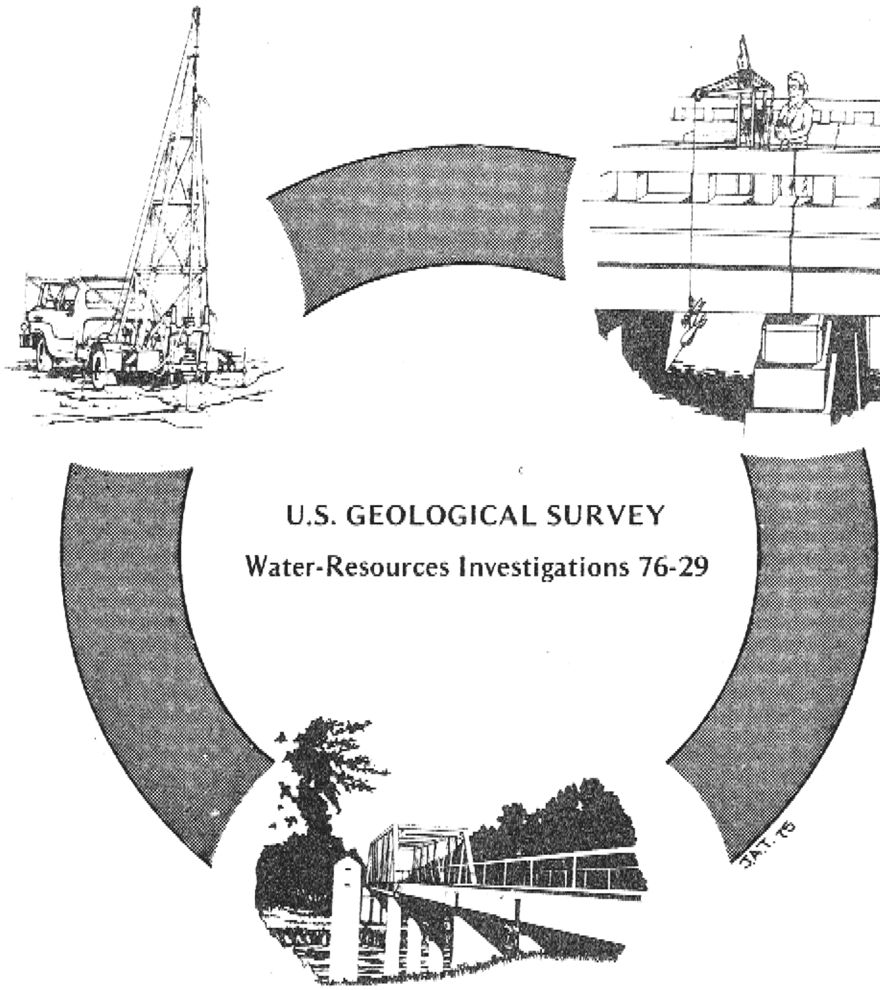
NITROGEN AND PHOSPHORUS UPTAKE IN THE EVERGLADES CONSERVATION AREAS, FLORIDA, WITH SPECIAL REFERENCE TO THE EFFECTS OF BACKPUMPING RUNOFF



U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 76-29

OF BACKPUMPING RUNOFF

Prepared in Cooperation with the
U.S. ARMY CORPS OF ENGINEERS

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16. Abstracts Water backpumped into Conservation Areas 1 and 3 is confined largely to canals and peripheral marshes. Water pumped into Area 2 extends into the interior marshes. Water that is backpumped into all three areas can alter water quality in the canals by breaking up water stratification, by resuspending bottom sediments, and by introducing water of a different chemical character. Concentrations of nitrogen and phosphorus decrease as water moves through the conservation areas in canals. This decrease is due partly to dilution by rainfall and runoff, and partly to net uptake in the canals and peripheral marsh. Uptake, estimated for three canals, accounted for a 2-percent decrease in phosphorus per mile and a 4-percent decrease in nitrogen per mile. Nitrogen and phosphorus and several trace metals are enriched in canal sediment near pumping stations compared with canal sediments remote from the pumping stations. Also, phosphorus is enriched, with respect to organic carbon and nitrogen, in canal sediments compared with marsh sediments.

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By

B. F. McPherson, B. G. Waller, and H. C. Mattraw

ABSTRACT

Water currently pumped into Everglades Conservation Areas 1 and 3 is largely confined to canals and their nearby marshes. In Area 2, however, canal water flows into the interior marshes.

In much of the water pumped into the northern Everglades, concentrations of inorganic nitrogen and phosphorus are relatively high. These nutrients are transported in the canals or into the peripheral marshes. Concentrations decrease sharply within 100 metres (330 feet) or less of the canals, whereas specific conductance remains essentially unchanged within this distance. The sharp decrease in inorganic nitrogen and phosphorus near the canal edge indicates net uptake in these shallow waters.

Concentrations of nitrogen and phosphorus also decrease as water moves through the conservation areas in canals. This decrease is due partly to dilution by rainfall and runoff, and partly to net uptake in the canals and their peripheral marsh.

The large canals of the northern and eastern parts of the conservation areas often have relatively low concentrations of dissolved oxygen which show little fluctuation within 24 hours. Also concentrations sometimes approach anaerobic levels near the bottom of the canals. This suggests that biological production is low and that respiration is the dominant metabolic process. Ground water influx may also contribute to low dissolved oxygen.

Long-term data from an index canal site in the western part of Area 3A, indicate that diel fluctuations in dissolved oxygen concentrations can be extremely variable from month to month and at the same season in different years. Maximum dissolved oxygen saturation at this site exceeded 100 percent about 20 percent of the time. Maximum oxygen production occurred in spring and was associated with low water level and flow.

Water pumped into the conservation areas can alter water quality in the canals by breaking-up water stratification, by resuspending bottom sediments, and by introducing water of a different chemical character. In Area 1 near pumping station S-5A in September 1973, ammonia and dissolved oxygen increased and orthophosphate, nitrate, and nitrite decreased after pumping. In Area 3A near pumping station S-9 in January 1973, ammonia increased and nitrate and dissolved oxygen decreased after pumping. These changes were detectable in canals several kilometres downgradient from S-9.

Backpumping into Conservation Area 3 added 230 tonnes (253 tons) of

total nitrogen and 1.8 tonnes (2 tons) of total phosphorus from July 1972 through June 1973. Backpumping 50 percent of the total annual canal runoff in southeast Florida would add from 900 to 5,600 tonnes (990 to 6,160 tons) of nitrogen and from 9 to 56 tonnes (10 to 62 tons) of phosphorus to the conservation areas.

The bottom sediments of the Everglades are a sink for nitrogen and phosphorus. They can, however, be a source of these nutrients when anaerobic conditions exist at the water-sediment interface or when bottom material becomes resuspended. With respect to organic carbon and nitrogen, phosphorus is enriched in canal sediments compared with marsh sediments. Also there is some indication that nitrogen and phosphorus and several trace metals are enriched in canal sediments near pumping stations that drain agricultural land compared with canal sediments remote from pumping stations.

Thirty-four samples of aquatic plants were analyzed for nitrogen, phosphorus, cárbon, copper, lead, and zinc. Except for slightly higher concentrations of phosphorus in plant tissue from two locations where water quality is poor, no significant differences in nutrient and metal concentrations were evident in aquatic plants collected either from remote, relatively undisturbed areas or from areas receiving agricultural runoff.

INTRODUCTION

The Everglades Environment

The Everglades is a wide, shallow, peat-filled depression that extends from Lake Okeechobee to the mangrove estuaries of Shark River (fig. 1). It is bounded on the east by the Atlantic Coastal Ridge and on the west by the sandy flatlands and the Big Cypress Swamp. It slopes gradually southward from Lake Okeechobee. The peat soil, derived from marsh vegetation, is 2 to 3 metres (7 to 10 ft) deep in the northern Everglades, and decreases to 1 metre or less near its southern extremity in the lower Shark River Slough.

The Everglades is a vast saw grass marsh interspersed with tree islands, sloughs, and wet prairies. It floods seasonally, and often becomes dry during several months in the spring. Water is deepest in the sloughs and becomes shallower progressively to the wet prairies, to the saw grass marsh, and to the tree islands. Differences in water depth between these communities are in the order of a few centimetres to several decimetres.

Direct rainfall is the prime source of the Everglades' water. Historically the water flowed slowly southward toward the Gulf of Mexico and Florida Bay, but during periods of heaviest rainfall also flowed toward the Atlantic Ocean through the transverse glades. During extremely wet years Lake Okeechobee overflowed southward. (Parker and others, 1955, p. 332).

The complexion of the Everglades has changed over the years because of drainage, flood control, and water management practices. The greatest changes in the hydrologic regime were caused by drainage and flood control. Much of the northern Everglades was drained in the early and mid 1900's for

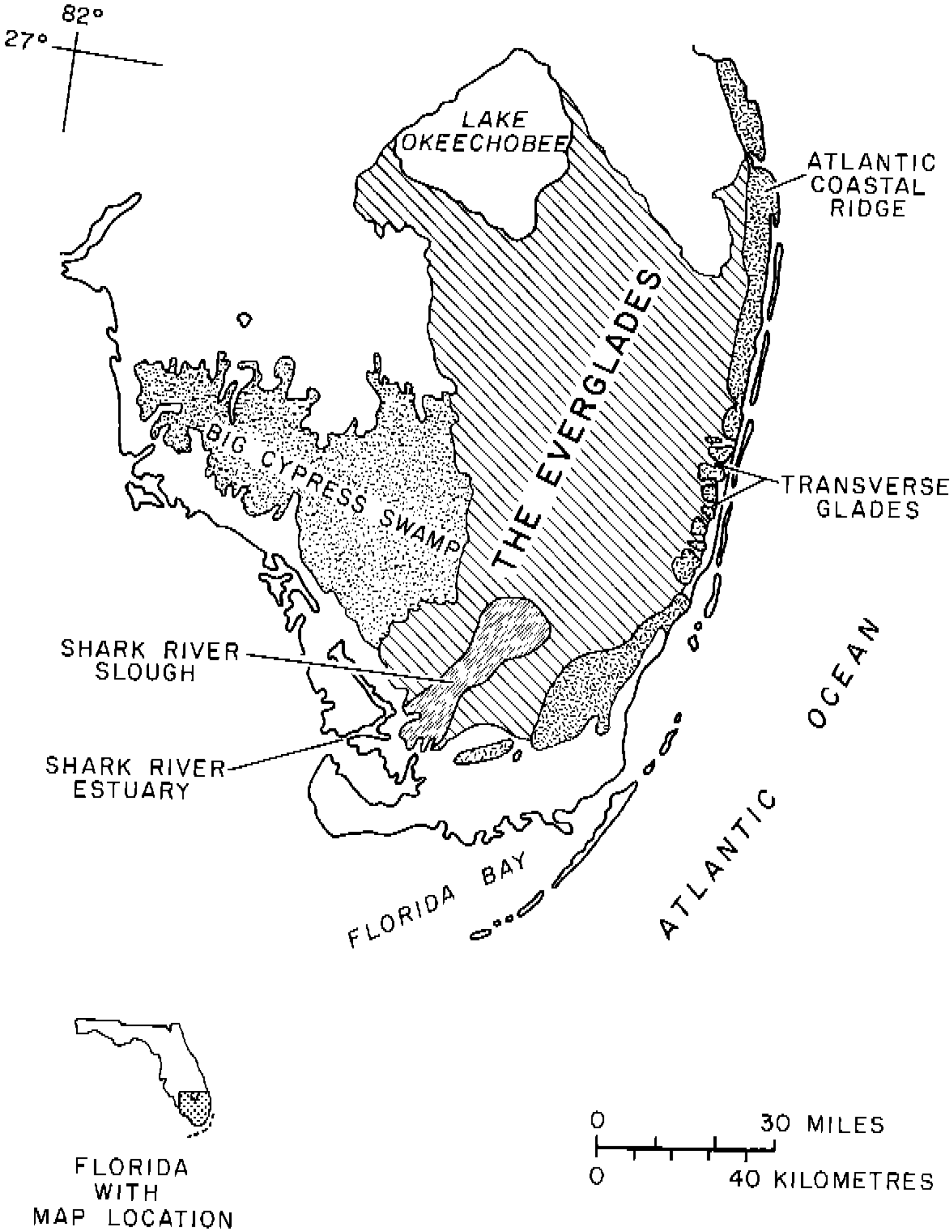

Figure 1.--The Everglades.

agricultural development (fig. 2).

In recent years emphasis in water management has been on water control and conservation. Lake Okeechobee became the prime unit for surface-water storage in the water system of southeast Florida, supplemented by the three conservation areas to the south. The conservation areas serve as replenishment sources for lower east coast municipalities and agriculture by releases into canals and by underseepage through the Biscayne aquifer. The remaining marshes of the Everglades are now mostly within the conservation areas and Everglades National Park (fig. 2).

Water to sustain the marshes of the conservation areas and Everglades National Park comes from direct rainfall and from canals which convey water from Lake Okeechobee and from agricultural lands to the north. Water flows southward down the canals by gravity or is pumped southward into the conservation areas. The three conservation areas are connected by spillway structures that enable water to be transferred directly from Lake Okeechobee through Conservation Area 3 and thence to Everglades National Park or to the Miami area during drought. In addition, water can be backpumped from the east into Conservation Area 3A at pumping station S-9. Control structures are operated to maintain the desired water levels for the conservation areas.

Water quality in parts of the Everglades has changed over the years. Pesticides and polychlorinated biphenyls (PCB's) now occur in relatively high concentrations in bottom sediment and fish in parts of the Everglades (McPherson, 1973). Concentration of dissolved solids are significantly higher in the northern canals and in Conservation Area 2 than in the southern Everglades or the interior of Area 1. Although dissolved solids concentrations have increased in places in the southern Everglades (Klein and others, 1974), they have changed little in the northern Everglades since the 1940's (Gleason, 1974). Concentrations of nitrogen and phosphorus tend to be higher in parts of the northern Everglades than in the south (B.G. Waller and J.E. Earle, 1975).

Increased concentrations of nutrients from agricultural and urban development will change the Everglades environment. Increased amounts of nutrients in aquatic environments often cause lush growth of aquatic plants, shifts in food webs, changes in animal populations, and deterioration of water quality.

Nutrients enter the Everglades mainly in rainfall and dry fallout, and in surface water inflow. Whereas rainfall and dry fallout are widely distributed, most surface water inflow enters at 6 pumping stations in the conservation areas.

Although over 20 elements are essential for growth and considered nutrients, only a few are required in large amounts. These include carbon, hydrogen, oxygen, nitrogen, and phosphorus. Carbon, hydrogen, and oxygen are usually abundant, whereas nitrogen and phosphorus sometimes are not, and limit growth. Because of the importance of nitrogen and phosphorus in controlling aquatic plant growth emphasis in this investigation was placed on those elements.

CONVERSION OF FACTORS

The following factors may be used to convert the Metric units published herein to English units.

