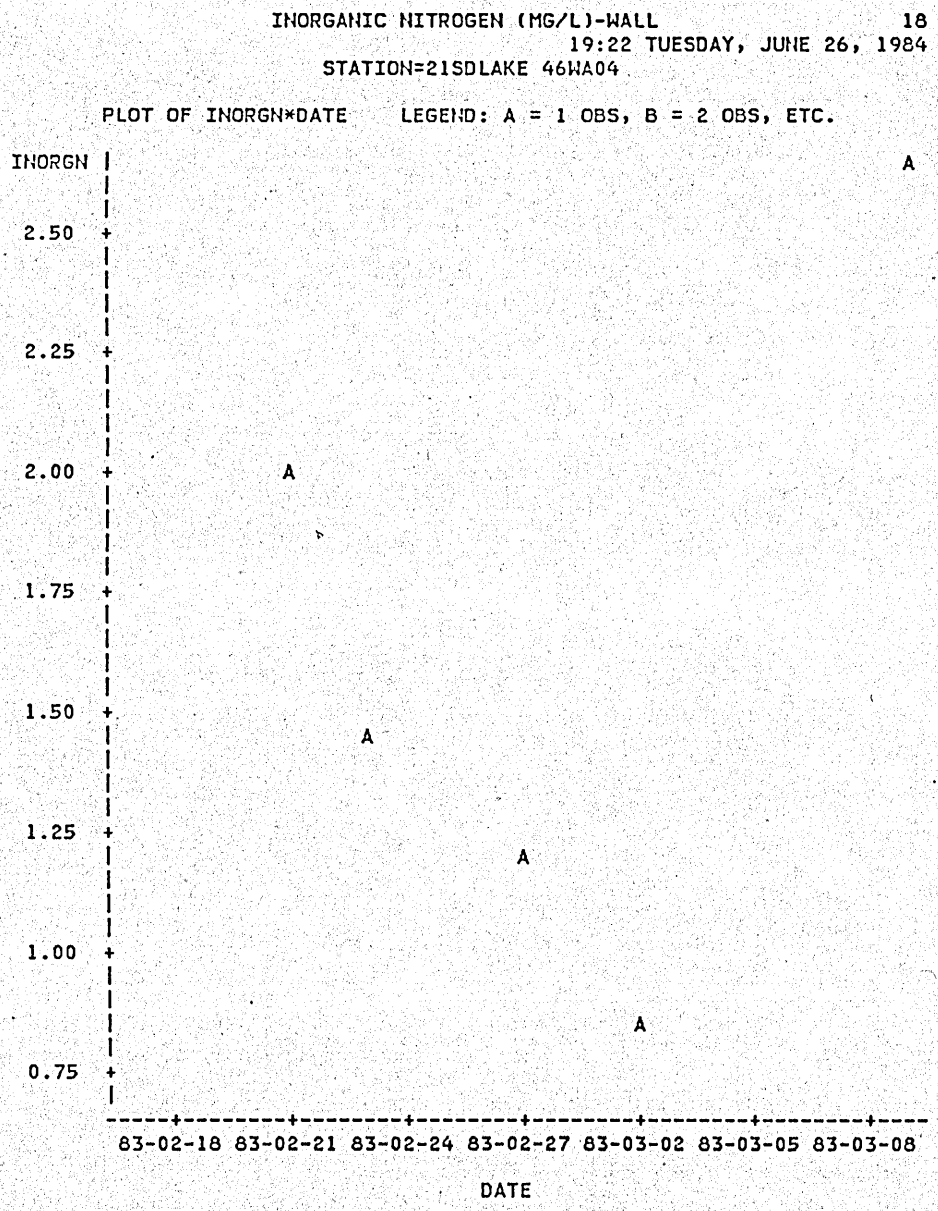

INORGANIC NITROGEN (MG/L)-WALL 18
19:22 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA04
PLOT OF INORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
83-02-18 83-02-21 83-02-24 83-02-27 83-03-02 83-03-05 83-03-08
DATE

Figure IV-68.

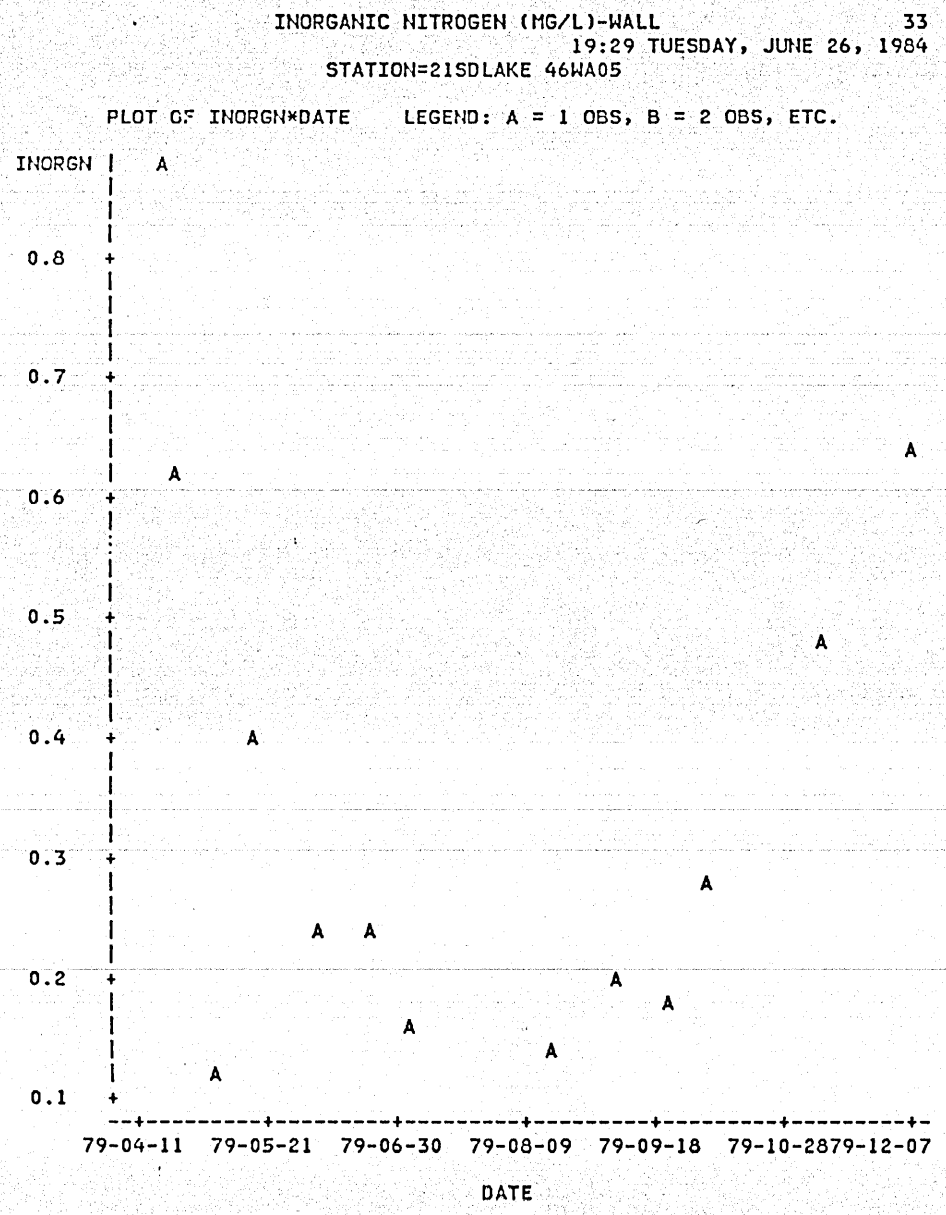

INORGANIC NITROGEN (MG/L)-WALL 33
19:29 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA05
PLOT OF INORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
79-04-11
79-05-21
79-06-30
79-08-09
79-09-18
79-10-28
79-12-07
DATE

Figure IV-69.

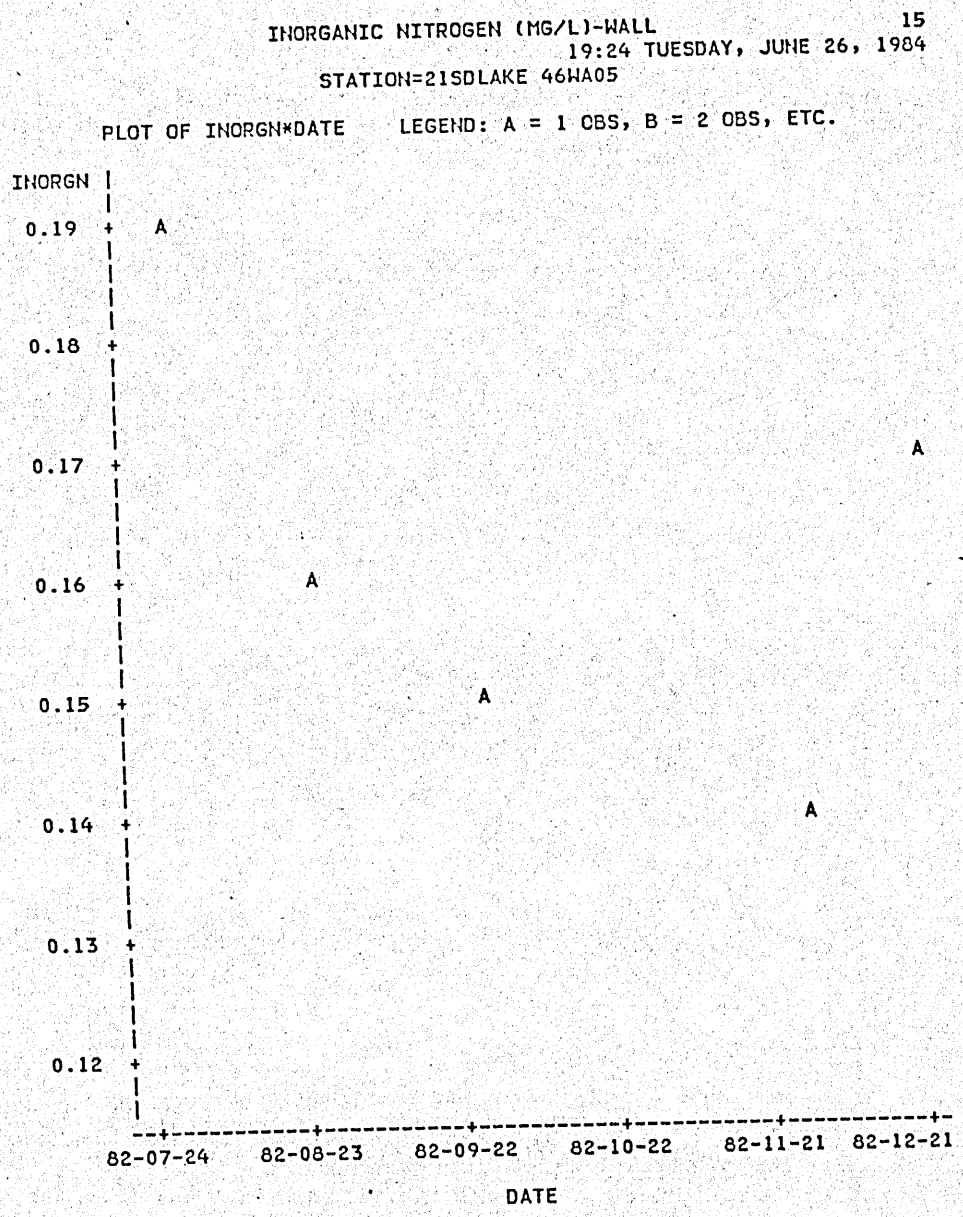

INORGANIC NITROGEN (MG/L)-WALL
15
19:24 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA05
PLOT OF INORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
A
82-07-24
82-08-23
82-09-22
82-10-22
82-11-21
82-12-21
DATE

Figure IV-70.