Multiply Metric Units	by	To obtain English Units
	Length	
millimetres (mm)	0.03937	inches (in)
metres (m)	39.37	
metres (m)	3.281	feet (ft)
kilometres (km)	0.6214	miles (mi)
	Area	
square kilometres (km^2)	0.3861	square miles (mi^2)
	Flow	
litres per second (l/s)	0.0353	cubic feet per second (ft^3/s)
cubic metres per second (m^3/s)	35.31	
	Mass	
tonne (t)	1.102	ton (short)

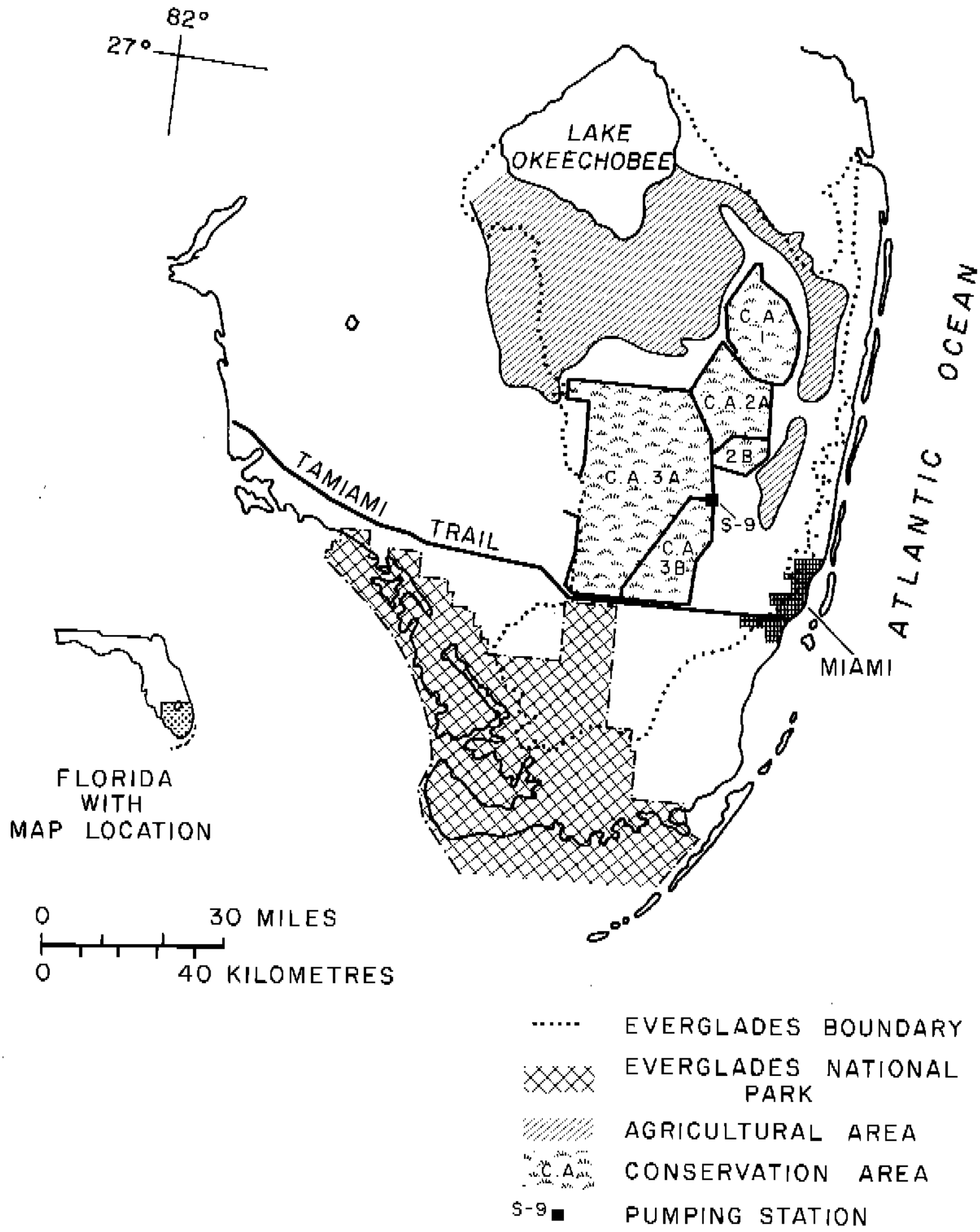

Figure 2.--Everglades boundary, the conservation areas, Everglades National Park, and areas of agricultural development.

Backpumping Plans

Plans for more efficient water management in southeast Florida by the Central and Southern Florida Flood Control District (FCD) include increased backpumping of surplus storm water to the conservation areas (U.S. Army Corps of Engineers, 1968). Recommended construction by the Corps of Engineers calls for completion by 1984. Existing and planned pumping stations are shown in figure 2A. Water can now be pumped into the conservation areas at six stations. Three additional stations have been proposed for pumping water into the conservation areas from the east. These include:

(1) S-319, with a pumping capacity of 82.7 m^3/s (2920 ft^3/s) which would backpump surplus water from a 718 km^2 (276 mi^2) area from the C-51 extension of the West Palm Beach Canal into Area 1 (FCD, 1973).

(2) S-320 with a pumping capacity of 33.7 m^3/s (1190 ft^3/s) which would backpump surplus water from a 309 km^2 (119 mi^2) area to the Hillsboro Canal.

(3) S-330 which would backpump surplus water from a 169 km^2 (65 mi^2) area into the southern part of Area 3.

Large-scale backpumping of water from land east of the conservation areas could affect the Everglades environment if water levels were altered permanently, or if additional loads of nutrients and pollutants were introduced. Vegetation has already changed in parts of the conservation areas where water levels have increased by impoundment (Alexander and Crook, 1974; Hagenbuck and others, 1974). The degree that large-scale pumping would alter the Everglades environment by introducing nutrients and pollutants is not clear. Although the marshes of the Everglades tie-up large amounts of nutrients in plant biomass and in sediments, the capacity of the marshes to retain and tolerate additional nutrients is not known.

Part of the water backpumped into Conservation Area 3 would eventually enter Everglades National Park. To assure that the quality of the water supplied to the Park will not deteriorate, the Committee on Public Works of the U.S. Senate requested, in Senate Document No. 91895, May 26, 1970, that the Corps of Engineers prepare a report within 1 year on the measures taken, and any agreement reached, to maintain good quality in the water delivered to the Park. The Corps contracted with a private consulting firm Water and Air Research, Inc. (WAR), Gainesville, Florida, to prepare the water quality report. One of the recommendations in the WAR (1971) report was that a permanent water quality monitoring program be established. In addition, WAR recommended a study on the ecological effects of backpumping of east coast runoff.

At the request of the Corps of Engineers, the U.S. Geological Survey undertook the recommended water-quality monitoring and backpumping investigations in the conservation areas. A monitoring network of 26 surface water sites and four bulk precipitation sites was started in July, 1972. Investigations of backpumping were begun in January, 1973.

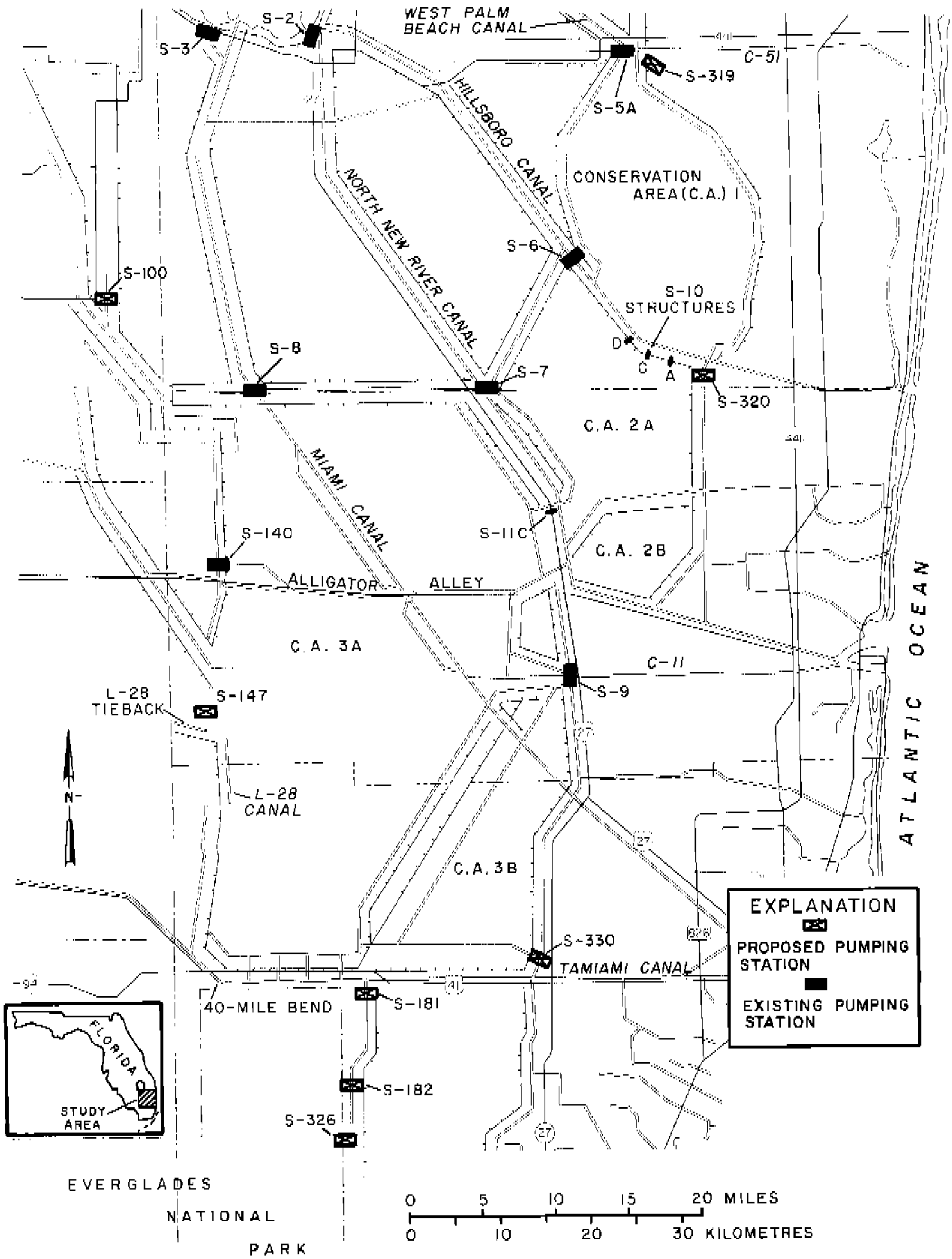

Figure 2A.--Existing and proposed pumping stations near the conservation areas.

B.G. Waller and J.E. Earle (1975) summarized the data collected between 1972 and 1974 at the 26 surface water sites and four precipitation sites. Waller (1975) also analyzed nitrogen and phosphorus loading in the conservation areas using selected sites in the monitoring network. This report summarizes the investigation of backpumping and its effects on the Everglades ecosystem. Acknowledgment is given to the Corps of Engineers for support of the investigation.

Purposes and Scope

The purposes of this investigation were to make a qualitative assessment of the effects on water quality of pumping water into the conservation areas, and specifically to evaluate the uptake by sediment and biota of nitrogen, phosphorus, and selected trace elements contained in the water.

The scope of the investigation includes the collection and interpretation of chemical data from water, sediment, and aquatic plants in the vicinity of and remote from pumping activities. Diel (24-hour) studies were included to determine changes in nitrogen, phosphorus, and dissolved oxygen and whether the concentrations of these constituents were affected by pumping. Nutrient transects were made to determine the distribution of water pumped into the areas and to evaluate the location and extent of nitrogen and phosphorus uptake. Diel studies and transects were made during high-and-low-water periods in 1973 and 1974.

Sampling Sites

Water samples for chemical analysis were collected in the conservation areas along transects and during diel periods for wet and dry seasons. Transects extended from perimeter canals into the marshes (fig. 3). Specific conductance, dissolved oxygen, temperature, inorganic nitrogen species and inorganic phosphorus were measured at selected points along each transet. Diel studies were carried out at seven locations in the conservation areas (fig. 3A). Dissolved oxygen and temperature were measured every few hours at one or more sites at each location. Specific conductance and inorganic forms of nitrogen and phosphorus were measured less frequently. Six sites were established near pumping station S-5A (fig. 4); eleven near pumping station S-9 (fig. 5); three on the Hillsboro Canal (one each at the S-10 structures A, C, D), and four just south of S-10C in Conservation Area 2A (fig. 3A). An index station, L-28, was established in the western part of Conservation Area 3A on Levee 28 canal about 19 kilometres (12 miles) north of 40-mile bend (fig. 3A).

In addition to the water samples collected on the transects and during diel studies, other water, sediment, and plant samples were collected at specific locations for analysis of inorganic and organic nitrogen, phosphorus, and trace elements. The locations of stations where bottom sediments, plant nutrients, and plant biomass data were collected are also shown in figures 3, 5A, and 5B.

Names of sampling areas with their latitude-longitude or downstream order number are given in Table 1.

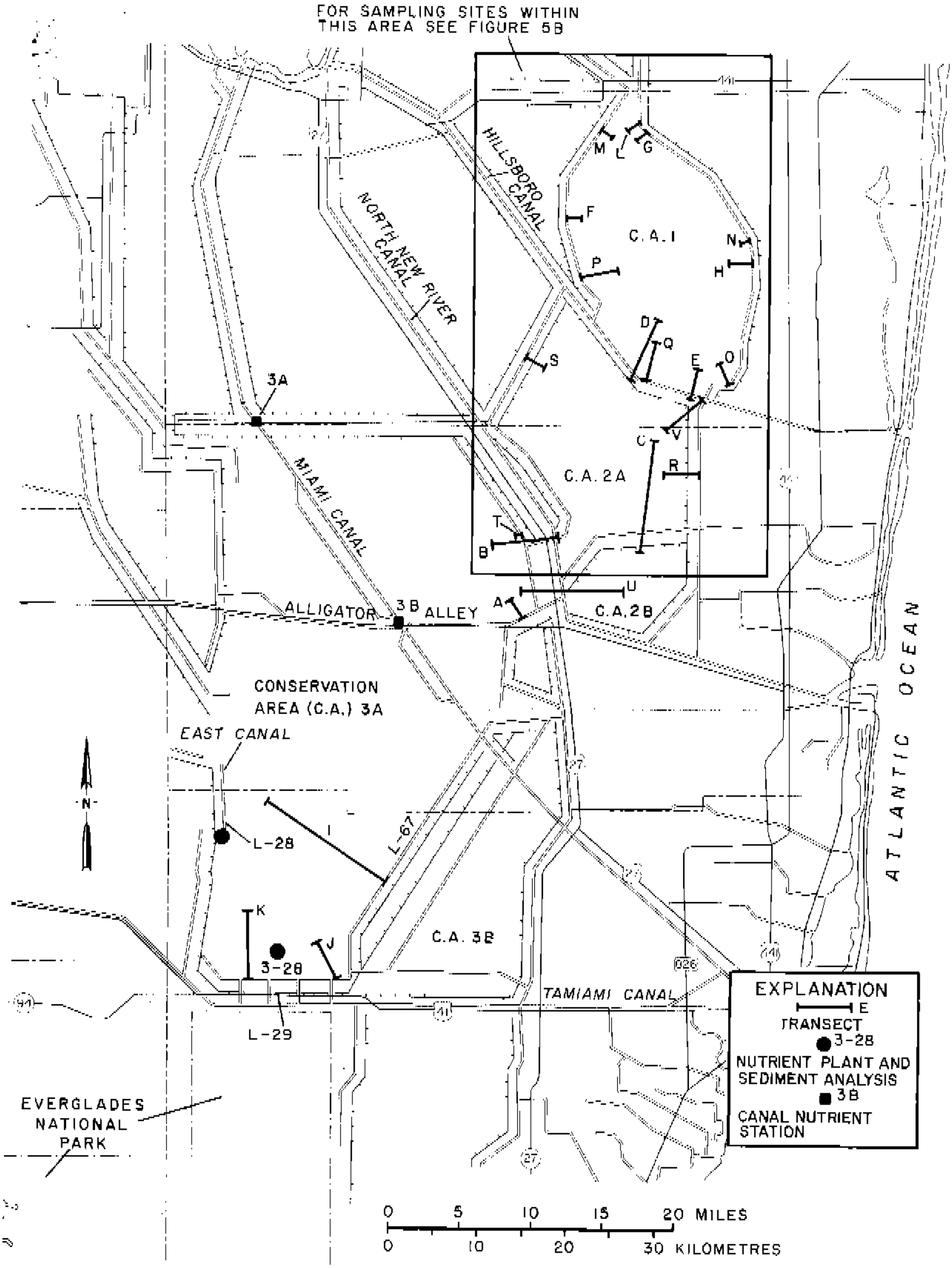

Figure 3.--Nutrient transects, canal nutrient stations, and plant sample areas.