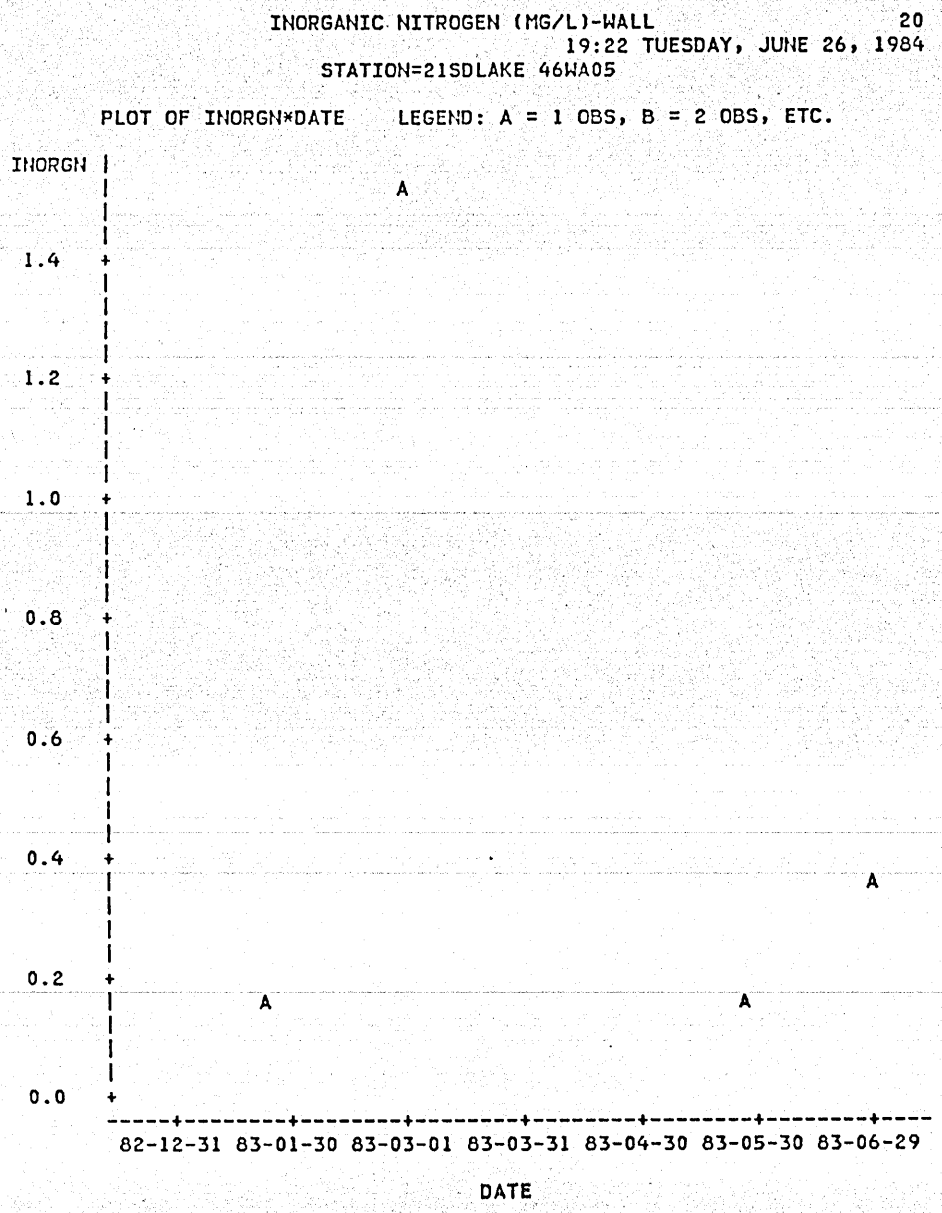

INORGANIC NITROGEN (MG/L)-WALL 20
19:22 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA05
PLOT OF INORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
82-12-31 83-01-30 83-03-01 83-03-31 83-04-30 83-05-30 83-06-29
DATE

Figure IV-71.

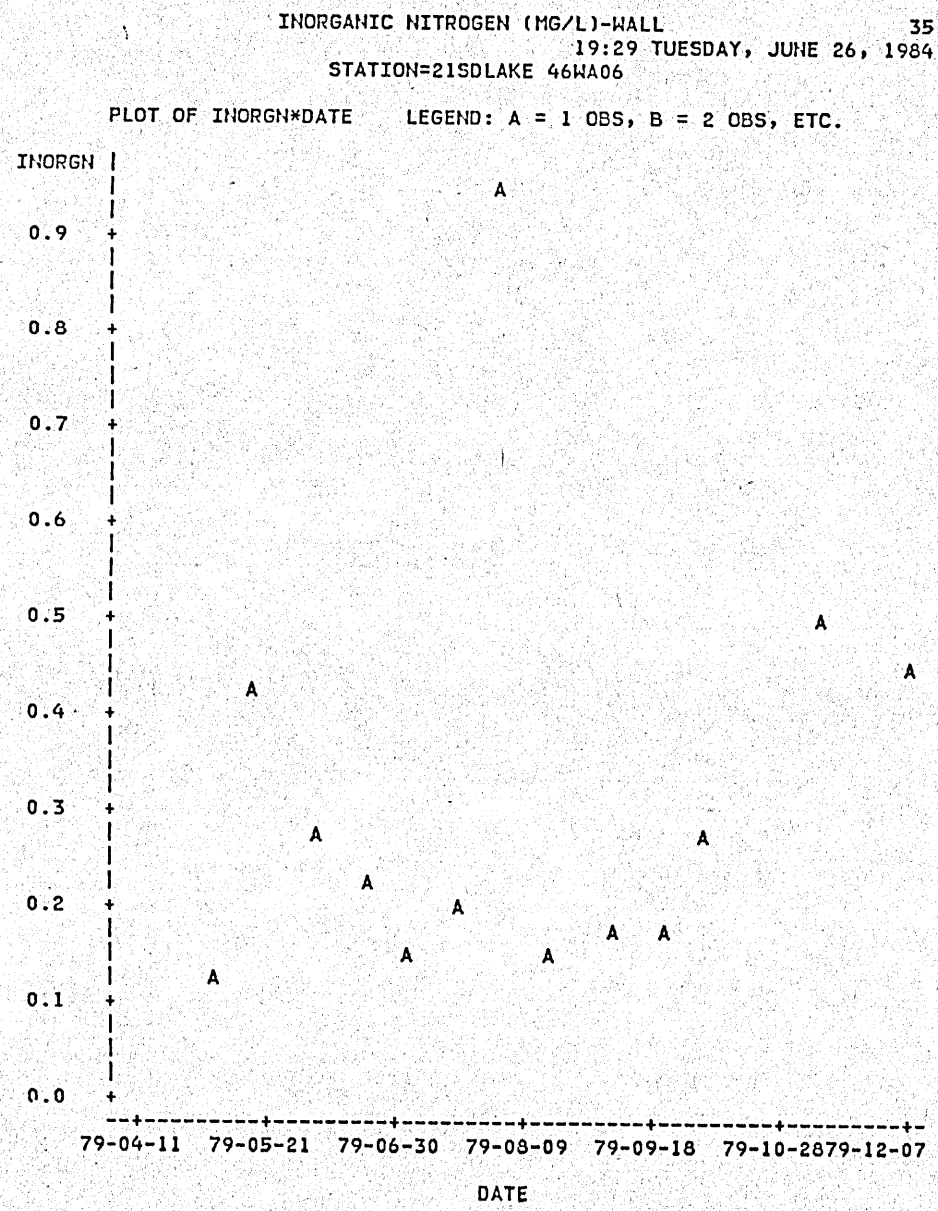

INORGANIC NITROGEN (MG/L)-WALL 35
19:29 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA06
PLOT OF INORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
79-04-11 79-05-21 79-06-30 79-08-09 79-09-18 79-10-28 79-12-07
DATE

Figure IV-72.

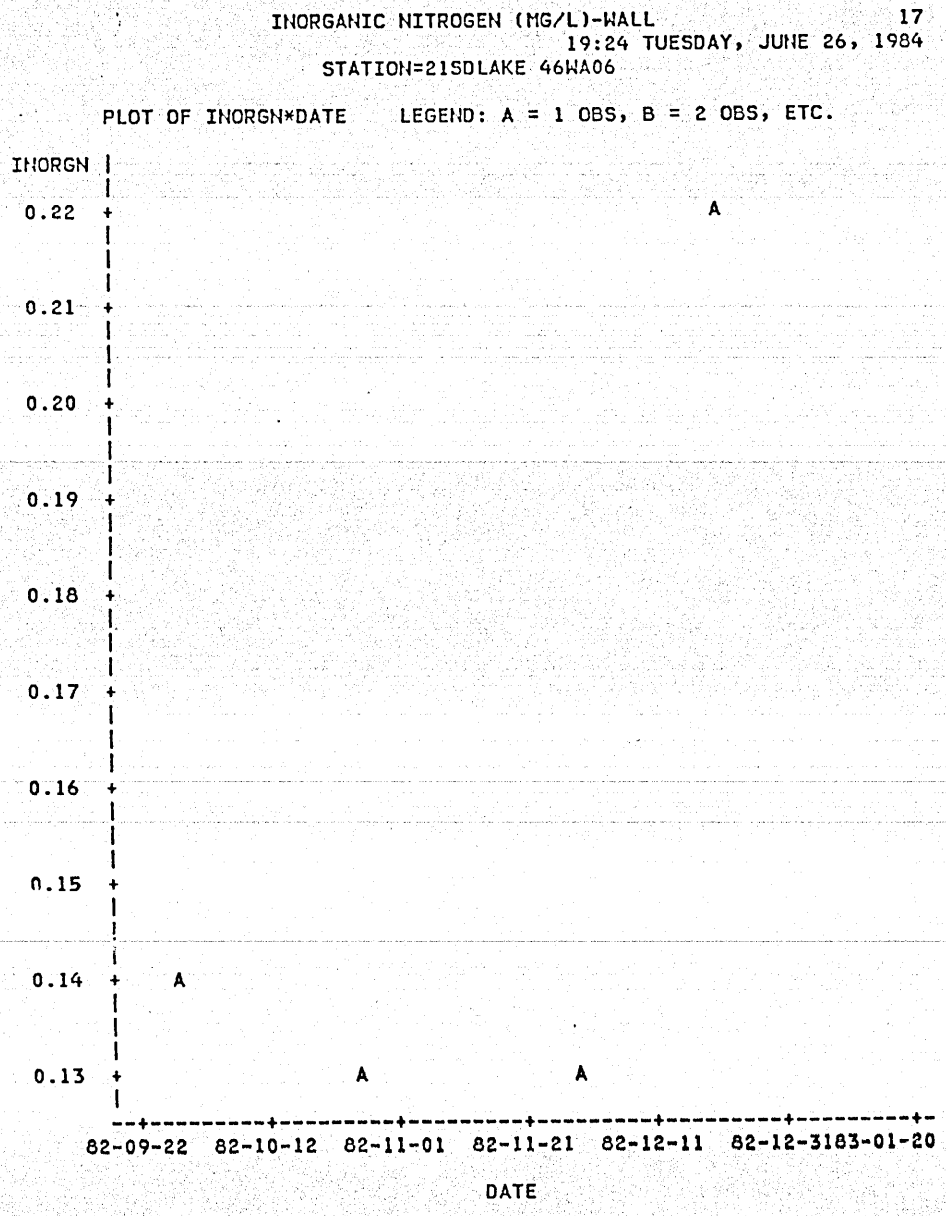

INORGANIC NITROGEN (MG/L)-WALL 17
19:24 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA06
PLOT OF INORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
0.22
0.21
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
82-09-22
82-10-12
82-11-01
82-11-21
82-12-11
82-12-31
83-01-20
DATE

Figure IV-73.

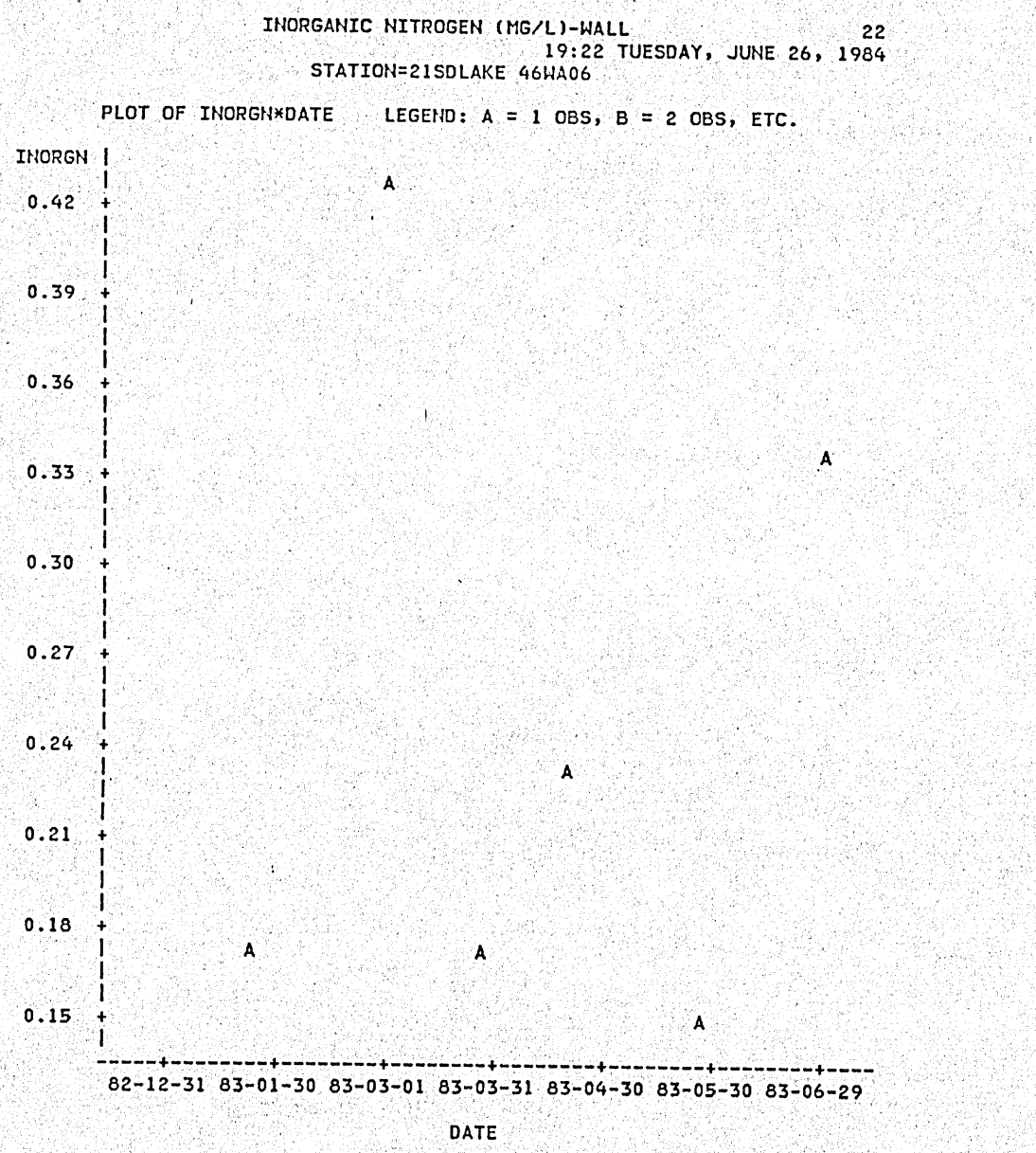

INORGANIC NITROGEN (MG/L)-WALL 22
19:22 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA06
PLOT OF INORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
INORGN
0.42
0.39
0.36
0.33
0.30
0.27
0.24
0.21
0.18
0.15
82-12-31 83-01-30 83-03-01 83-03-31 83-04-30 83-05-30 83-06-29
DATE

Figure IV-74.

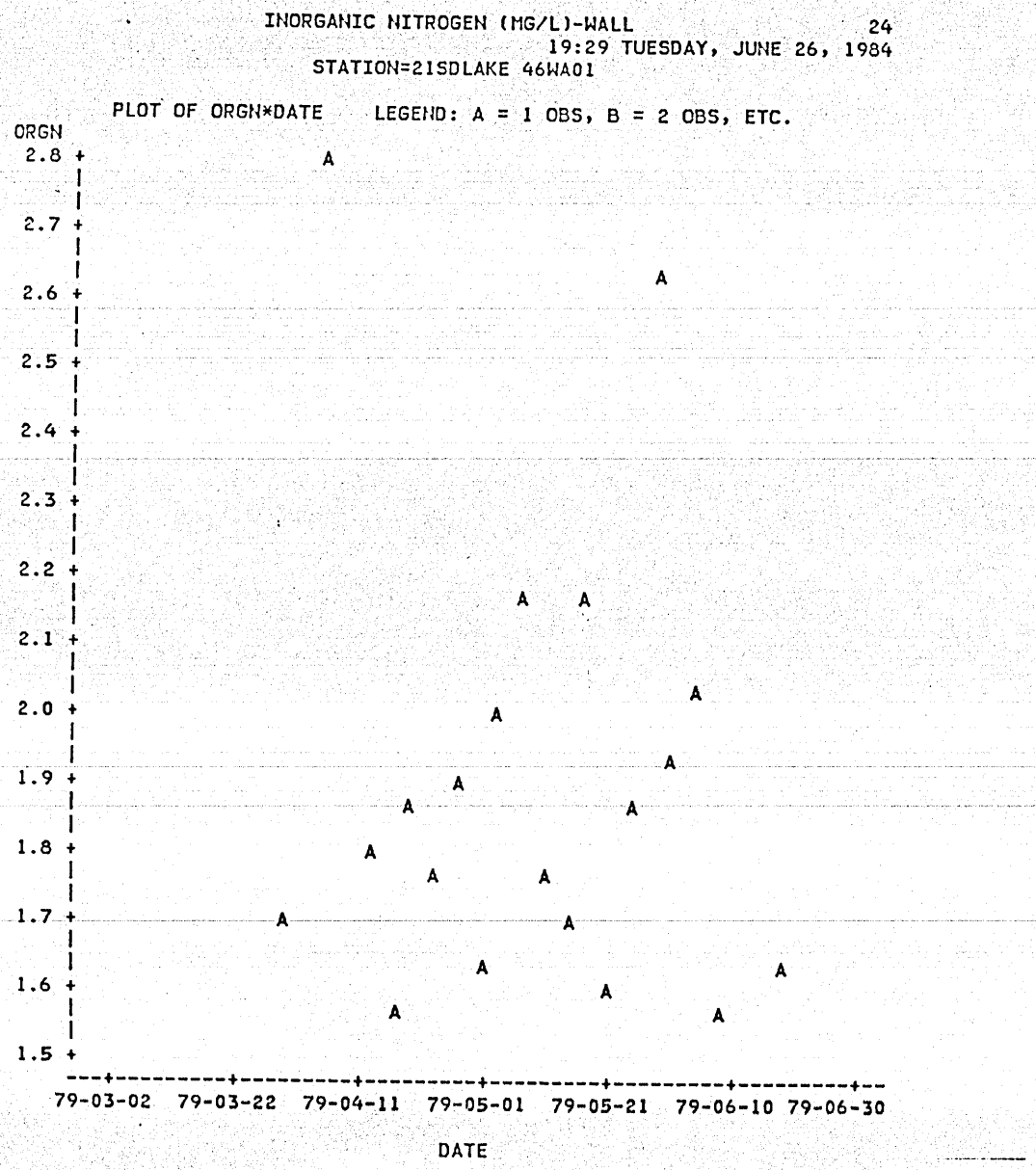

INORGANIC NITROGEN (MG/L)-WALL 24
19:29 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA01
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
79-03-02
79-03-22
79-04-11
79-05-01
79-05-21
79-06-10
79-06-30
DATE

Figure IV-75.

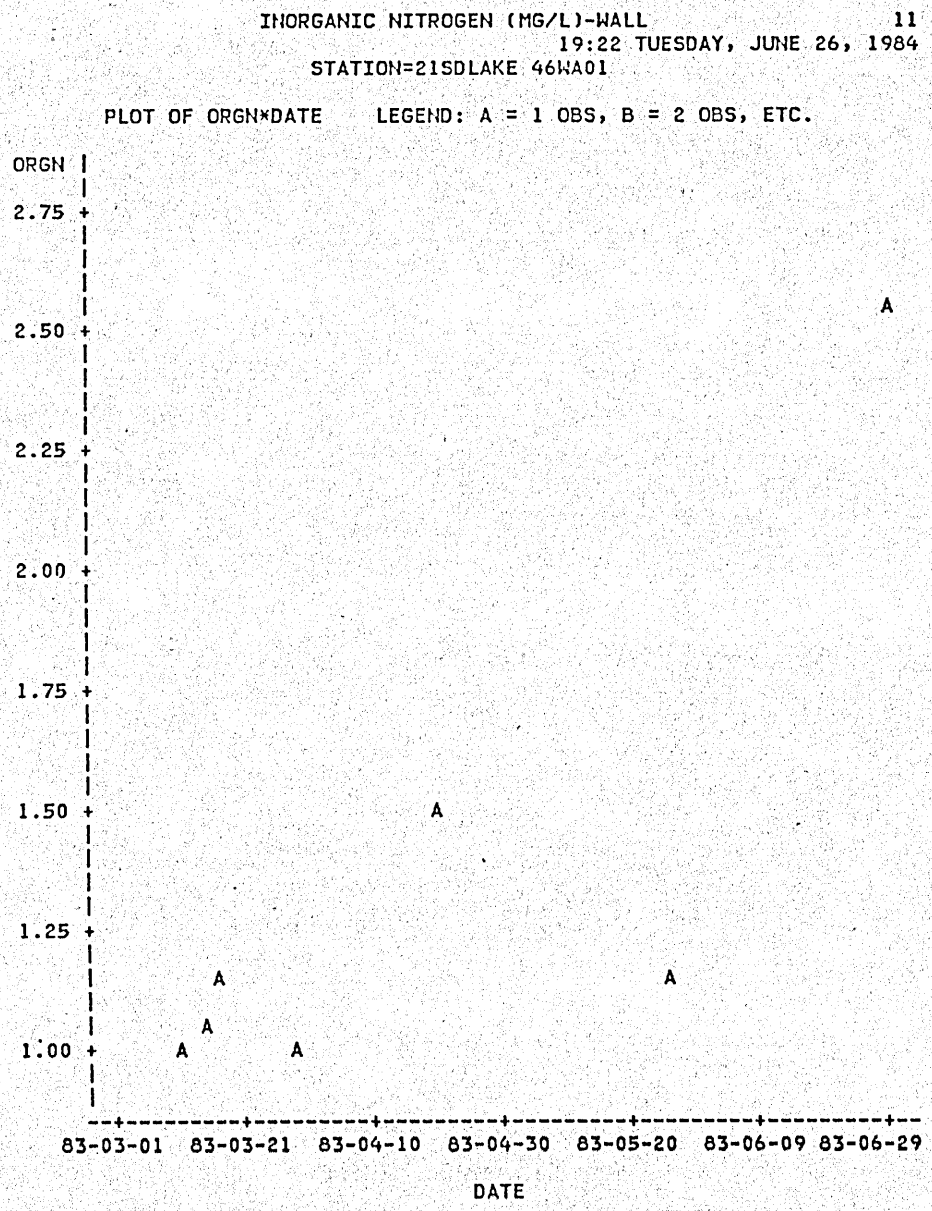

INORGANIC NITROGEN (MG/L)-WALL 11
19:22 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA01
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
83-03-01 83-03-21 83-04-10 83-04-30 83-05-20 83-06-09 83-06-29
DATE

Figure IV-76.