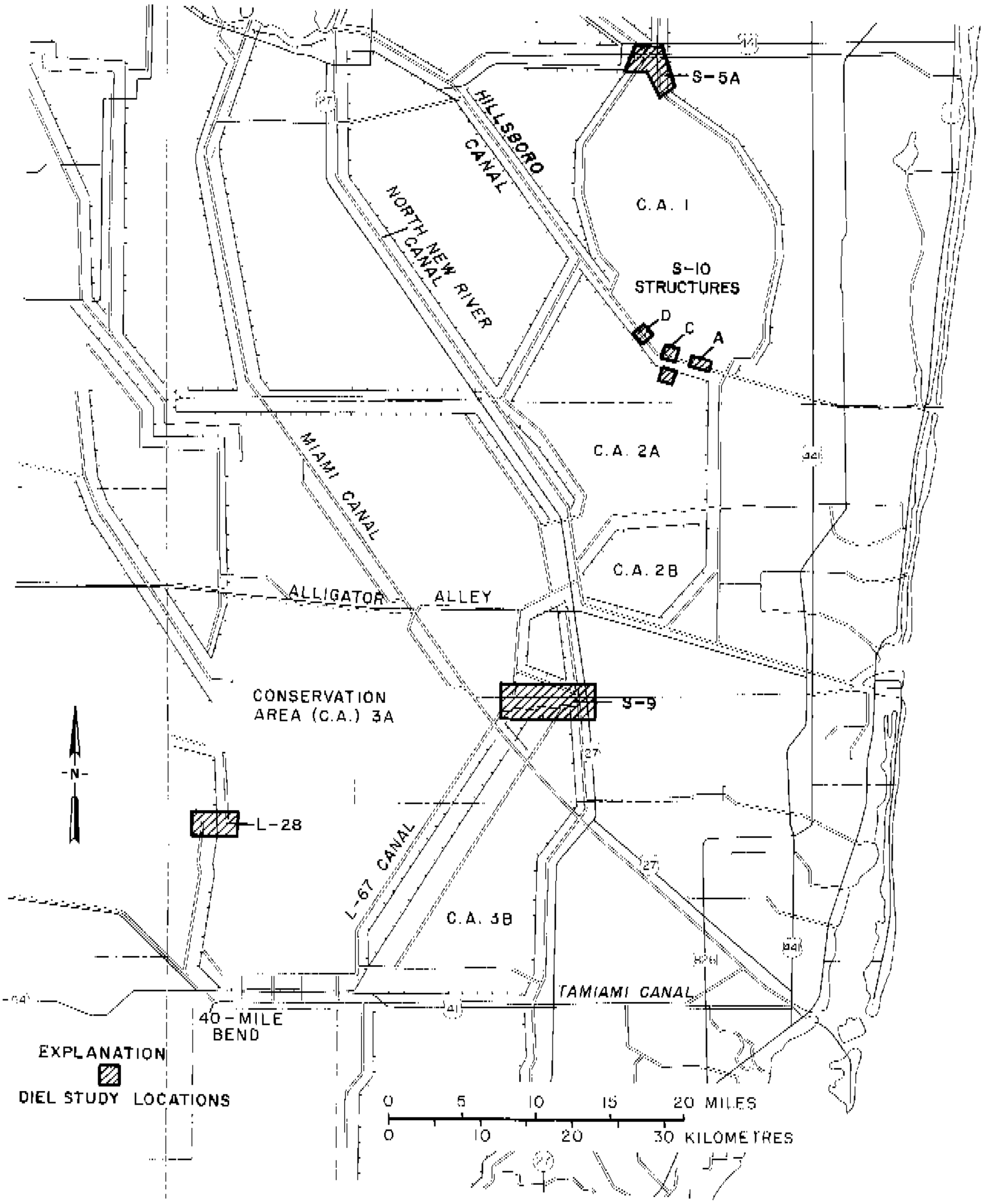

Figure 3A.--Locations of diel study.

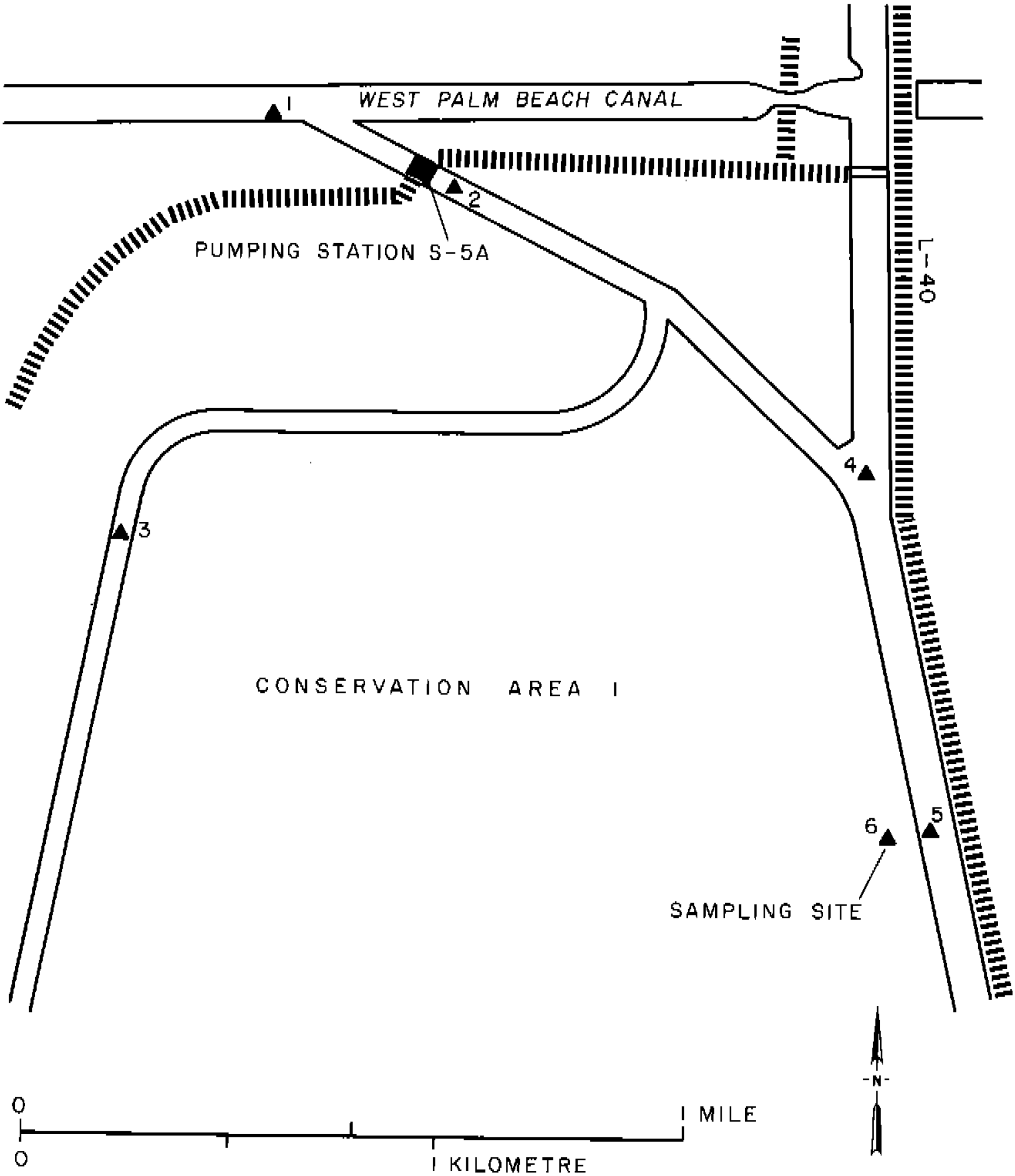

Figure 4.--Sampling sites near pumping station S-5A.

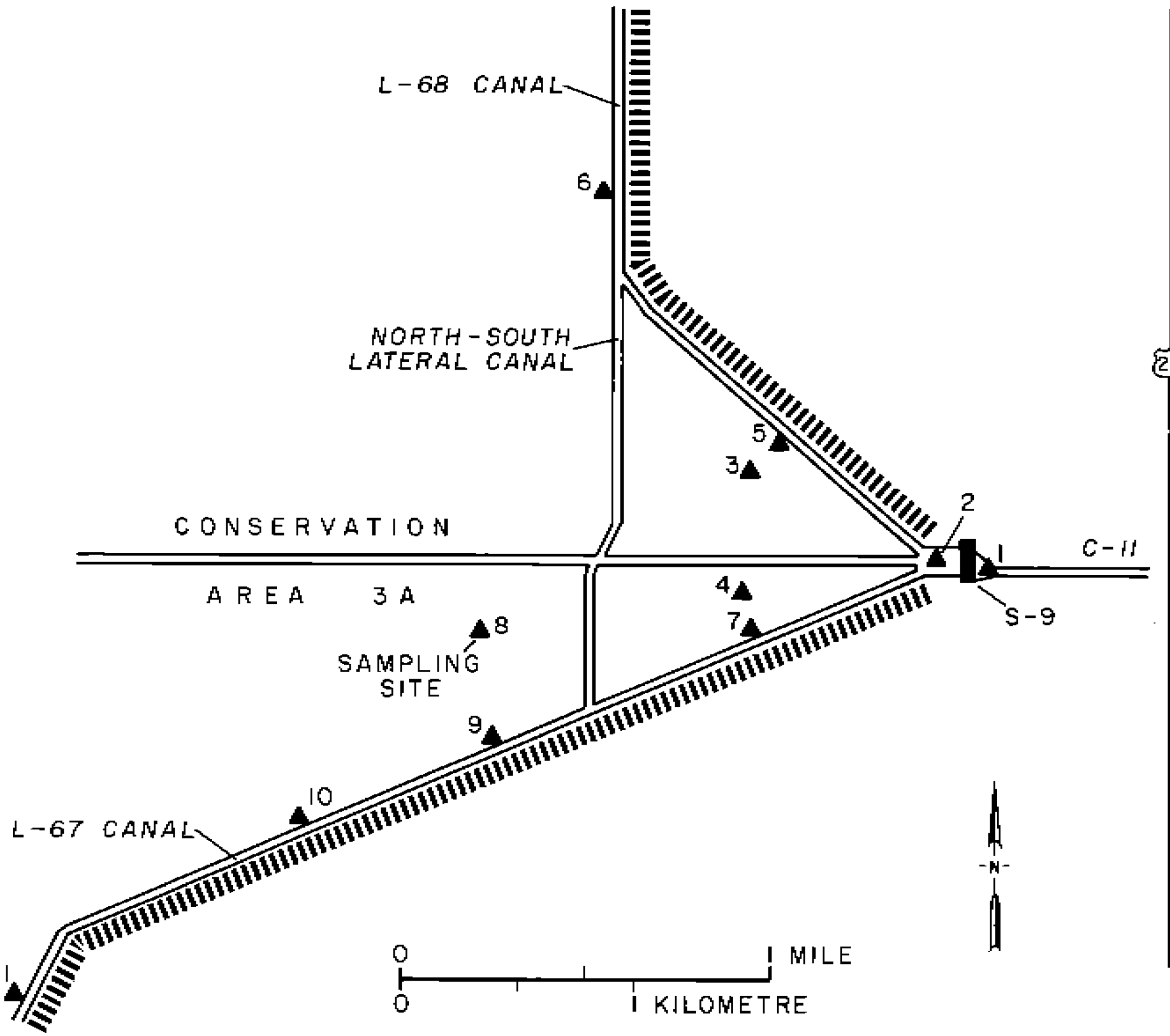

Figure 5.--Sampling sites near pumping station S-9.

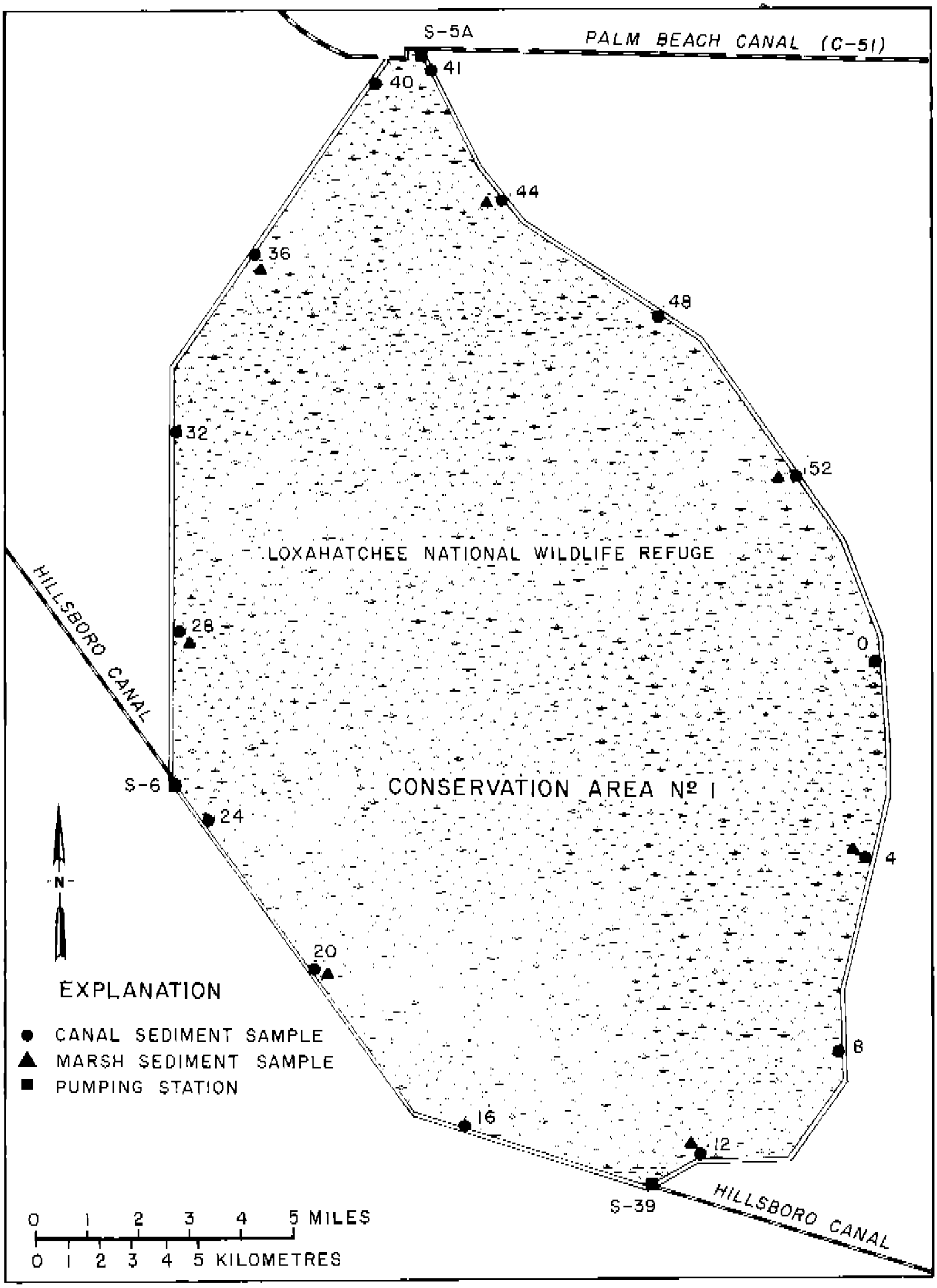

Figure 5A.--Location of bottom sediment samples collected in canals and marshes of Conservation Area 1 in February 1974.