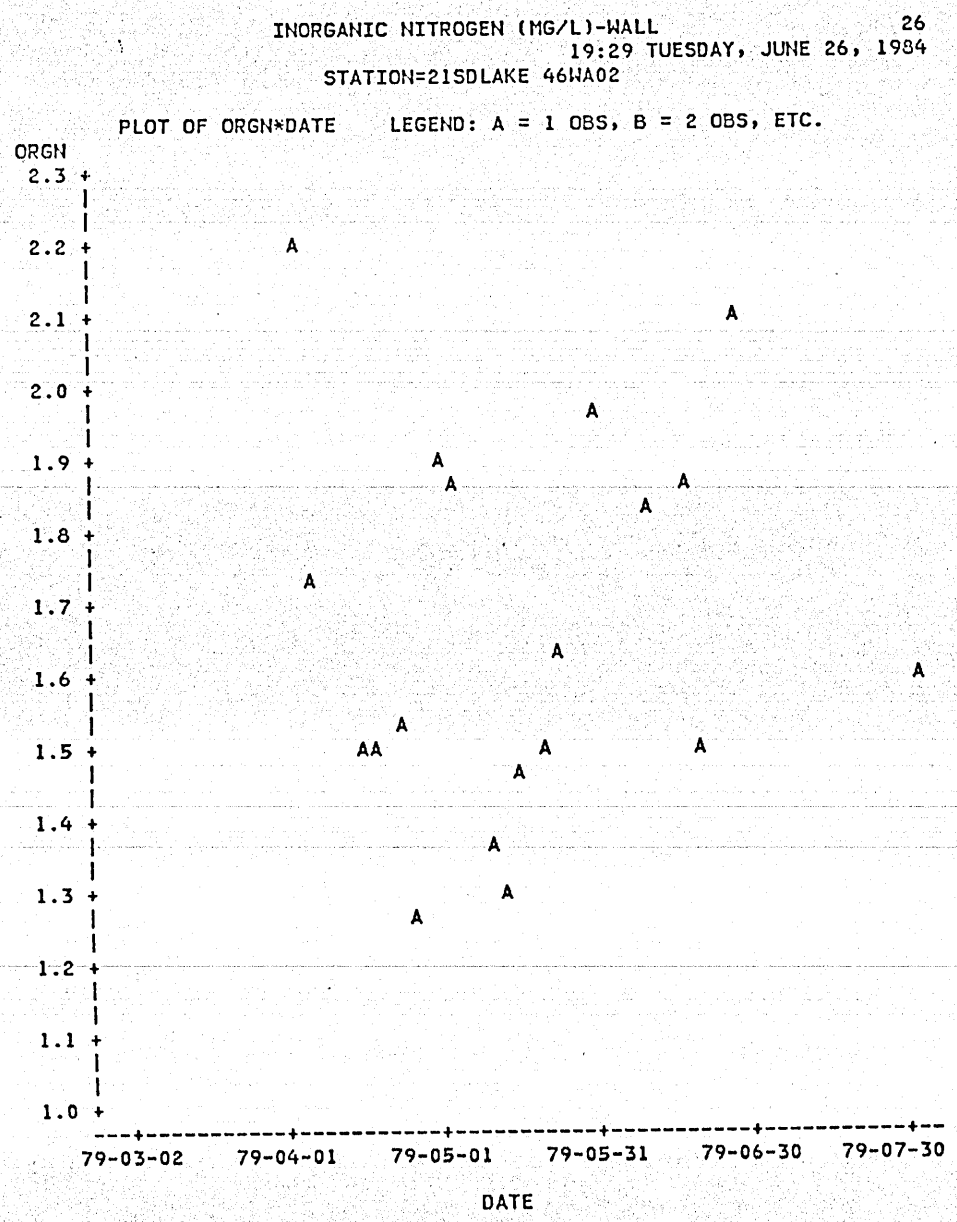

INORGANIC NITROGEN (MG/L)-WALL
26
19:29 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA02
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
79-03-02
79-04-01
79-05-01
79-05-31
79-06-30
79-07-30
DATE

Figure IV-77.

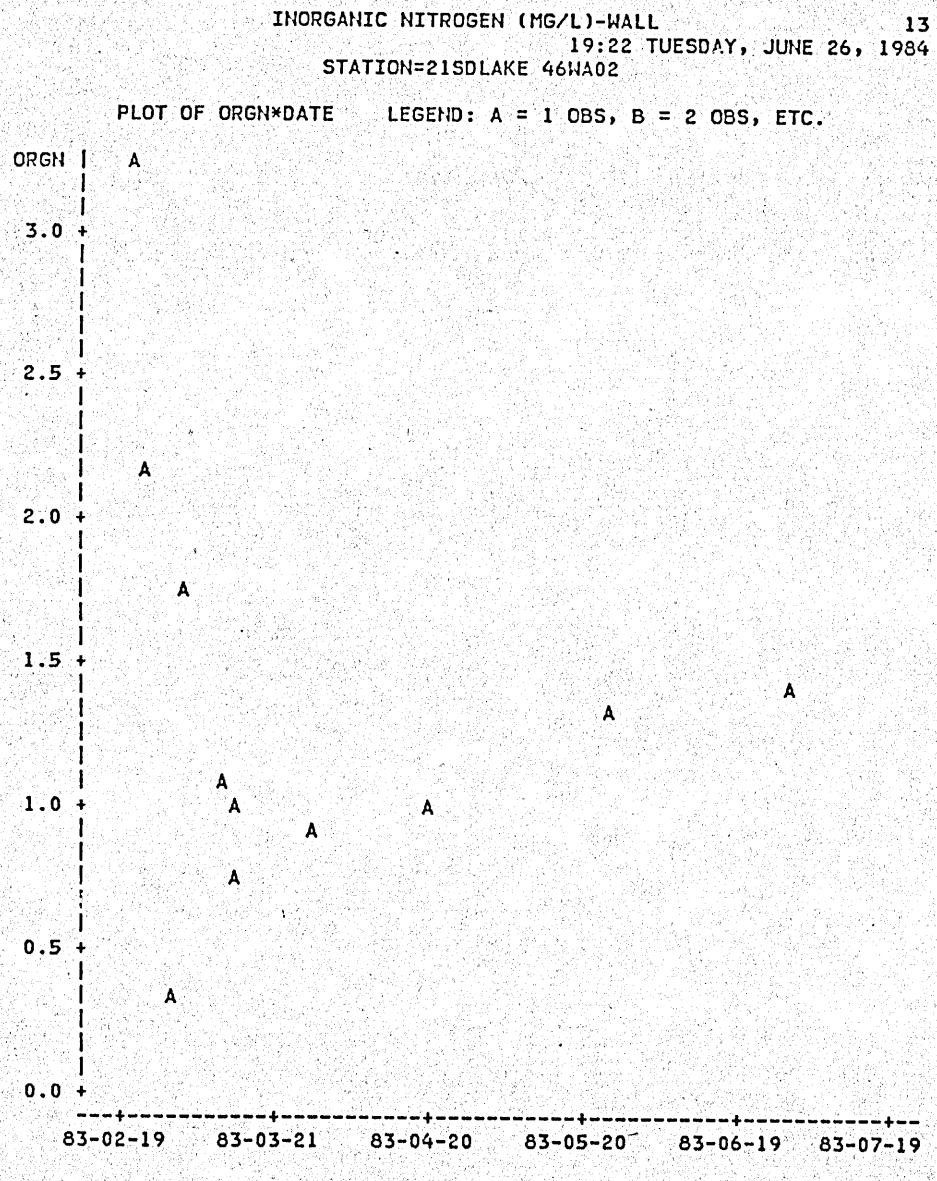

INORGANIC NITROGEN (MG/L)-WALL 13
19:22 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA02
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
3.0
2.5
2.0
1.5
1.0
0.5
0.0
83-02-19
83-03-21
83-04-20
83-05-20
83-06-19
83-07-19
DATE

Figure IV-78.

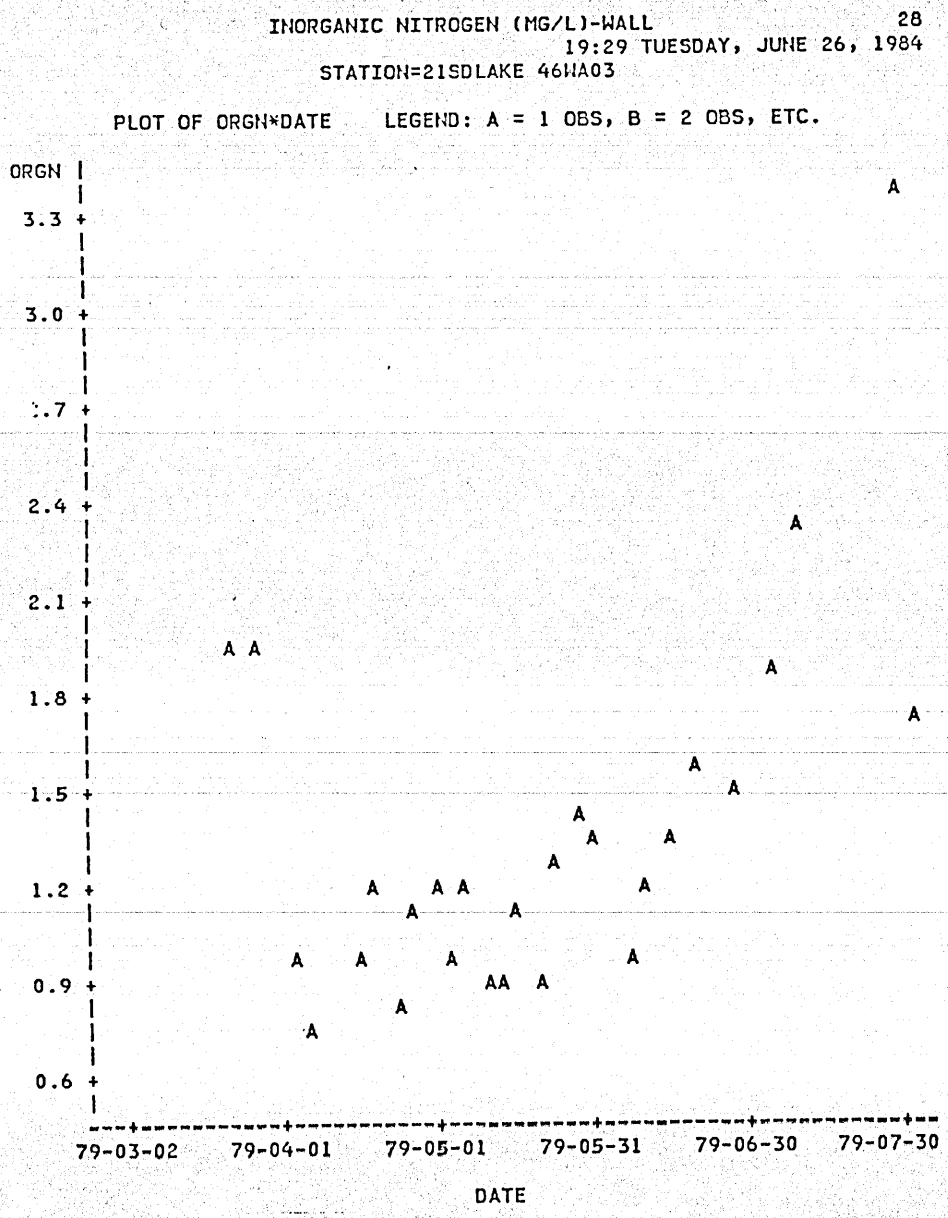

INORGANIC NITROGEN (MG/L)-WALL
28
19:29 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA03
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
3.3
3.0
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
79-03-02
79-04-01
79-05-01
79-05-31
79-06-30
79-07-30
DATE

Figure IV-79.