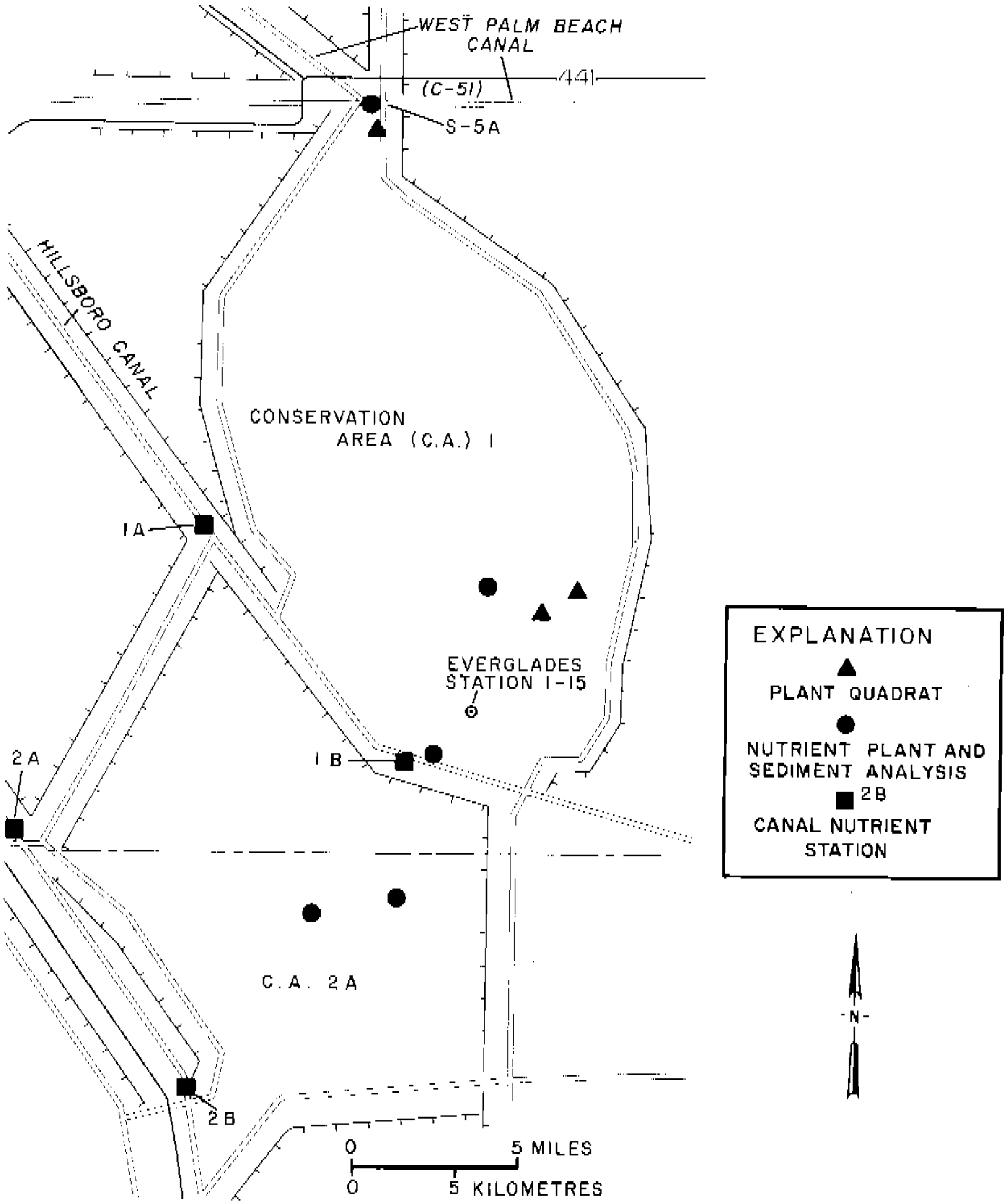

Figure 5B.--Sample areas and stations in Conservation Areas 1 and 2A.

Table 1.--Names of sampling areas and stations. Locations shown on Figures 2A, 3, 3A or 5B.

Description	Downstream order number or latitude-longitude
Pumping Station S-5A	02278450
Pumping Station S-9	02285400
L-28 East Canal	255600080484500
Hillsboro Canal above S-10C	262400080230000
Everglades No. 3-28	02289043
1A Hillsboro Canal above S-6	02281200
1B Hillsboro Canal above S-10	2624000802300
2A North New River Canal above S-7	2620000803210
2B North New River Canal above S-11C	02284501
3A Miami Canal at S-8	02286700
3B Miami Canal Alligator Alley	2608500803810
5 miles South of S-10C	2620050802050
Everglades Station 2-17	02284642
South-center Area 1 quadrat Site 3	2627300801600
South-center Area 1 quadrat Site 4	2626000801700
South-center Area 1 nutrient sample	2627300801900
Pumping Station S-6	02281200
Pumping Station S-7	262000080320500
Pumping Station S-8	02286700
Everglades Station 1-15	02281295
L-67A Canal	25462008039500

WATER CHEMISTRY CHARACTERISTICS

Nitrogen and Phosphorus Concentrations at Selected Sites

Data were collected monthly from July 1972 to July 1974 at five pumping stations to characterize concentrations of nitrogen and phosphorus pumped into the conservation areas (B. G. Waller and J. E. Earle, 1975). These data are summarized in Table 2. Median concentrations of nitrate, nitrite, ammonia, inorganic nitrogen, organic nitrogen, total nitrogen, and total phosphorus are given. For comparison median concentrations for samples collected during this period at three marsh sites and at an index site remote from pumping stations are also shown on Table 2.

Median concentrations of inorganic nitrogen, ranging from 0.13 to 0.75 mg/l (milligram per litre), were higher at the pumping stations than at the three marsh sites or at the L-28 canal index site, where they ranged from 0.04 to 0.13 mg/l (table 2). Ammonia was the most abundant form of inorganic nitrogen at 3 of the pumping stations, the marsh sites, and L-28 (table 2). The relatively high concentrations of ammonia at S-6 (0.39 mg/l) and S-9 (0.41 mg/l) probably result from high ammonia concentrations in ground water which seeped into the feeder canal during pumping. Also, at pumping station S-9, dissolved oxygen is often near zero. Under such conditions other forms of inorganic nitrogen would tend to be converted to ammonia. Freiberger (1973) reported marked decreases in dissolved oxygen and nitrate concentrations and increases in ammonia concentration in Conservation Area 3A during backpumping at pumping station S-9. Nitrate was virtually absent at S-9, but exceeded 0.10 mg/l at the other pumping stations. It was the most abundant form of inorganic nitrogen at pumping stations S-5A and S-8. For comparison, median nitrate concentrations were zero at the marsh sites, presumably because this form of nitrogen is readily taken up by organisms in the marsh.

Median concentrations of organic nitrogen and total nitrogen were slightly lower at the L-28 canal site and 2 marsh sites, 3-28 and 1-15, than at pumping stations S-5A, S-6, S-7 and S-8. The median value at marsh site 2-17 (Conservation Area 2), however, is in the same range as those at the pumping stations.

Median concentrations of total phosphorus were higher at pumping stations S-5A and S-6 (0.05 mg/l) than at the other pumping stations, at L-28, and at the marsh sites (0.01 - 0.02 mg/l) (table 2).

Nitrogen and Phosphorus Uptake in Canals

Downstream changes in nitrogen, phosphorus, and specific conductance were measured in 3 canals in the conservation areas; the Hillsboro Canal, the North New River Canal, and the Miami Canal. A pair of sites in each canal was sampled monthly from September 1972 to June 1974. The sites in each canal were about 16 kilometres (10 miles) apart and are shown on figures 3 and 5B.

In the canals specific conductance decreased downstream 1 percent per kilometre (2 percent per mile), on the average, whereas total phosphorus and

Table 2.--Median concentrations of nitrate, nitrite, ammonia, organic nitrogen, total nitrogen, and total phosphorus in mg/l (as N or P) at pumping stations S-5A, S-6, S-7, S-8 and S-9; at Canal L-28 remote from pumping stations and agricultural activity; and at marsh sites 3-28, 1-15, and 2-17. (Data collected monthly between July 1972 and July 1974. Location of sites shown on 2A or 3.)

	Inorganic-N						
Pumping Stations	Nitrate	Nitrite	Ammonia	Inorganic Nitrogen	Organic Nitrogen	Total Nitrogen	Phosphorus
S-5A	0.48	0.07	0.20	0.75	1.8	2.4	0.05
S-6	.24	.08	.39	.71	2.2	3.1	.05
S-7	.13	.03	.15	.31	1.8	2.2	.02
S-8	.13	.02	.08	.23	1.9	2.2	.02
S-9	.01	.01	.41	.13	1.4	1.8	.02
Canal L-28 (index site)	.03	.01	.09	.13	1.6	1.7	.02
Marshes							
3-28	.00	.00	.04	.04	1.6	1.6	.02
1-15	.00	.00	.04	.04	1.3	1.4	.01
2-17	.00	.01	.05	.06	2.2	2.4	.01

inorganic nitrogen decreased 3 percent and 4 percent per kilometre (4 percent and 6 percent per mile) (table 2A). The decrease in specific conductance indicates dilution from rainfall on the marsh and canal. The decrease in phosphorus and nitrogen indicates: 1) dilution from rainfall plus uptake; or, 2) addition from rainfall plus uptake in excess of the addition. Rainfall contributes large loads of nitrogen and phosphorus to the conservation areas, but much of this is retained in the marshes (Waller, 1975). Concentrations of inorganic nitrogen and phosphorus in the water of the marshes are typically lower than in the water of the canals in the conservation areas (table 2). The decrease in nitrogen and phosphorus downstream in these canals, then, probably reflects dilution plus uptake.

Nitrogen and phosphorus Uptake in Marshes

Samples were collected along twenty-two transects during high water (September 1973) and low water (January 1974) periods (fig. 3). The purpose of the transects was to evaluate the movement of water from the canals into the marshes, and the changes in water chemistry caused by this movement. Each transect extended from a canal, or across a canal, into the marshes of the conservation areas. Inorganic forms of nitrogen and phosphorus, specific conductance, dissolved oxygen, and temperature were measured at selected distances along the transects (Basic data A).

Specific conductance, which is not readily altered by biological activity, was used as an indicator of water movement. Canals in the northern parts of the conservation areas tend to have relatively high conductance, often above 1,000 µmhos/cm (micromhos per centimetre). Because canal water has higher conductance than rainfall (rain water is usually below 100 µmhos/cm) the movement of the canal water into the marshes can be estimated from the specific conductance of water in the marshes. Concentrations of dissolved oxygen and the inorganic forms of nitrogen and phosphorus, however, are much more susceptible to biological changes than is specific conductance.

Around much of the perimeter of Conservation Area 1 specific conductance decreased to that of the interior (100-150 µmhos/cm) within a few kilometres indicating that canal water was a minor part of the water at those distances (figs. 6 and 7). In the southwest, however, specific conductance values half that of canal water were measured at several kilometres in the marsh, indicating that water from canals, mixed with rain water, extended farther into the interior in the southwest than in other parts of Area 1. Average specific conductance for all marsh sites in Area 1 was only 248 µmhos/cm in September 1973 (table 3).

While canal water did not flow into the marshes of Conservation Area 1 much beyond several kilometres, it did penetrate into the interior of Conservation Area 2A and alter quality there. Specific conductance, for example, was only slightly higher in 1972-73 in the Hillsboro Canal at S-6 (1,340 µmhos/cm) than in the marshes near the center of Area 2A (1,150 µmhos/cm).

Data are not available to adequately evaluate the effect of canal water on specific conductance in Area 3. Three transects in September 1973 indicate, however, that the spread of canal water outward from L-67 and L-29 canals into

Table 2A.--Changes in nitrogen (N) and phosphorus (P) in milligrams per litre and specific conductance in micromhos per centimetre at 25°C at paired sampling sites on canals in the conservation areas. (The values represent monthly averages of 24 samples except 2A which had 23 samples) over the period September 1972 to June 1974. Location of sites shown on Figures 3 and 5B.