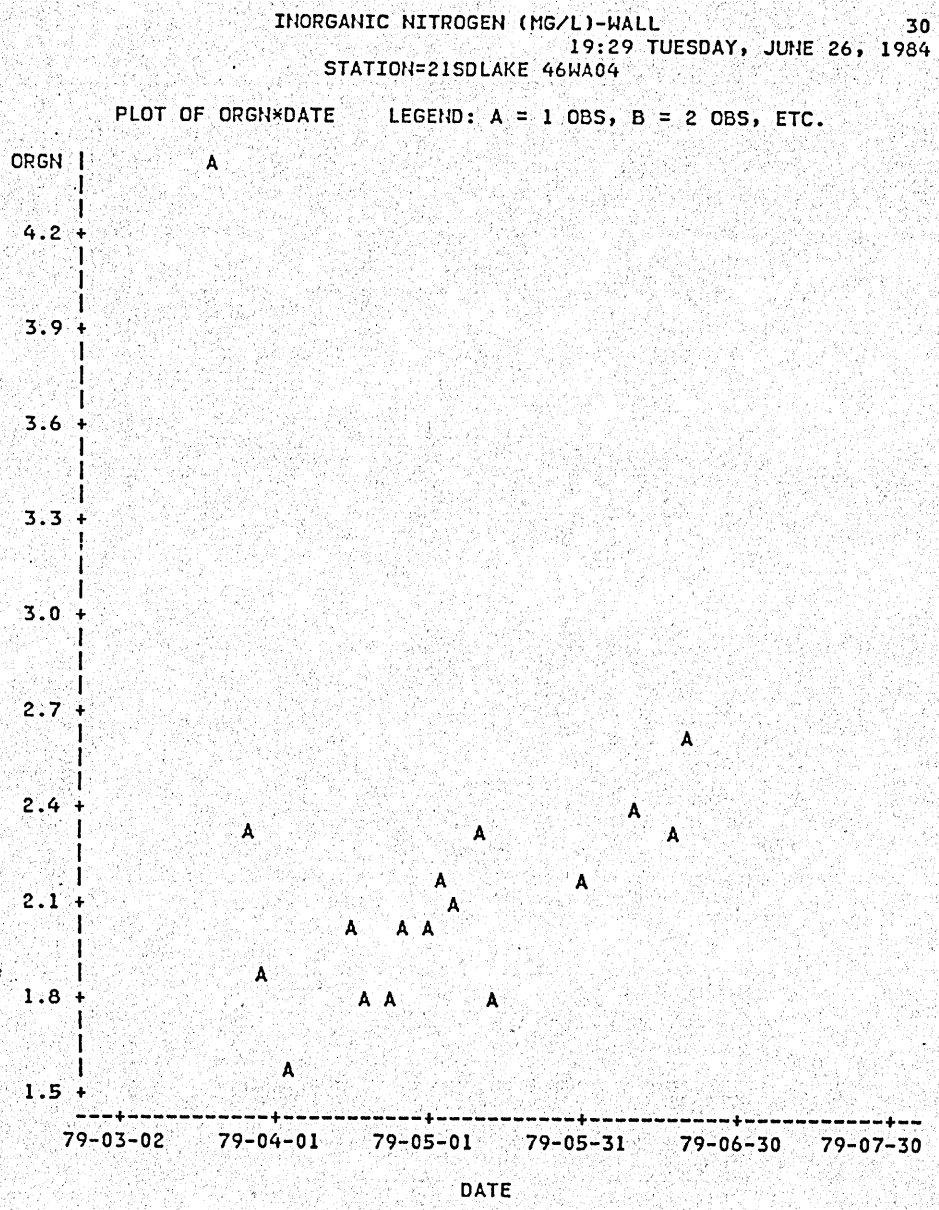

INORGANIC NITROGEN (MG/L)-WALL 30
19:29 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA04
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
4.2
3.9
3.6
3.3
3.0
2.7
2.4
2.1
1.8
1.5
79-03-02
79-04-01
79-05-01
79-05-31
79-06-30
79-07-30
DATE

Figure IV-80.

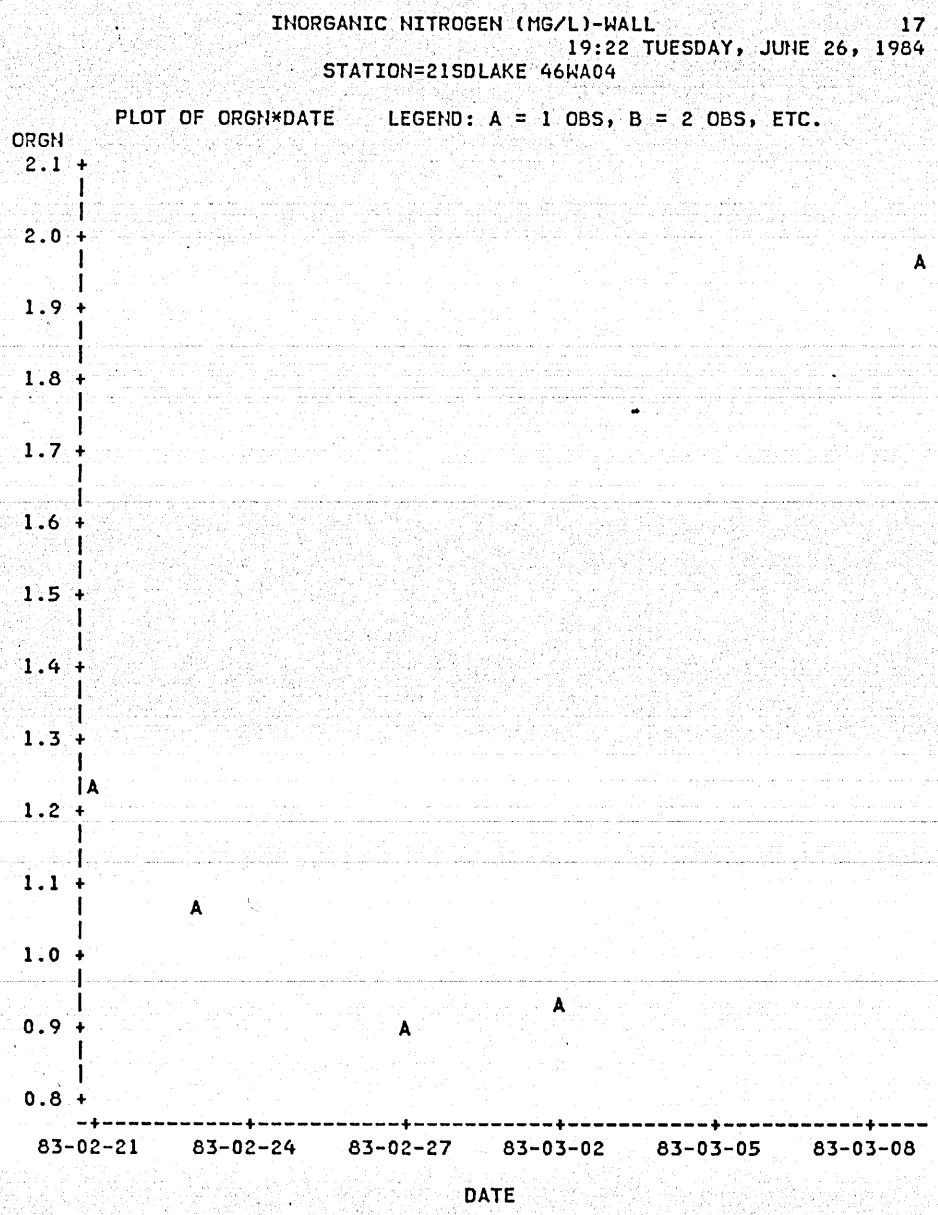

INORGANIC NITROGEN (MG/L)-WALL 17
19:22 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA04
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
83-02-21
83-02-24
83-02-27
83-03-02
83-03-05
83-03-08
DATE

Figure IV-81.

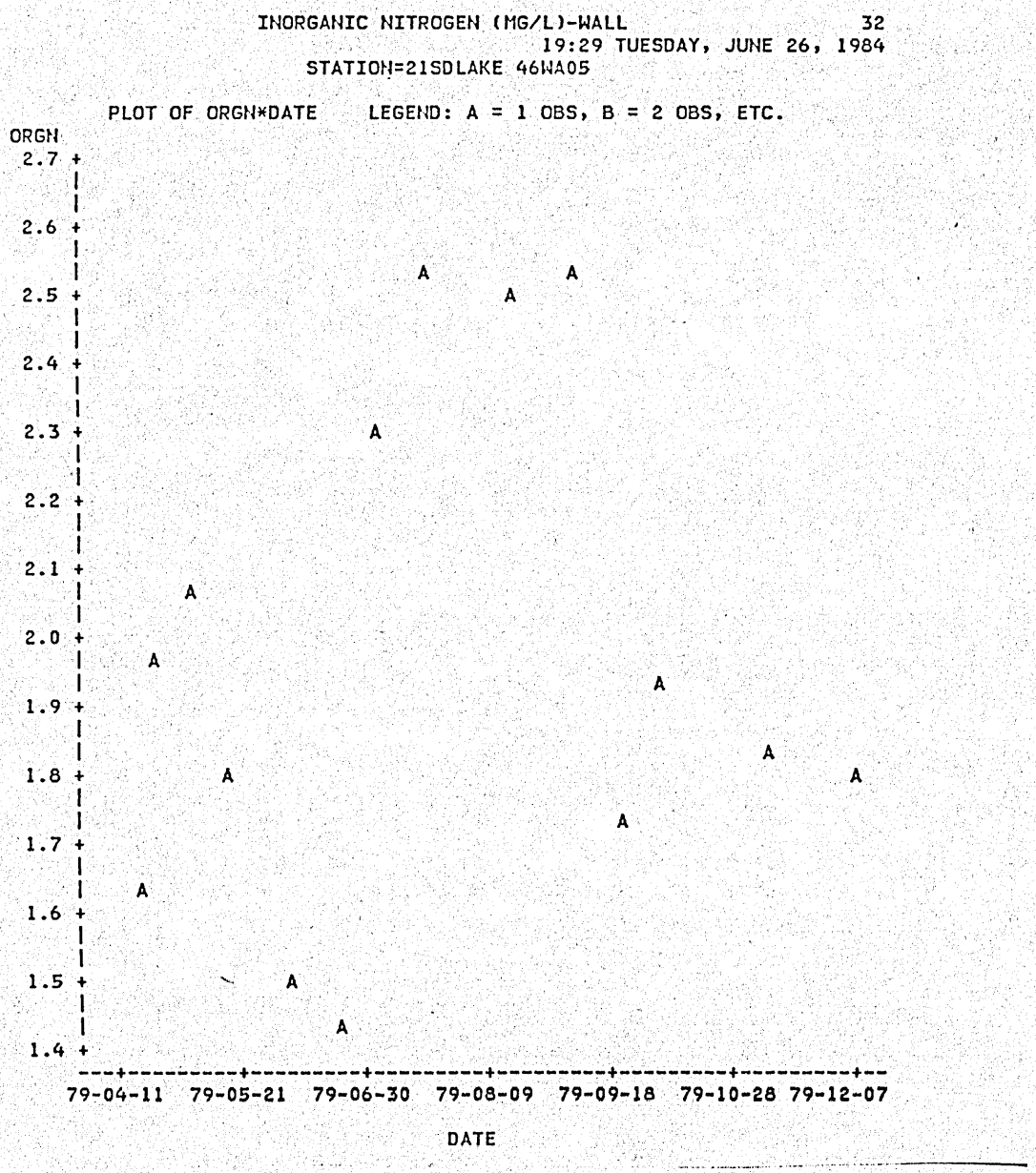

INORGANIC NITROGEN (MG/L)-WALL 32
19:29 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA05
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
79-04-11
79-05-21
79-06-30
79-08-09
79-09-18
79-10-28
79-12-07
DATE

Figure IV-82.