Site	Dist. Downstream Kilometres	NO_3-N	NO_2-N	NH_3-N	Inorganic N	Total P	Specific Cond. umhos
1A	11	0.64	0.10	0.44	1.2	.12	1270
1B		.11	.02	.10	.23	.04	1000
Percent change		-83	-80	-77	-81	-66	-22
2A	13	.37	.04	.19	.60	.04	1150
2B		.10	.02	.15	.27	.03	1000
Percent change		-73	-50	-22	-55	-25	-13
3A	24	.70	.05	.12	.87	.03	930
3B		.46	.02	.08	.56	.02	740
Percent change		-33	-60	-33	-36	-33	-20
Average percent change		-63	-63	-44	-57	-41	-18
Percent change per kilometre		- 4	- 4	- 3	- 4	- 3	- 1

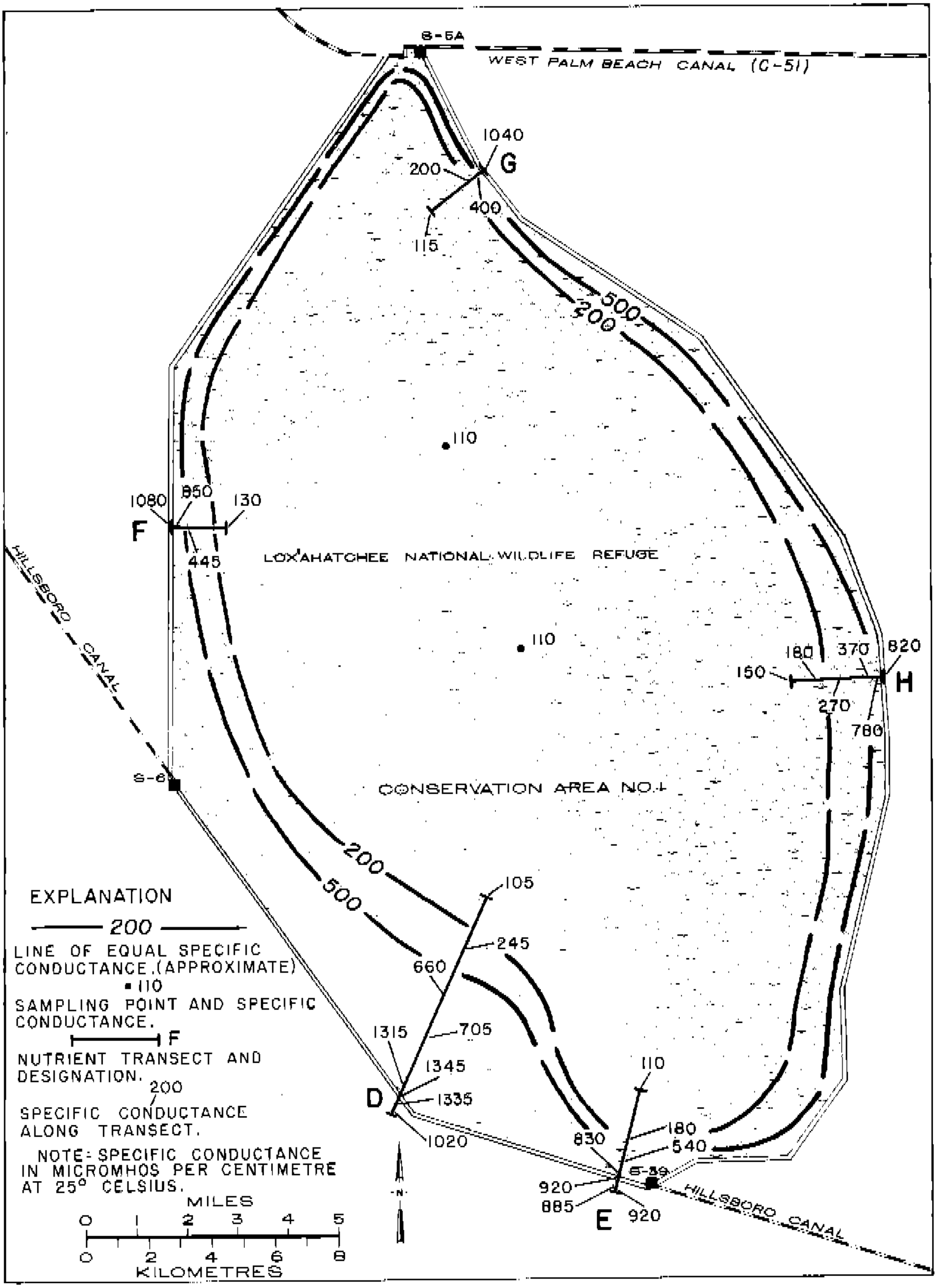

Figure 6.--Specific conductance in Conservation Area 1 in September 1973 (high water). 25

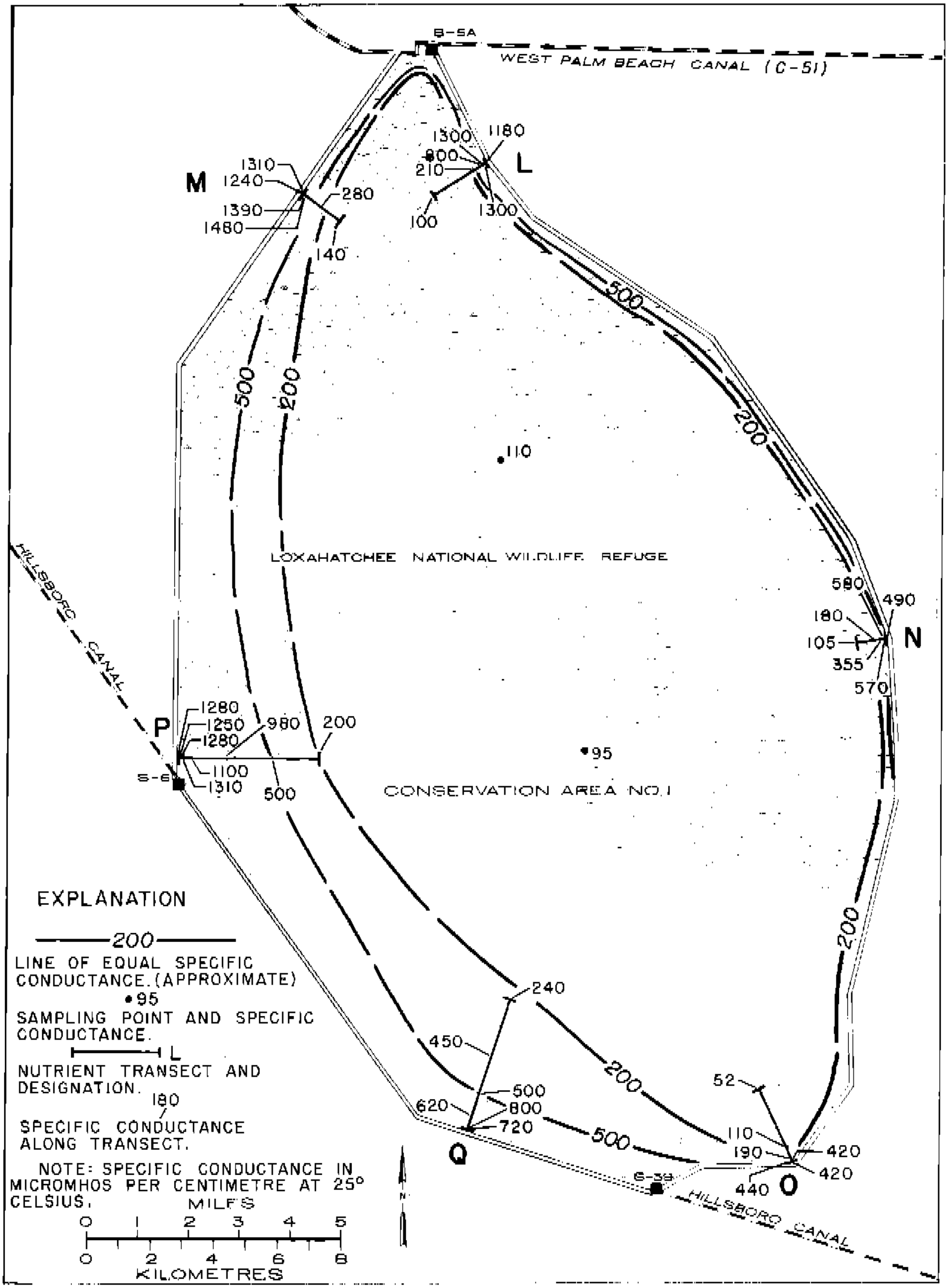

Figure 7.--Specific conductance in Conservation Area 1 in January 1974 (low water).

Table 3.--Average concentrations in mg/l of NO_3, NO_2, NH_3 (as N) and PO_4 (as P) in the conservation areas and adjacent canals on 10-11 September 1973 and 16-17 January 1974. (Specific conductance in micromhos/cm at 25 C.)

	Habitat type	Number of Samples	NO_3-N	NO_2-N	NH_3-N	PO_4-P	Specific Cond.
September 1973	Perimeter canals	16	0.11	0.03	.38	0.02	1,040
	Marsh, Conser. Area 1	21	.00	.00	.21	.00	248
	Marsh, Area 2	4	.00	.00	.16	.01	1,025
	Marsh, Area 3	14	.00	.00	.12	.00	395
	Total Marsh	39	.00	.00	.17	.01	443
	Transects A, E. F (canals)	3	.18	.05	.65	.04	980
	Transects A, E, F (100-metres in marsh)	3	.00	.00	.26	.01	677
	Interior marshes of Areas 1 and 3	5	.01	.00	.17	.01	163
	Agricultural canals at Area 1	10	.15	.06	.86	.05	1,070
January 1974	Perimeter canals	11	.18	.02	.38	.04	972
	Marshes 1/	36	.01	.00	.14	.00	650
	100 metres in marshes	8	.04	.02	.18	.00	859
	Interior marshes of Area 1	2	.00	.00	.17	.00	102

1 includes all measurements beyond 100 metres from a canal.

the marshes in the south part of Area 3A was slight. In the northeast, however, canal water spread farther. (Basic data A).

Concentrations of phosphorus and inorganic nitrogen tended to decrease to marsh background levels within 100 metres (330 feet) of the perimeter canals (figures 8-11 and Basic Data A). Within this distance changes in specific conductance tended to be relatively small. The high specific conductance indicates dilution is not an important factor in the decrease in phosphorus and inorganic nitrogen.

Ammonia (NH_3-N) was the most abundant form of inorganic nitrogen in both wet and dry seasons. In September 1973 and January 1974 ammonia averaged 0.38 mg/l in the perimeter canals. In the marshes it averaged 0.17 mg/l in September, and 0.14 mg/l in January. Within 100 metres of the perimeter canals ammonia declined to less than 50 percent of the concentration in those canals (table 3).

Nitrate (NO_3-N) concentrations in the perimeter canals averaged 0.11 mg/l in September 1973 and 0.18 mg/l in January 1974. It was only occasionally detected beyond 100 metres (330 feet) from the canals.

Nitrite (NO_2-N) was detected in about 30 percent of the canal water samples, and averaged 0.03 and 0.02 mg/l in September 1973 and January 1974. It was seldom detected in the interior marshes.

Orthophosphate (PO_4-P) averaged 0.02 mg/l and 0.04 mg/l in the perimeter canals in September 1973 and January 1974 (table 3). Concentrations in the marsh averaged 0.01 mg/l in September and less than 0.01 mg/l in January. In September 1973 orthophosphate apparently penetrated farther into the marshes. Concentrations above 0.01 mg/l were recorded in 43 percent of the samples and some of these higher values were at distances more than a kilometre from a canal. In January 1974, values did not exceed 0.01 mg/l beyond 100 metres (330 feet) from the canals.

Concentrations of dissolved oxygen tended to increase from canals into the marshes (figs. 8-9). In January 1974, for example, concentrations of 5 canal samples in Area 1 averaged 2.9 mg/l, as compared with 5.9 mg/l in the marshes at the end of the transects. The concentrations at the center of Area 1 at that time averaged 7.5 mg/l. The increase in dissolved oxygen with distance from canals may be attributed to an increase in photosynthetic production. Photosynthesis in canals could be restricted by influx of anaerobic ground water, rapid water movement, water depth, the absence of large stands of aquatic plants or other factors.

Diel Chemical Changes

Dissolved Oxygen

Oxygen is replenished to the waters of the Everglades by photosynthesis of submerged aquatic plants, and it is depleted by respiration of these plants and other organisms. Oxygen also enters and leaves the water by diffusion to

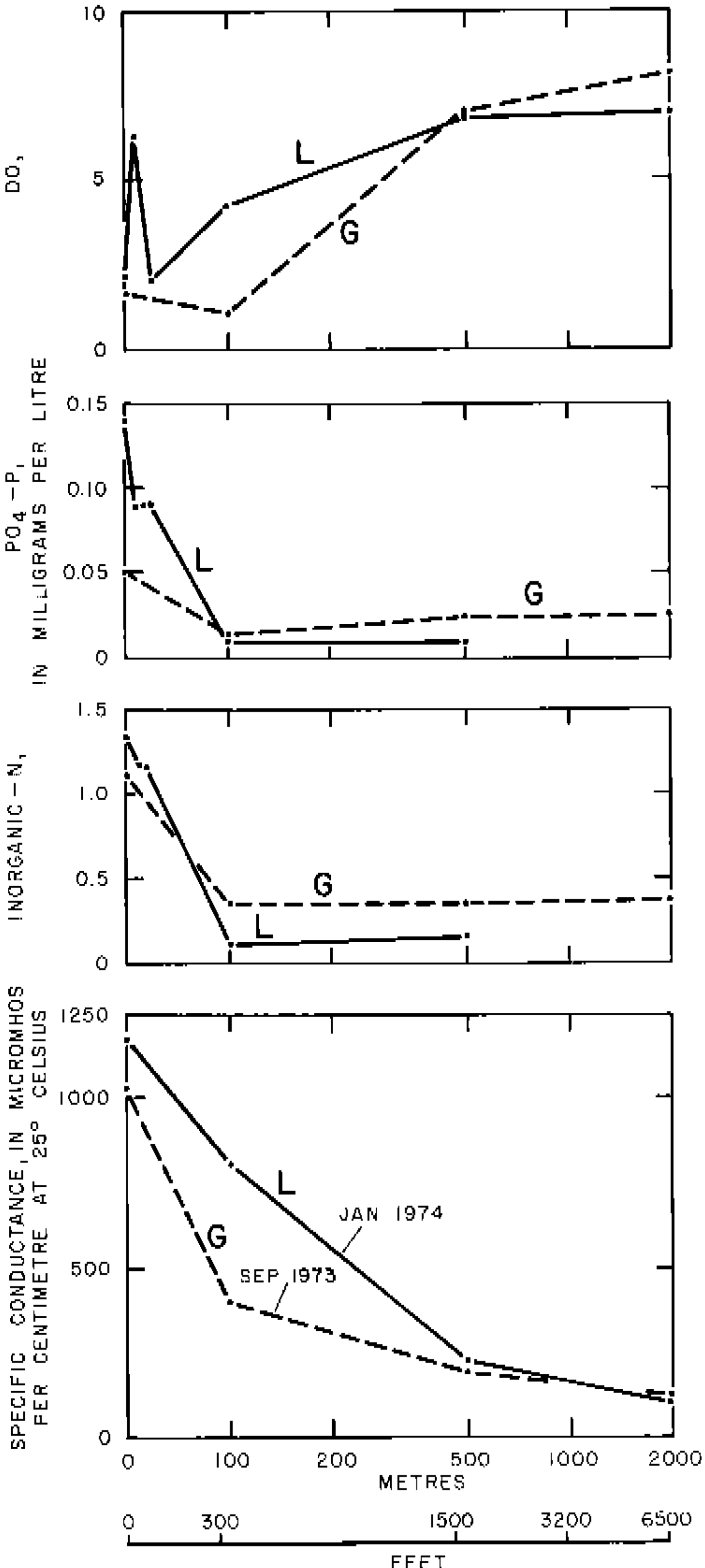

Figure 8.--Changes in specific conductance and nutrients along transects C (September 1973) and L (January 1974) in the northern part of Conservation Area 1. Zero to 100 metres a conventional scale; 100 to 2000 metres is a log scale.

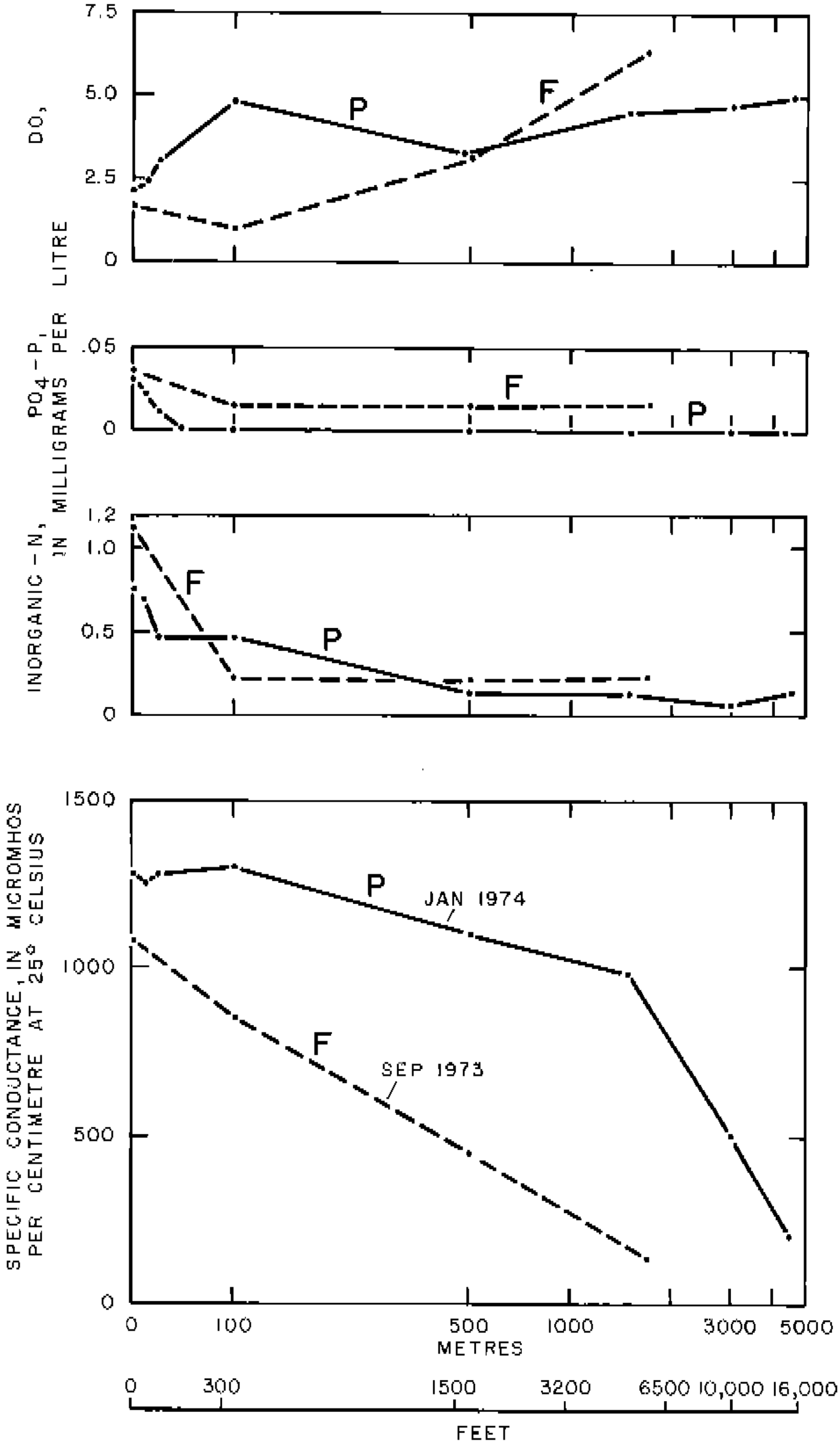

Figure 9.--Changes in specific conductance and nutrients along transects F (September 1973) and P (January 1974) in the western part of Conservation Area 1. Zero to 100 metres is a conventional scale; 100 to 5000 metres is a log scale.

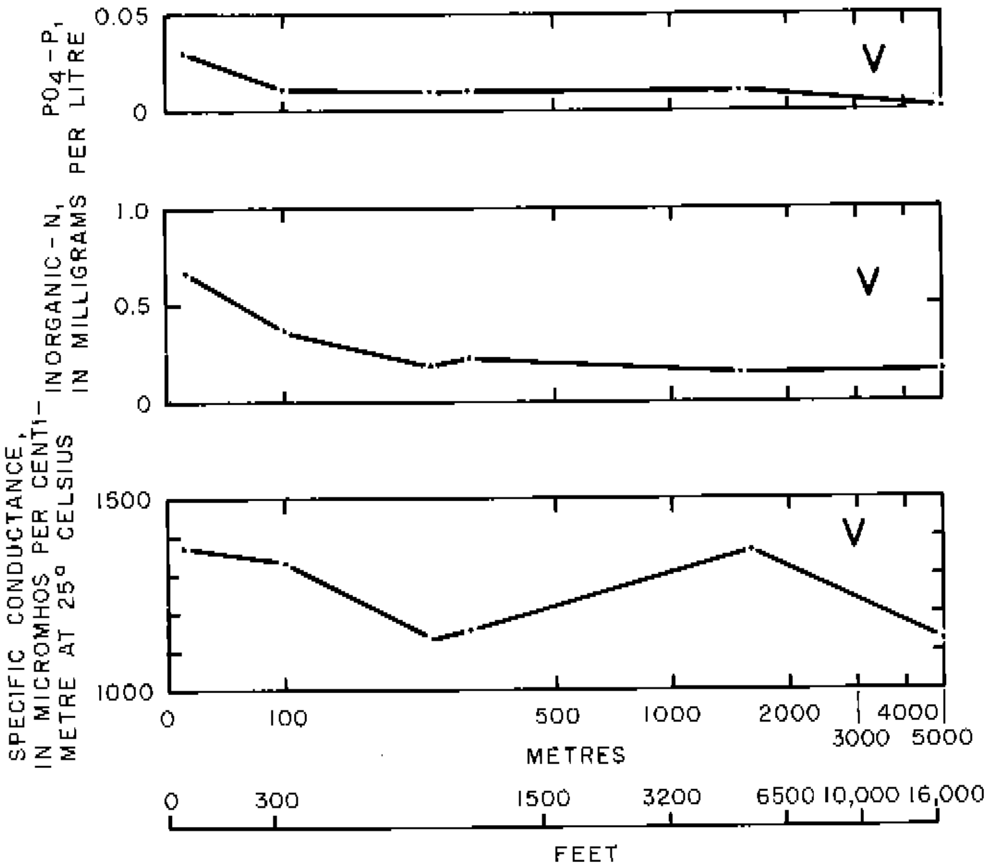

Figure 10.--Changes in specific conductance and nutrients along transect V in Conservation Area 2A, January 16, 1974. Zero to 100 metres is a conventional scale; 100 to 5000 metres is a log scale.

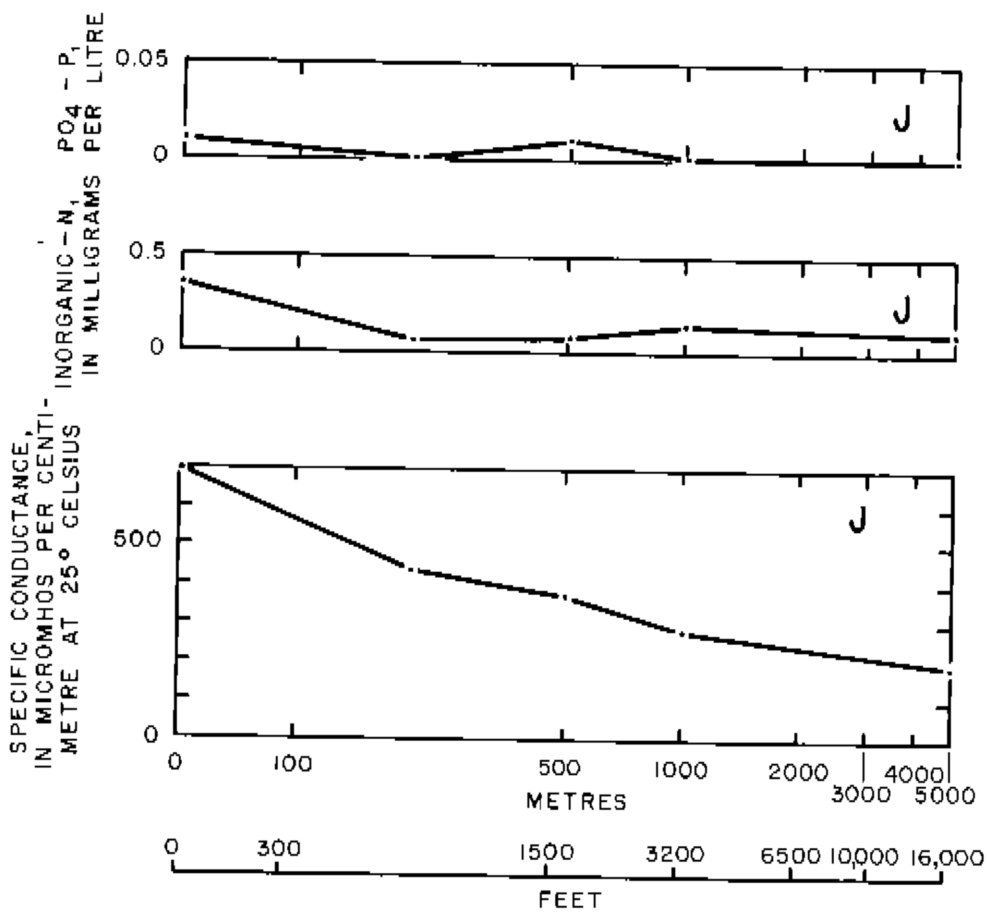

Figure 11.--Changes in specific conductance and nutrients along transect J in Conservation Area 3A, September 11, 1973. Zero to 100 metres is a conventional scale; 100 to 5000 metres is a log scale.

and from the atmosphere. Changes in dissolved oxygen over a 24-hour cycle reflect, to a large degree, biological metabolism--respiration and photosynthesis. Large increases in dissolved oxygen during the day usually indicate photosynthetic production; decreases in concentration at night usually indicate oxygen uptake by respiring organisms.

Emergent plants produce and release oxygen mostly above the water surface. The submerged plants, particularly the periphyton, produce and release oxygen into the water. Thus, measurements of changes in dissolved oxygen in the water reflect primarily the metabolism of submerged organisms.

Diel studies were made at four locations in the conservation areas (fig. 3A). Two of these, S-5A and the Hillsboro Canal at S-10A, C, and D, receive water of relatively poor quality pumped from agricultural areas to the north. At the third location, S-9, water of better quality is pumped from the east. The index location, L-28 canal, is remote from pumping and farming activities.

The concentration of dissolved oxygen in the large canals near S-5A and S-9 and in the Hillsboro Canal fluctuated little over 24 hours (Basic Data B, C,D,E). In canals near S-5A oxygen saturation near the surface ranged from about 60 to 70 percent on January 16-17, 1973, and about 10 to 30 percent on September 10-11, 1973. In the Hillsboro Canal (January 1974) and in the canals near S-9 (January 1973) saturation near the surface fluctuated from about 40 to 70 percent. The concentration of dissolved oxygen decreased with depth; in the Hillsboro Canal, for example, saturation ranged from about 30 to 55 percent near the bottom (2-3 metres). At S-5A conditions were nearly anaerobic close to the bottom. For comparison, saturation of dissolved oxygen near the surface at the index station, L-28 Canal, ranged from about 60 to 100 percent on January 16-17, 1973 and from about 35 to 75 percent on September 10-11, 1973. Dissolved oxygen decreased with depth on September 10-11, 1973 and near the bottom ranged between about 25 and 45 percent saturation over 24 hours.

The relatively small fluctuations in dissolved oxygen in the large canals near S-5A and S-9, and in the Hillsboro Canal (S-10A, C, D) indicate a photosynthetic production near zero. This low productivity may be attributed to water movement which tends to inhibit large plankton blooms, and to deep water which restricts sunlight penetration and inhibits benthic plant production. The low dissolved oxygen in bottom waters indicates respiratory consumption of oxygen. Ground water influx and other factors may also contribute to low dissolved oxygen near the bottom of canals.

A few diel studies were made in the marshes of the northern and eastern Everglades. Near S-10C in Conservation Area 2A, measurements were made on January 16-17, 1974 at 15, 30, and 800 metres from the collector canal. The maximum daytime concentration of dissolved oxygen (65 percent) occurred at 15 metres (50 feet) and the minimum (20 percent) occurred at 30 metres (100 feet). At 800 metres (2,640 feet) in the marsh saturation reached 55 percent. Conditions at the 3 marsh sites were nearly anaerobic by early morning (fig. 12). At a second location, near S-9, maximum oxygen saturation at 3 marsh sites on January 16-17, 1973 ranged between 72 and 105 percent, while minimum saturation ranged between 15 and 78 percent.

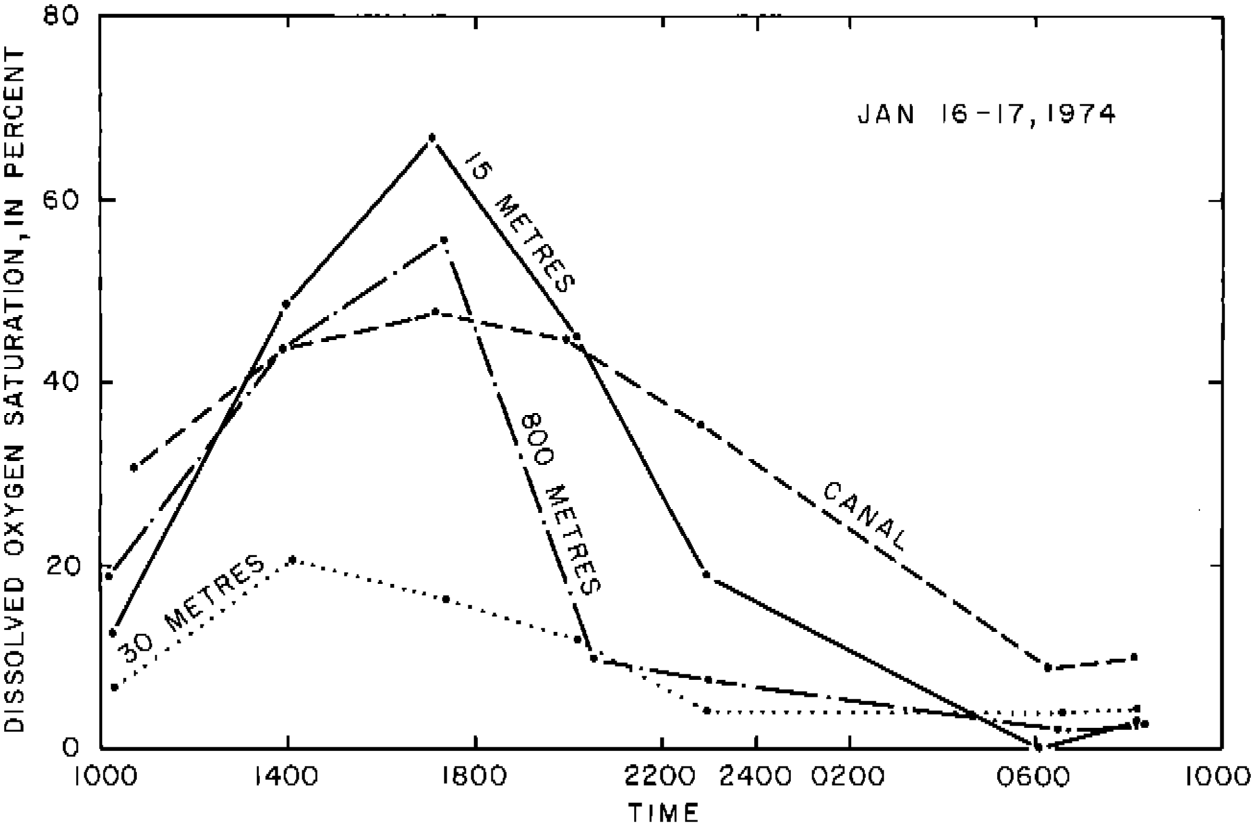

Figure 12.--Diel changes in dissolved oxygen in a canal and its peripheral marshes at the north end of Conservation Area 2A near S-10C. Distances are from canal south into marshes of Conservation Area 2A. (For location see figure 3A).