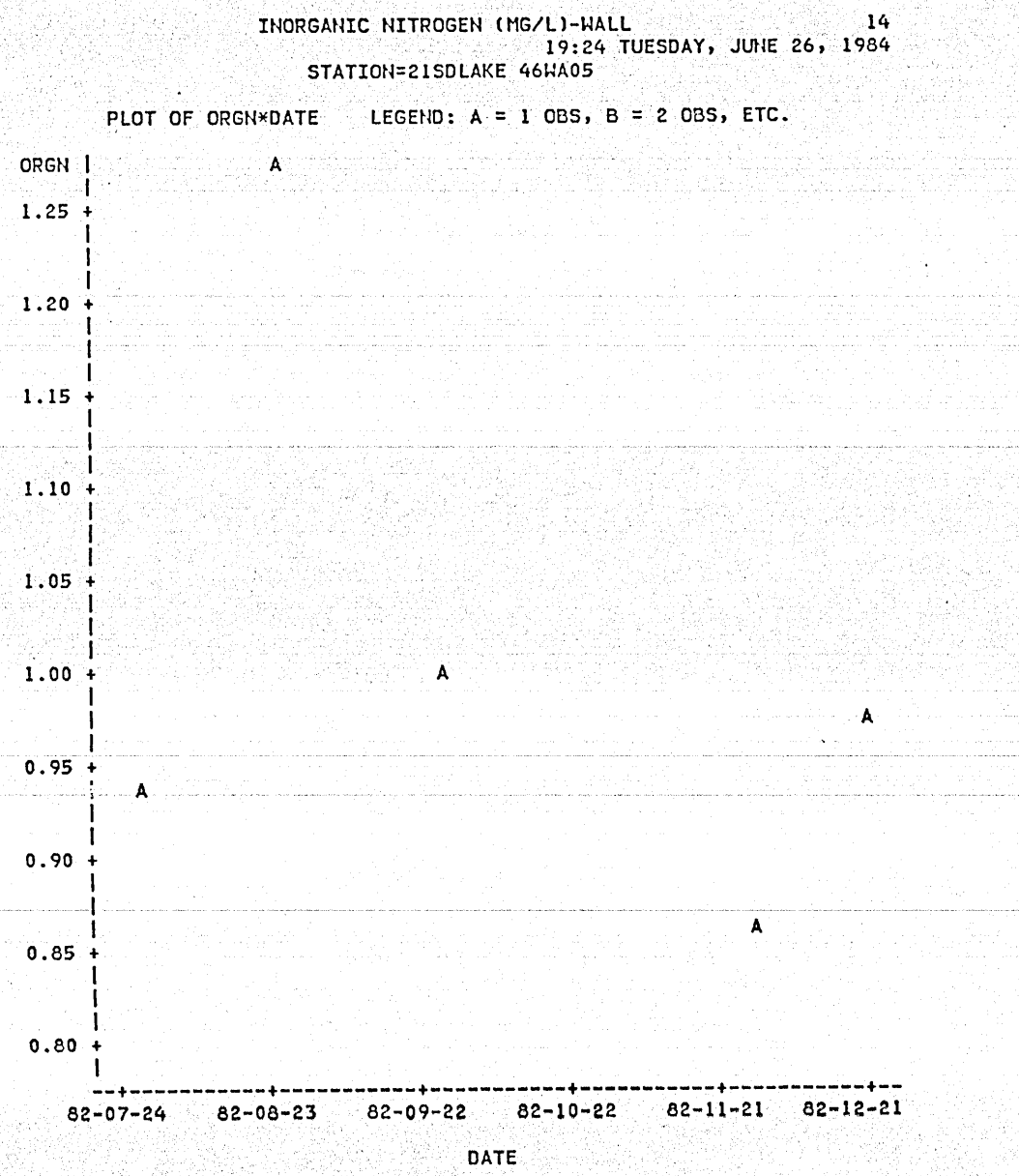

INORGANIC NITROGEN (MG/L)-WALL 14
19:24 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA05
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
82-07-24
82-08-23
82-09-22
82-10-22
82-11-21
82-12-21
DATE

Figure IV-83.

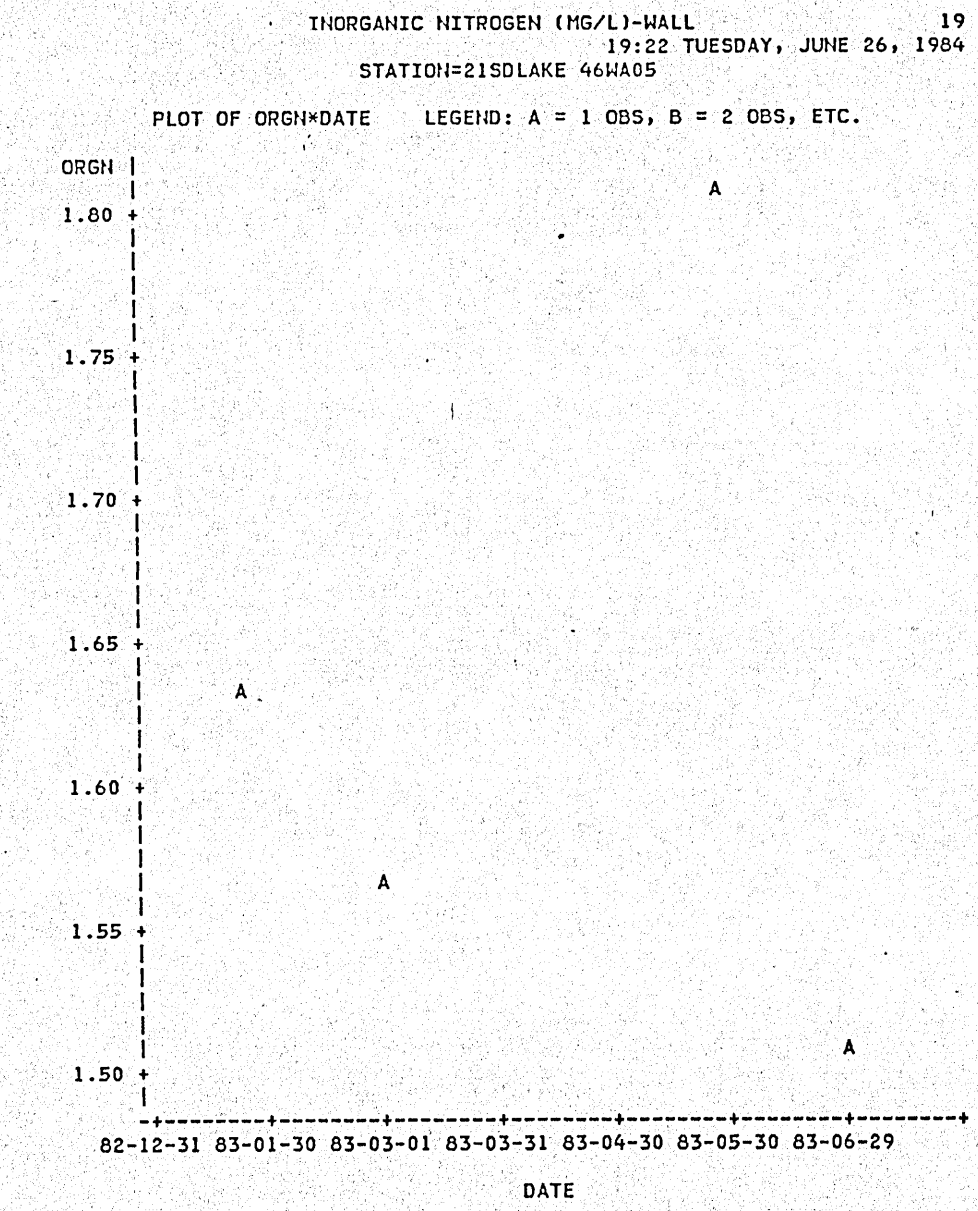

INORGANIC NITROGEN (MG/L)-WALL 19
19:22 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA05
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
1.80
1.75
1.70
1.65
1.60
1.55
1.50
A
A
A
A
82-12-31 83-01-30 83-03-01 83-03-31 83-04-30 83-05-30 83-06-29
DATE

Figure IV-84.