Data are available to document seasonal diel fluctuations of dissolved oxygen at L-28 canal in the western part of Conservation Area 3A. These data indicate that diel fluctuations are variable from month to month, from season to season, and from year to year during the same month (figs. 13 and 14). Maximum oxygen saturation, measured quarterly or monthly for 4 years, exceeded 100 percent 4 of 18 times. Greatest oxygen production occurred in spring and was closely related to low water level. Highest oxygen concentrations occurred at lowest water level, in May 1971 (fig. 14). Dissolved oxygen fluctuated less than 50 percent over 24 hours in most cases.

Nitrogen and Phosphorus

Inorganic nutrients in water might be expected to change in concentration during 24-hour periods in response to biological metabolism. They would be removed from the water during the day by photosynthesis and released to the water at night by respiration. If photosynthesis exceeded respiration, a net decrease in nutrients would occur in the water.

Data were collected over 24-hour periods for nitrate, nitrite, ammonia, and orthophosphate (or orthophosphate plus acid hydrolyzable phosphorus) at sites near S-5A (January 16-17, 1973 and September 10-12, 1973), S-9 (January 16-17, 1973), the Hillsboro Canal (January 16-17, 1974), and at L-28 Canal (September 10-11, 1973). Some changes in these nutrients were recorded over diel cycles; however, these changes are largely attributable to inflow of water of a different chemical character as indicated by changes in specific conductance. Thus, metabolic changes in concentrations of phosphorus and inorganic nitrogen were not evident over diel cycles at these sites (Basic Data B, C, D).

Chemical Changes with Backpumping

Pumping Station S-5A

On September 10, 1973 diel studies were begun near pump station S-5A. Water had last been pumped into Area 1 on September 7 (15.0 m^3/s or 530 ft^3/s). On September 8 and 9 water was pumped from Area 1 into the West Palm Beach Canal (2.7 m^3/s and 2.5 m^3/s or 95 ft^3/s and 88 ft^3/s). During the diel study 5.6 m^3/s (198 ft^3/s) of water were pumped from the canal into Area 1 on on the 10th and 3.4 m^3/s (120 ft^3/s) on the 11th.

In the West Palm Beach Canal (site 1, fig. 4), water remained relatively stratified during the first day of the diel study. Specific conductance near the bottom was about double that near the surface. By September 11, however, the water was mixed and specific conductance was relatively uniform with depth.

The concentration of dissolved oxygen tended to be higher at site 1, in the West Palm Beach Canal, where it ranged from 32 to 68 percent saturation near the surface, than at the other canal sites within Area 1, where it ranged from about 10 to 30 percent saturation (see Fig. 4 for site locations). For comparison, dissolved oxygen at the index site at L-28 ranged from about 35 to 75 percent saturation near the surface and from about 25 to 45 percent saturation near the bottom.

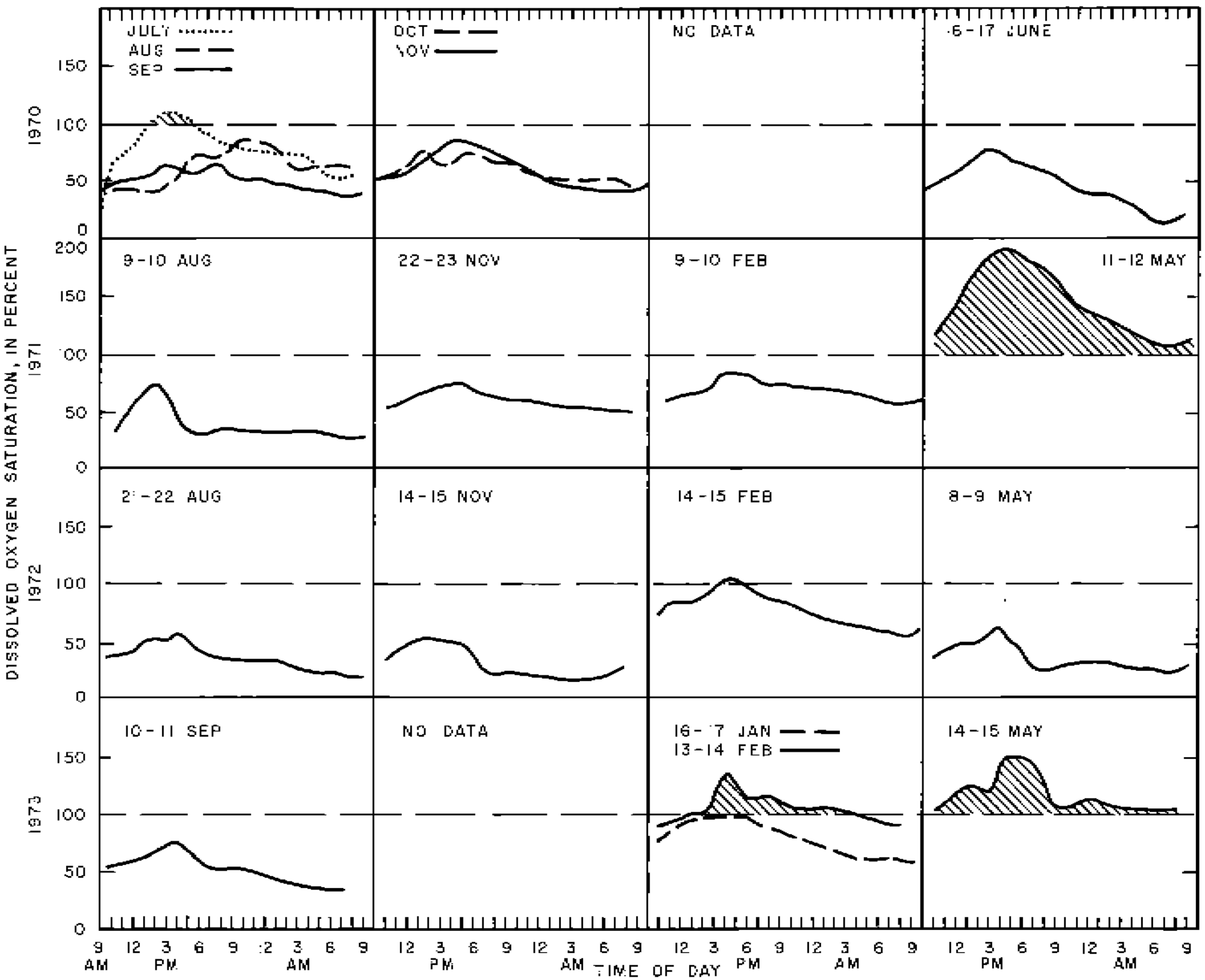

Figure 13.--Diel changes in percent saturation of dissolved oxygen during four seasons at L-28 east canal, Conservation Area 3A. (For location of site see figure 3).

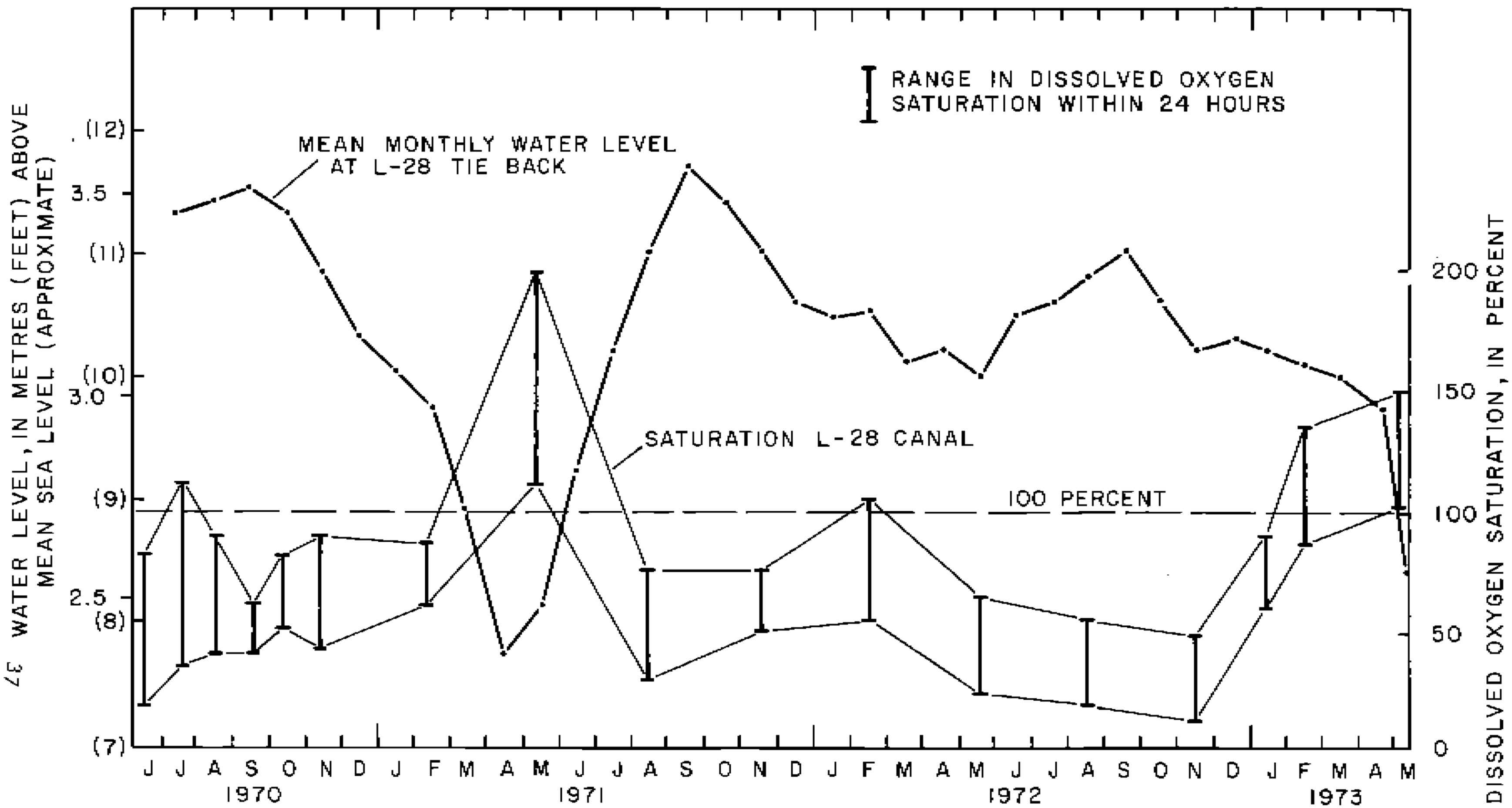

Figure 14.--Seasonal changes in percent saturation of dissolved oxygen at L-28 east canal, 1970-73. (For location of L-28 canal and L-28 tie back see figure 2A).

Pumping appeared to have little effect on dissolved oxygen in the West Palm Beach Canal (site 1), but caused a nearly uniform concentration in the Area 1 canal (site 2) downstream of S-5A (Fig. 15). Before pumping, bottom waters at all sites (2.4 to 3.6 metres or 7.9 to 11.8 feet) were virtually devoid of oxygen; after pumping, dissolved oxygen at sites within Area 1 was only slightly lower at the bottom than at the top. The average dissolved oxygen increased after pumping began, caused partly by the influx of water from the West Palm Beach Canal which contained higher concentrations of oxygen.

Probably the most pronounced effect on water quality after pumping was the sharp rise in the concentrations of ammonia at sites downstream (table 4). At site 2, for example, the average concentration on September 10, 1973 increased from 0.53 to 1.4 mg/l (NH_3-N). The high concentration of ammonia may result from an appreciable ground water contribution to the Area 1 canals, from a mixing effect that releases ammonia from bottom sediments, or from the breakdown of organic nitrogen to ammonia. Concentrations of ammonia did not increase in the West Palm Beach canal with pumping, and remained less than half of those in the conservation area canals. This suggests a mixing effect, which facilitates the breakdown of organic nitrogen or which releases ammonia from the bottom sediment, may be the most important cause of the rise in ammonia concentration. The increase in ammonia occurred at least 2 kilometres downstream on September 10; no increase was detected at 3 kilometres (site 7) throughout the diel study ending at 0725 hours on September 12.

The average concentrations of orthophosphate, nitrite, and nitrate decreased slightly after pumping at most of the sites in the conservation area canals (table 4). The greatest decreases were at sites 2, 3, and 4 which were nearest the pump station. Specific conductance increased slightly at the same sites. This suggests that the mixing effect of pumping locally increased the uptake of the orthophosphate, nitrite, and nitrate.

Pumping Station S-9

Diel studies were made at S-9 (fig. 5) on January 16-18, 1973. On January 16 no water was backpumped west into Conservation Area 3A; on the 17th water was backpumped for about 7 hours.

On January 17, 52.4 m^3/s (1850 ft^3/s) of water were backpumped from the South New River Canal westward into Conservation Area 3A. Of that water 27.8 m^3/s (981 ft^3/s) moved northwest in L-68 canal and 24.6 m^3/s (868 ft^3/s) moved southwest in L-67 canal.

The water in the South New River Canal at sampling site 1 was characterized by high concentrations of ammonia (mostly greater than 0.50 mg/l as NH_3-N), and low concentrations of nitrate (0.01 mg/l NO_3-N) and dissolved oxygen (about 10 to 15 percent saturation or 1.0 mg/l). According to Freiberger (1973) the reason for the high concentration of ammonia east of S-9 is that most of the canal is in an anaerobic state much of the year due to inflow of ground water during backpumping. Ground water is generally low in dissolved oxygen; under anaerobic conditions ammonia is the common form of inorganic nitrogen.