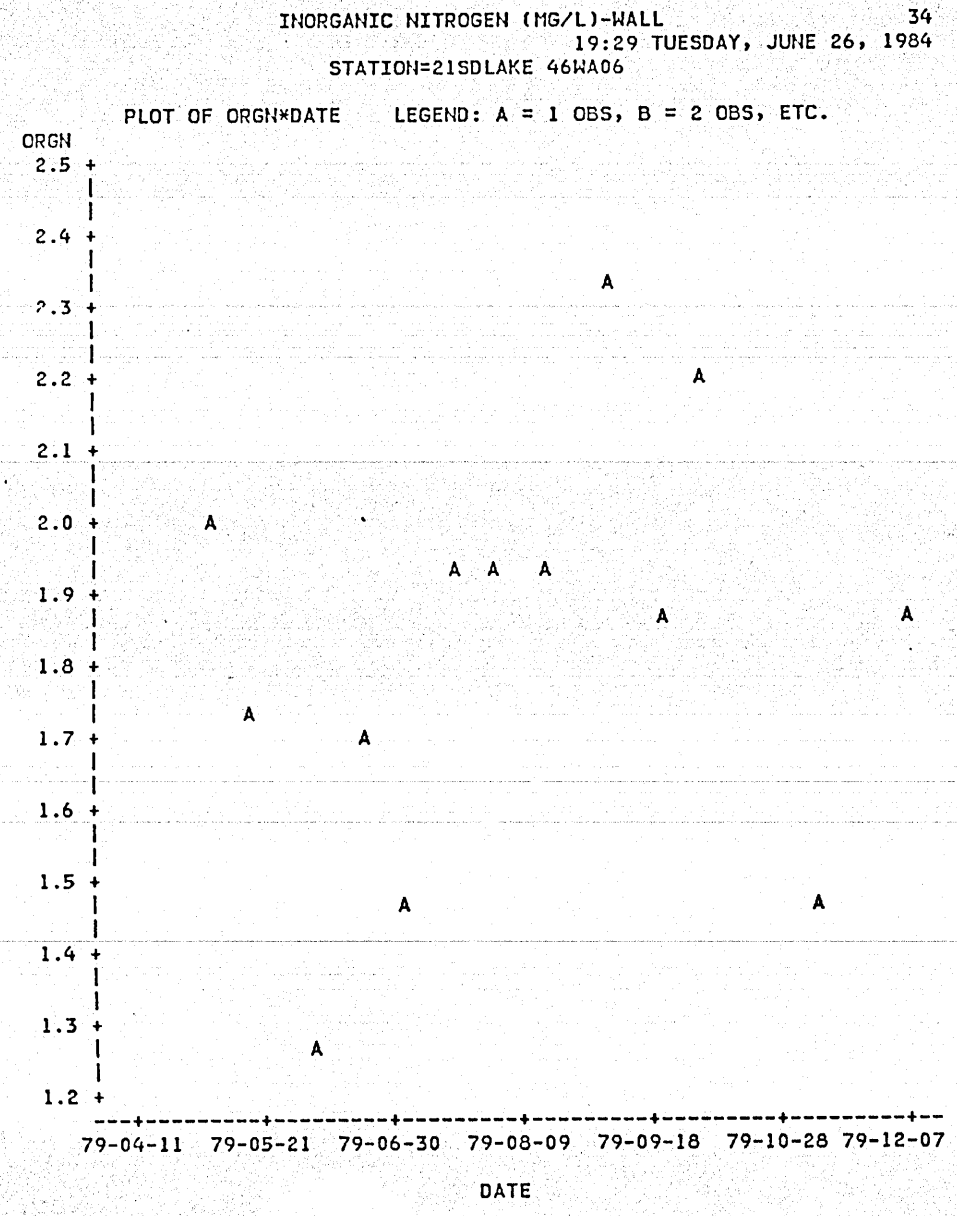

INORGANIC NITROGEN (MG/L)-WALL 34
19:29 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA06
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
79-04-11
79-05-21
79-06-30
79-08-09
79-09-18
79-10-28
79-12-07
DATE

Figure IV-85.

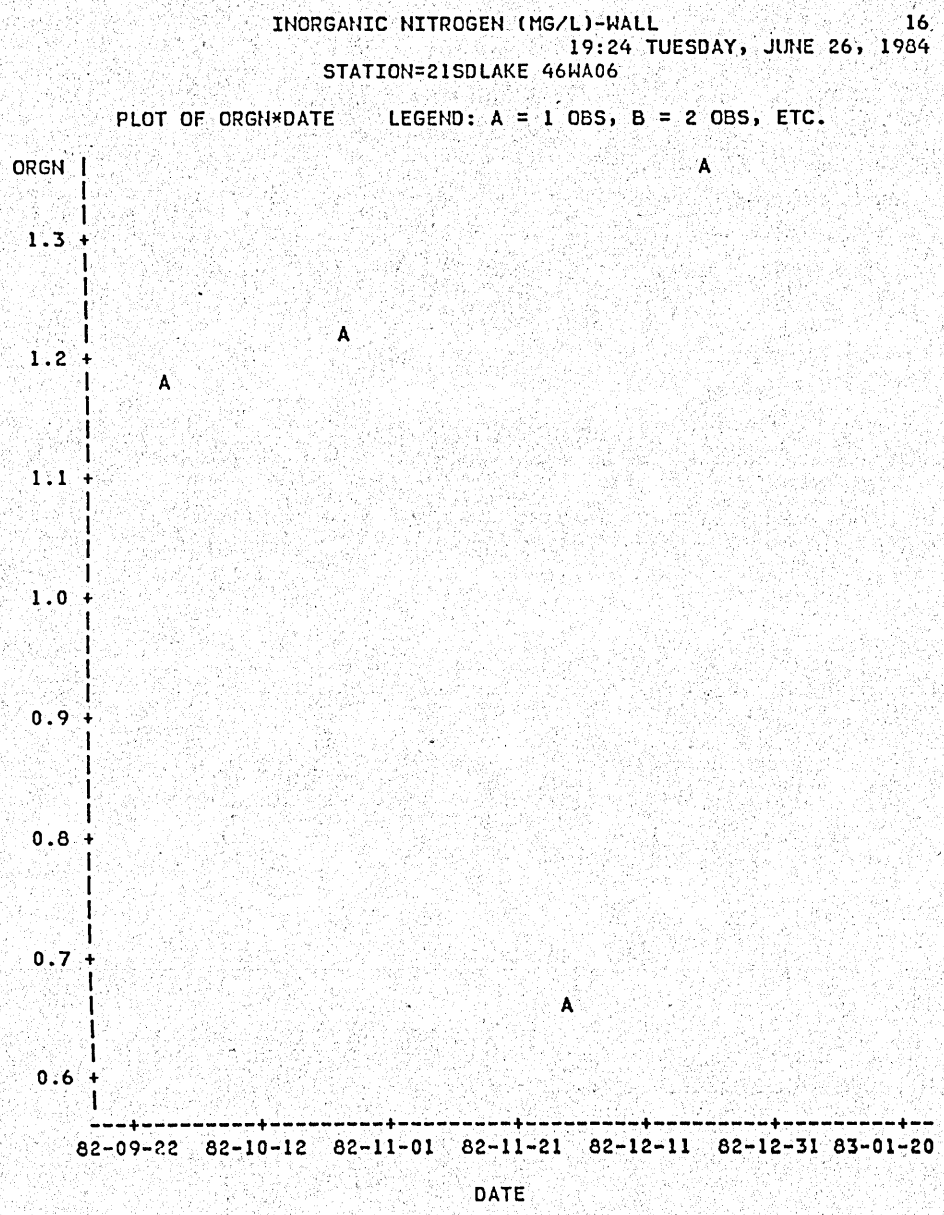
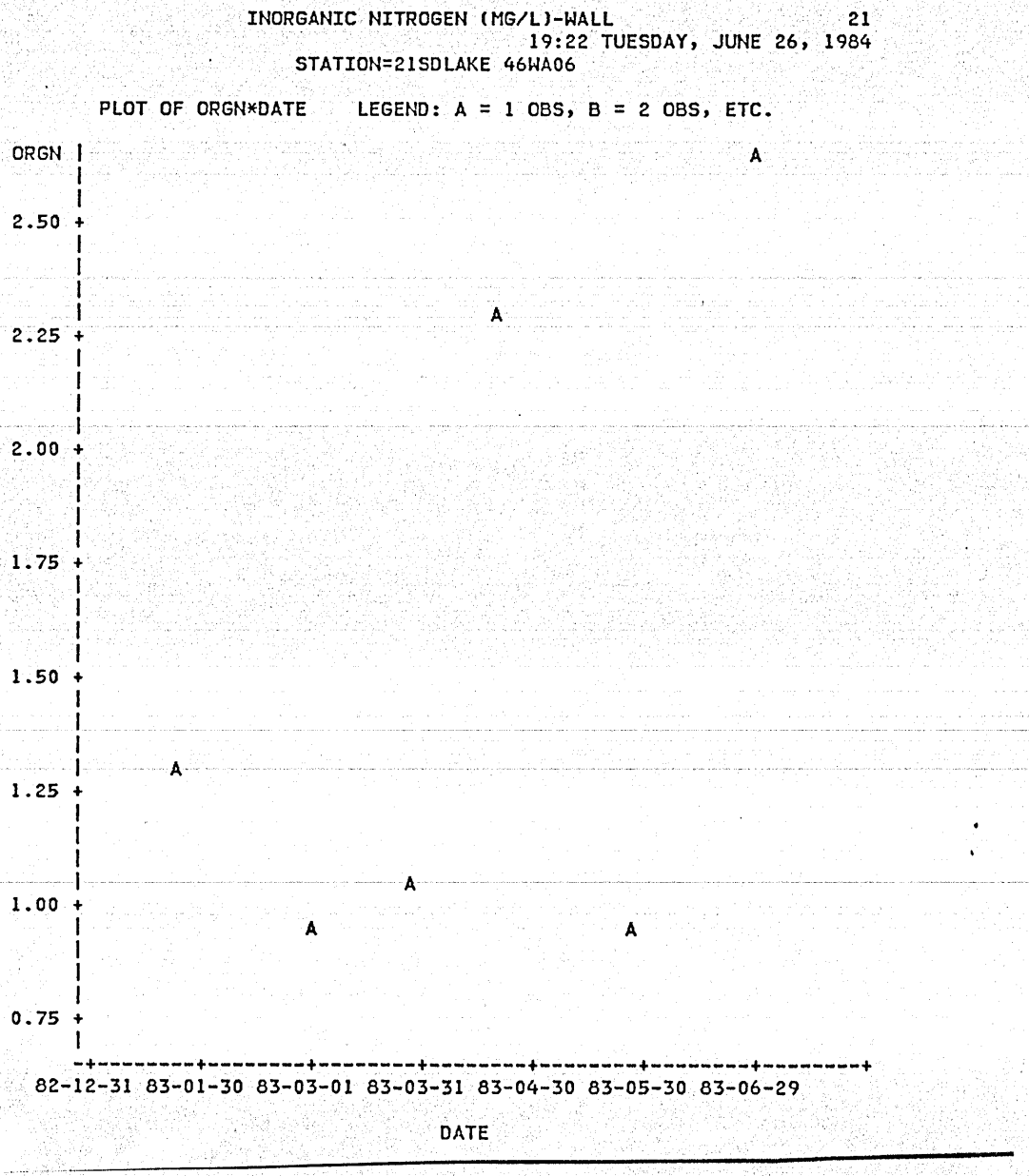

INORGANIC NITROGEN (MG/L)-WALL 16
19:24 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA06
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
82-09-22
82-10-12
82-11-01
82-11-21
82-12-11
82-12-31
83-01-20
DATE

Figure IV-86.


INORGANIC NITROGEN (MG/L)-WALL 21
19:22 TUESDAY, JUNE 26, 1984
STATION=21SDLAKE 46WA06
PLOT OF ORGN*DATE LEGEND: A = 1 OBS, B = 2 OBS, ETC.
ORGN
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
82-12-31 83-01-30 83-03-01 83-03-31 83-04-30 83-05-30 83-06-29
DATE

Appendix G

Miscellaneous Correspondence

LUFCO, INC.

BOX 73 RR 1

HARTFORD, SOUTH DAKOTA 57033

December 19, 1984

RECEIVED

DEC 20 1984

SOUTH DAKOTA DEPARTMENT OF WATER AND NATURAL RESOURCES
OFFICE OF WATER QUALITY

Dept. of Water & Natural Resources
Joe Foss Building
523 E. Capital
Pierre, S.D. 57501-3181

Attn: Mr. Terry L. Aaker

Dear Mr. Aaker:

In answer to your letter of December 12, 1984 concerning potential run-off from our feedlot, we would like to update you on our actions since your letter of June 25, 1984.

This summer, we spent a good deal of time studying our feedlot arrangement and how the yards could be improved or re-arranged to minimize run-off. We determined that our biggest problem was the inability to get equipment into the yards to haul manure during high moisture times, such as the last couple of years. Consequently, we built 2 additional buildings and poured approximately 1500 square yards of concrete. This will greatly reduce the amount of mud and manure mixture created plus enabling us to clean the yards on a more timely basis. We intend to add approximately the same amount of concrete again next year.

Secondly, we have talked to a couple of contractors and have developed a plan which would effectively collect the liquid run-off and divert it to a holding pond. The cost, however, of this drainage system is considerably more than the $3,500.00 that you advise is available from SCS. If you know of any other funds which could be available for this work, we would appreciate your help. I will be contacting SCS this winter to see if they have any other ideas which might assist in designing and funding this project.

As I mentioned previously, we feel that our contribution to the pollution problems of Wall Lake is very minute in comparison to the overall picture. However, we fully intend to have a retention system of some sort in operation by this time next year and would encourage your office and GF & P to direct your efforts toward rectifying the other contributors to the problem. I would not feel it very equitable, if we are to spend 10's of thousands of dollars, only to find that the problems of Wall Lake continue unabated.

Very truly yours,

LUFCO, Inc.

Warren Luke

Warren Luke

Appendix H

Wall Lake Dredging Proposal Correspondence

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
1860 LINCOLN STREET
DENVER, COLORADO 80295

JAN 26 1981

Ref: 8W-PM

FEB 02 1981

Mr. James Seyfer
South Dakota Water and
Natural Resources
Joe Foss Building
Pierre, South Dakota 57501

Dear Jim:

I have received and reviewed the grant application for Wall Lake submitted by DWNR. Although a significant amount of data has been collected, the application does not adequately justify the expenditure of funds for dredging at this time. Consequently, I have not forwarded the grant application to EPA Headquarters for a funding decision.

The grant application, as submitted, does not address quantification of internal nutrient loading. Consequently, projected impacts of sediment removal on reduction of nutrient loading is only conjecture. In view of the stated fact that present nutrient loading from inflow streams alone is sufficient to perpetuate eutrophic in-lake conditions, the projected impact of dredging on trophic status must be seriously questioned. Before dredging can be justified, present external and internal loading sources should be quantified and external loading sources identified. Projected feasible reductions in external sources then can be viewed in conjunction with internal loading to determine the most cost-effective restoration technique. If extreme nutrient loading can not be significantly reduced, alternatives to dredging should be considered for prevention of winter kill.

The application also states that internal loading will be reduced by dredging due to reduction of wind induced, turbulance disruption of the mud-water interface. Theoretically, if wind induced turbulance is sufficiently strong to disrupt bottom sediments, the turbulance would also be of sufficient strength to inhibit thermal stratification and maintain acceptable dissolved oxygen levels throughout the water column. The oxic conditions should inhibit sediment nutrient release.

In summary, I feel that Wall Lake has significant promise as a Clean Lakes project. The data collection planned for this summer will hopefully answer many of the outstanding questions. Until such questions are more fully addressed, however, dredging as a sole restorative technique can not be justified. If you have any questions, please call.

Sincerely yours,

Ronald M. Eddy
Clean Lakes Coordinator

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE APR 28 1981

SUBJECT: Sediment nutrient loading proposal

MAY 01 1981

FROM: Ron Eddy, Coordinator
Clean Lakes

TO:

Roger Dean, Environmental Engineer
Water Quality Management Section

In general, the research proposal is well written and comprehensive. Although I have some questions in regard to methodology, my questions could be better addressed in the work plan. I have long encouraged DWNR to address in their grant proposals the issue of nutrient loading due to sediment releases. Consequently, I feel this type of work is long overdue. I have two major areas of concern with the present proposal. First, in regard to Wall Lake, the proposal must be linked by DWNR with ongoing and anticipated study of the watershed. One of the major reasons why the proposal was rejected was the reported nutrient loading from unidentified sources in the watershed (see attachments). The sources of the watershed nutrient loading contribution must be identified. If external loading can not be significantly reduced, expenditure of funds for reduction in internal loading is highly questionable. Second, the issue of development of a methodology and model applicable to other waterbodies was not fully discussed. Additional information is needed concerning verification of the methodology/model in regard to other lakes, especially those in existing WQSA project areas and the potential RCWP area..

If the above comments can be addressed satisfactorily, I recommend funding.

Ref: 8W-PM

Mr. James Seyfer
South Dakota Water and
Natural Resources
Joe Foss Building
Pierre, South Dakota 57501

Dear Jim:

I have received and reviewed the grant application for Wall Lake submitted by DWNR. Although a significant amount of data has been collected, the application does not adequately justify the expenditure of funds for dredging at this time. Consequently, I have not forwarded the grant application to EPA Headquarters for a funding decision.

The grant application, as submitted, does not address quantification of internal nutrient loading. Consequently, projected impacts of sediment removal on reduction of nutrient loading is only conjecture. In view of the stated fact that present nutrient loading from inflow streams alone is sufficient to perpetuate eutrophic in-lake conditions, the projected impact of dredging on trophic status must be seriously questioned. Before dredging can be justified, present external and internal loading sources should be quantified and external loading sources identified. Projected feasible reductions in external sources then can be viewed in conjunction with internal loading to determine the most cost-effective restoration technique. If extreme nutrient loading can not be significantly reduced, alternatives to dredging should be considered for prevention of winter kill.

The application also states that internal loading will be reduced by dredging due to reduction of wind induced, turbulance disruption of the mud-water interface. Theoretically, if wind induced turbulance is sufficiently strong to disrupt bottom sediments, the turbulance would also be of sufficient strength to inhibit thermal stratification and maintain acceptable dissolved oxygen levels throughout the water column. The oxic conditions should inhibit sediment nutrient release.

In summary, I feel that Wall Lake has significant promise as a Clean Lakes project. The data collection planned for this summer will hopefully answer many of the outstanding questions. Until such questions are more fully addressed, however, dredging as a sole restorative technique can not be justified. If you have any questions, please call.

Sincerely yours,

Ronald M. Eddy
Clean Lakes Coordinator

1/24/81

Ref: 8W-PM REDDY:cas 1/22/81 W44748, rev.1-26-81,jm.

Wall Lake
South Dakota

The proposed project involves the removal of bottom sediments ($10^6 yd^3$) by hydraulic dredging. Dredge spoils would be pumped to disposal sites in the immediate area, where the solids would be removed by settling. Dredging would take place over a three-year period. During the first two years, carriage water from the disposal sites would be returned to the lake to minimize the lowering of lake levels. During the third year, the return water would be routed to the lake's outlet stream. (However, it is also mentioned that the clarified water might be used for irrigation. If so, only part, or perhaps none, of the carriage water would be returned to the lake.)

Disturbance of the bottom sediments by the cutterhead of the dredge will cause localized areas of the lake to experience increased turbidity and increased concentrations of iron, copper, ammonia, and other chemical substances normally trapped within the sediments. These effects are likely to be concentrated near the dredge, however, thus minimizing the impact on fish because they could avoid the area. Also, the fishery is composed primarily of bullheads, a species quite tolerant of the stress conditions caused by dredging.

Winterkill conditions are a distinct possibility during the project period. The lake has been subjected to winterkill several times in the past, and the combined effect of lowering the lake level (i.e. reduced volume) and disturbing the sediments will increase the likelihood of winterkill. However, only bullheads and a few species of minnows have established self-sustaining populations in the lake. Perch and walleyes are maintained through stocking. Therefore, even if winterkill should occur, its effects would not be particularly damaging over the long term. Winterkill could conceivably be beneficial if it were severe enough to reduce populations of undesirable species.

The disposal sites for the dredge spoils apparently have not been selected. If wetland areas are avoided, wildlife impacts are likely to be temporary. A possible exception to this could be toxicity problems associated with the copper content (25 mg/kg) of the lake sediments. The possibility for copper toxicity to plants and fish should be considered in the design of the sediment disposal plan.

If return waters from the disposal site are routed to the outlet stream

for one year as proposed, provisions should be made to offset downstream sedimentation. The return waters will not be completely clarified (and may contain traces of coagulants if used), and fine sediments may settle out in ponded areas. The same concern applies to the tributary channels above the lake if they are used for return flows.

The inlet and outlet streams for Wall Lake reportedly flow only intermittently, so year-round fish populations could not be sustained. Use of the inlet streams for return water might induce some fish to "run" these streams during periods when the channels were normally dry, and variations in flow rates could cause fish to be stranded and killed. Nevertheless, this is not likely to be a serious concern. Game fish populations in Wall Lake are maintained only through repeated stocking in any event, so losses could be offset readily.

Considering the fishery of Wall Lake, and the intermittent nature of the connecting streams, unacceptable impacts on fish and wildlife do not appear likely.

WALL LAKE, SOUTH DAKOTA

Background

This shallow (mean depth 2.7 m, max. depth 3.7 m), small (area - 1372 ha) lake is located 12 miles from Sioux Falls. It is in an area short of water-based recreational resources and is extensively used for boating, fishing, swimming, etc. However, there has apparently been a decline in water quality, associated with noxious summer blooms of blue-green algae, in recent years. Data are inadequate to permit an adequate assessment of trophic status. The extremely high orthophosphate values reported for both the tributaries and the lake itself coupled with low nitrate-N concentrations suggest that P must be present in excess and that lack of available nitrogen has been compensated for in the algal community through the dominance of N-fixing blue-greens.

Hydraulic input to Wall Lake is via surface inflow from its 1372 ha watershed. Retention time has not been determined. Sediment input is minimal due to the settling basin action of the numerous potholes and sloughs in the watershed.

Technical Feasibility of Project

The applicant fails to establish a valid case for the proposed project insofar as water quality improvement during the summer recreational season is concerned. The fact that water quality has deteriorated during "recent" years suggests that substantial changes in nutrient input must have occurred. Since the lake is not in a state of rapid infilling, it is illogical to suppose that internal recycling of nutrients is the primary cause of increased phytoplankton standing crops.

The dominance of the algal community by N-fixing blue-greens indicates that phosphorus must be the key nutrient for eventual control of eutrophication. Have agricultural practices in the watershed undergone recent changes? How many cattle are in the watershed's four feedlots and what are they contributing to tributary inflow? These types of questions need answering. The applicant seems to confuse removal of suspended solids, as overland flow is intercepted by potholes, with the removal of solubalized nutrients. Data on the chemistry of tributary inputs to Wall Lake suggest that such mechanisms are <u>not</u> effective in controlling P from edaphic sources.

Insofar as the proposed dredging operation is concerned, this appears to be well thought out from a technical standpoint except that no mention is made of possible adverse effects downstream (may be especially important during the third year of the project when spoil will be disposed of below the lake). The method of dredging selected and the limiting of the dredged area to prevent shoreline erosion are well thought through. However, no rationale is developed to justify the proposed new bathymetry as being what is needed to substantially alter mixing and hence nutrient recycling. I would expect that during the ice-free period mixing from surface to bottom would still occur over most of the lake's area.

The dredging program would have the beneficial effect of reducing winter oxygen stress on the fish community. However, if it is successful in limiting

vertical mixing during the summer months, an anoxic hypolimnion would be established. It is even possible that when this is mixed during early autumn resultant oxygen and ammonia concentrations could produce fish kills at that time. This occurs in some of the hypereutrophic potholes lakes of Manitoba.

Proposed Scope of the Project

Valid phosphorus (soluble and total) budgets with major sources clearly identified should be determined and the project reassessed at that time. For the reasons noted above the present nature and scope of the project is unlikely to produce substantive water quality improvement in Wall Lake.

A new project design should include: (1) estimation of potential adverse effects on the outlet stream, (2) determination of P inputs and a consideration of their control through BMP's for non-point sources and through improved septic tank systems' location, design and maintenance for private residences and facilities associated with public recreation, (3) planning for controlling waste inputs from additional residential development and increased numbers of recreationists should water quality improvement be affected and (4) an improved pre-project monitoring program which will determine the spatial and temporal distribution of chlorophyll and provide additional data on oxygen (especially during the winter), temperature water transparency, and ammonia against which changes resulting from restorative actions can be judged.

Proposed Monitoring Plan

This is adequate provided a proper baseline (see previous section) is established against which any changes can be judged.

Suggestions

A competent limnologist, versed in the management of eutrophication problems, should be retained to design a Phase I project, interpret the data obtained, and recommend alternatives for the restoration of Wall Lake.