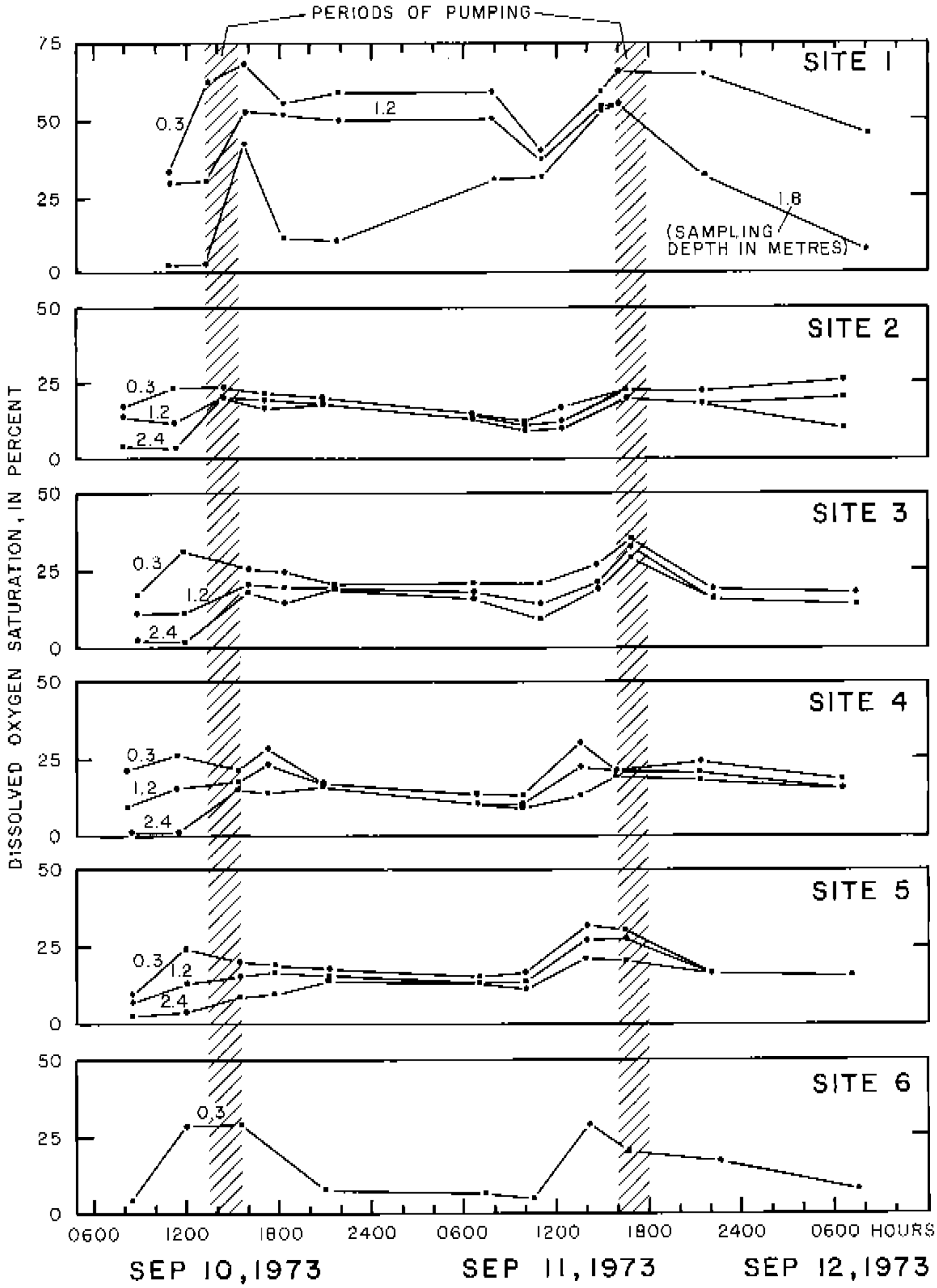

Figure 15.--Dissolved oxygen concentrations in waters around S-5A in Conservation Area 1, September 10-12, 1973.

Table 4.--Average concentrations of nutrients on September 10, 1973 at sampling sites near S-5A before pumping and after pumping (Basic Data E). (No water was pumped into Area 1 for 2 days before September 10, 1973. For location of sampling sites see figure 4.)

	Before pumping	After pumping
Sampling site 1 (above S-5A)		
Number of samples (N)	4	4
Specific conductance	780	677
PO_4 as P (mg/1)	0.03	0.02
NH_3 as N (mg/1)	0.60	0.54
NO_2 as N (mg/1)	0.04	0.03
NO_3 as N (mg/1)	0.30	0.27
Dissolved oxygen (DO) mg/1	1.5	3.3
Sampling site 2 (below S-5A)		
N	8	12
Specific Conductance	1101	1158
PO_4 as P	.05	.03
NH_3 as N	.53	1.4
NO_2 as N	.11	.09
NO_3 as N	.41	.30
DO	.8	1.5
Sampling site 3 (Canal 7)		
N	4	6
Specific Conductance	1090	1209
PO_4 as P	.06	.03
NH_3 as N	.54	1.3
NO_2 as N	.10	.08
NO_3 as N	.43	.30
DO	1.1	1.6
Sampling site 4 (Canal 40)		
N	4	6
Specific Conductance	1090	1253
PO_4 as P	.04	.03
NH_3 as N	.43	1.3
NO_2 as N	.08	.08
NO_3 as N	.31	.31
DO	1.1	1.4
Sampling site 5		
N	4	6
Specific Conductance	1030	1048
PO_4 as P	.04	.05
NH_3 as N	.39	.55
NO_2 as N	.06	.08
NO_3 as N	.23	.29
DO	.9	1.3

Table 4.--Continued - Average concentrations of nutrients on September 10, 1973 at sampling sites near S-5A before pumping and after pumping (Basic Data E). (No water was pumped into Area 1 for 2 days before September 10, 1973. For location of sampling sites see figure 4.)

	Before pumping	After pumping
Sampling site 7		
N	2	4
Specific Conductance	-	1005
PO_4 as P	.05	.04
NH_3 as N	.42	.38
NO_2 as N	.07	.06
NO_3 as N	.21	.20
DO	1.0	1.4

Backpumping from the South New River Canal had a definite effect on three water quality constituents in Conservation Area 3A. This effect is consistent with that reported by Freiberger (1973). First, it increased the concentration of ammonia (fig. 16). For example, at site 2 near the S-9 discharge the average concentration increased from 0.28 to 0.45 mg/l (table 5). The increase extended along L-67 canal at least 5 kilometres (3 miles) southwest of S-9 some 8 hours after backpumping began (fig. 17). Second, backpumping decreased the concentration of nitrate at canal stations in the conservation area (fig. 18 and Table 5). Third, it lowered the dissolved oxygen at canal stations (fig. 19 and Table 5). Marsh sites 4 and 8 were not immediately affected, but dissolved oxygen was lower on the day after pumping than on the day before pumping (fig. 20). Nitrate and ammonia increased slightly at marsh sites 4 and 8 after backpumping began. At marsh site 3, northwest of S-9, nitrogen and phosphorus changed little with backpumping.

Nitrogen and Phosphorus Loads

Rainfall and dry fallout (bulk precipitation) contributed 78 percent (5,200 tonnes or 5,720 tons) of the total nitrogen and 90 percent (207 tonnes or 228 tons) of the total phosphorus that entered the conservation areas from July 1972 to June 1973 (Waller, 1975). The remaining 22 percent of nitrogen and 10 percent of phosphorus entered at 6 pumping stations and by uncontrolled surface-water inflow. Pumping water into the conservations added 1,300 tonnes (1,420 tons) of nitrogen and 21 tonnes (23 tons) of phosphorus. Backpumping, which now occurs only at station S-9, added 230 tonnes (253 tons) of nitrogen and 1.8 tonnes (2 tons) of phosphorus to Conservation Area 3.

With the construction of additional pumping stations, canal flow to the sea could be reduced by increased backpumping into the conservation areas. It is estimated that 50 percent of the total annual canal runoff in southeast Florida, which ranges from 28 m^3/s (1,000 ft^3/s) to 190 m^3/s (6,800 ft^3/s) could be backpumped (Howard Klein, written communication, 1975). Assuming an average concentration for total nitrogen of 2 mg/l and for total phosphorus of 0.02 mg/l (values comparable with those found today at S-9, see table 2), backpumping 50 percent of the total annual canal runoff would add 900 to 5,600 tonnes (990 to 6,160 tons) of nitrogen and 9 to 56 tonnes (10 to 62 tons) of phosphorus. This constitutes about 15 to 100 percent of the nitrogen and 4 to 27 percent of the phosphorus that entered the conservation areas by bulk precipitation in 1972-73. Urbanization or further agricultural development east of the conservation areas would likely increase these loads.

BOTTOM SEDIMENT CHEMICAL CHARACTERISTICS

Bottom sediment in the Everglades is a combination of organic and inorganic constituents. Sediment in marshes is mostly organic--peat, decaying vegetation, and sometimes periphyton. Sediment in canals contains limestone, sand, and clay in addition to organic detritus. Composition of the sediment is variable depending on runoff, flow velocity, and age of the canals.

Nitrogen and phosphorus occur in the bottom sediment in organic and inorganic forms. Nitrogen is mostly organic with small amounts of inorganic

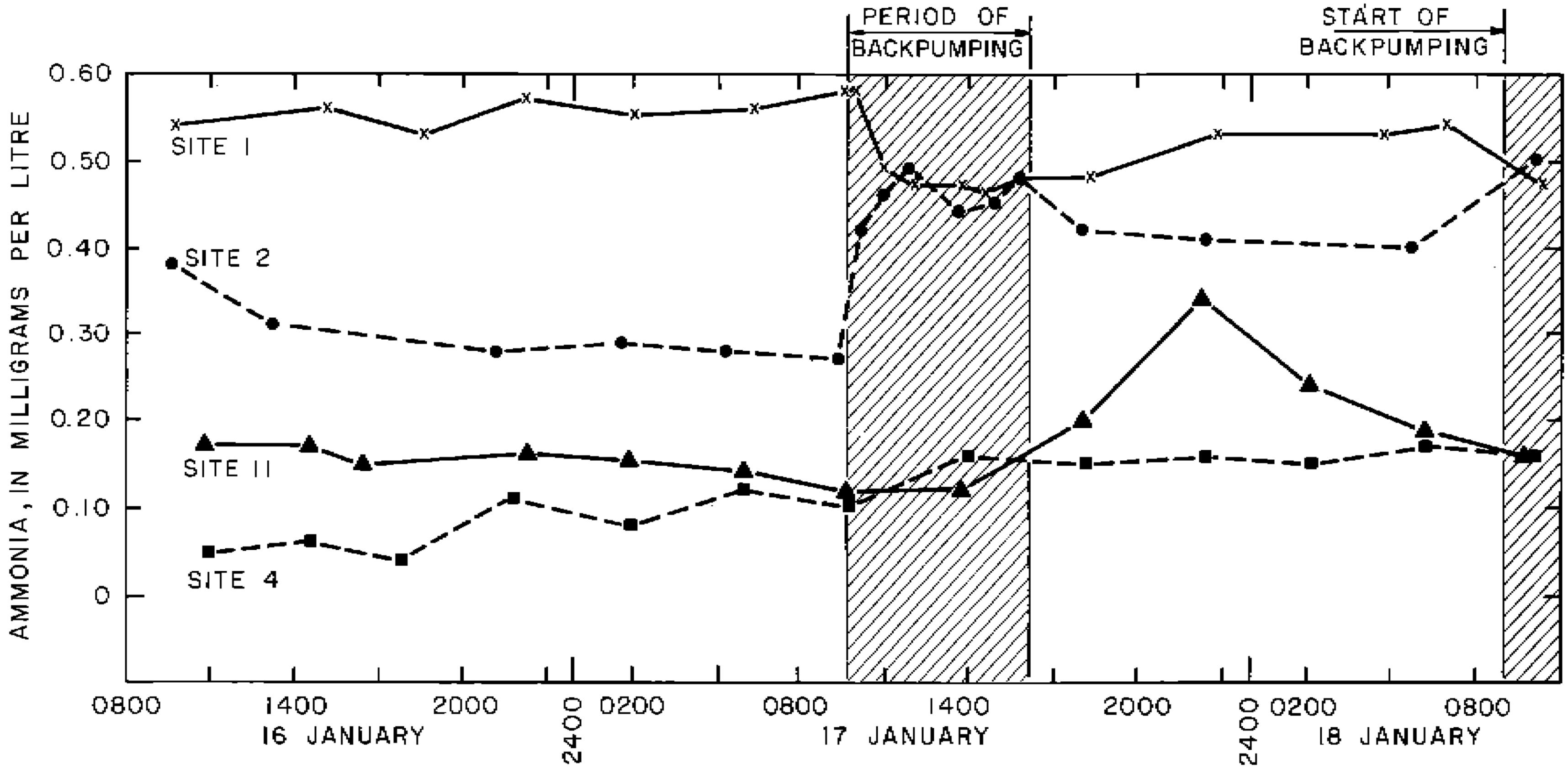

Figure 16.--Changes in concentration of ammonia (NH_3-N) at four sampling sites near S-9, January 16-18, 1973. Sites 1, 2, and 11 are in canals. Site 4 is in the marsh. (For site locations see figure 5).

Table 5.--Average concentration of nutrients before and after pumping at S-9 on 16-18 January 1973. (Basic Data D). (Selected sites and parameters are graphed in figures 16-20. Sites are shown on figure 5.)

	Before pumping (0900 to 0950)	During and after pumping
Site 1 (South New River Canal)		
Number (N)	5-8	7-11
Specific Conductance	680	766
Acid hydrolizable P and PO_4 as P	.00	.00
NH_3-N as N (mg/l)	.56	.50
NO_2-N as N (mg/l)	.02	.00
NO_3-N as N (mg/l)	.01	.01
Dissolved oxygen (DO)	1.1	1.1
Site 2		
N	7-8	8-11
Specific Conductance	751	757
PO_4 as P	.00	.00
NH_3 as N	.28	.45
NO_2 as N	.01	.00
NO_2 as N	.16	.03
DO	4.1	1.4
Site 3 (Marsh)		
N	7	6
Specific Conductance	734	745
PO_4 as P	.00	.00
NH_3 as N	.02	.02
NO_2 as N	.00	.00
NO_3 as N	.00	.00
DO	9.5	9.0
Site 4 (Marsh)		
N	6	7
Specific Conductance	762	747
PO_4 as P	.00	.00
NH_3 as N	.08	.15
NO_2 as N	.00	.00
NO_3 as N	.00	.01
DO	4.1	1.7
Site 5 (Canal North)		
N	7	6
Specific Conductance	894	805
PO_4 as P	.00	.00
NH_3 as N	.10	.34
NO_2 as N	.00	.01
NO_3 as N	.11	.03
DO	6.5	2.3

Table 5.--Continued - Average concentration of nutrients before and after pumping at S-9 on 16-18 January 1973. (Basic Data D). (Selected sites and parameters are graphed in figures 16-20. Sites are shown on figure 5.

	Before pumping (0900 to 0950)	During and after pumping
Site 6		
N	7	6
Specific Conductance	878	873
PO_4 as P	.00	.00
NH_3 as N	.11	.12
NO_2 as N	.01	.00
NO_3 as N	.08	.07
DO	6.9	6.5
Site 7		
N	7	6
Specific Conductance	797	768
PO_4 as P	.00	.00
NH_3as N	.24	.41
NO_2 as N	.02	.00
NO_3 as N	.14	.04
DO	3.9	1.8
Site 8 (Marsh)		
N	7	6
Specific Conductance	785	813
PO_4 as P	.00	.00
NH_3 as N	.04	.05
NO_2 as N	.00	.00
NO_3 as N	.03	.05
DO	4.1	3.7
Site 9		
N	7	5-6
Specific Conductance	846	795
PO_4 as P	.00	.00
NH_3 as N	.18	.33
NO_2 as N	.01	.00
NO_3 as N	.12	.05
DO	5.2	3.6
Site 10		
N	6-7	6
Specific Conductance	867	827
PO_4 as P	.00	.00
NH_3 as N	.14	.23
NO_2 as N	.00	.00
NO_3 as N	.12	.06
DO	6.0	4.7

Table 5.--Continued - Average concentration of nutrients before and after pumping at S-9 on 16-18 January 1973. (Basic Data D). (Selected sites and parameters are graphed in figures 16-20. Sites are shown on figure 5.

	Before pumping (0900 to 0950)	During and after pumping
Site 11		
N	7	6
Specific Conductance	861	843
PO_4 as P	.00	.00
NH_3 as N	.15	.21
NO_2 as N	.00	.00
NO_3 as N	.13	.07
DO	9.4	4.3

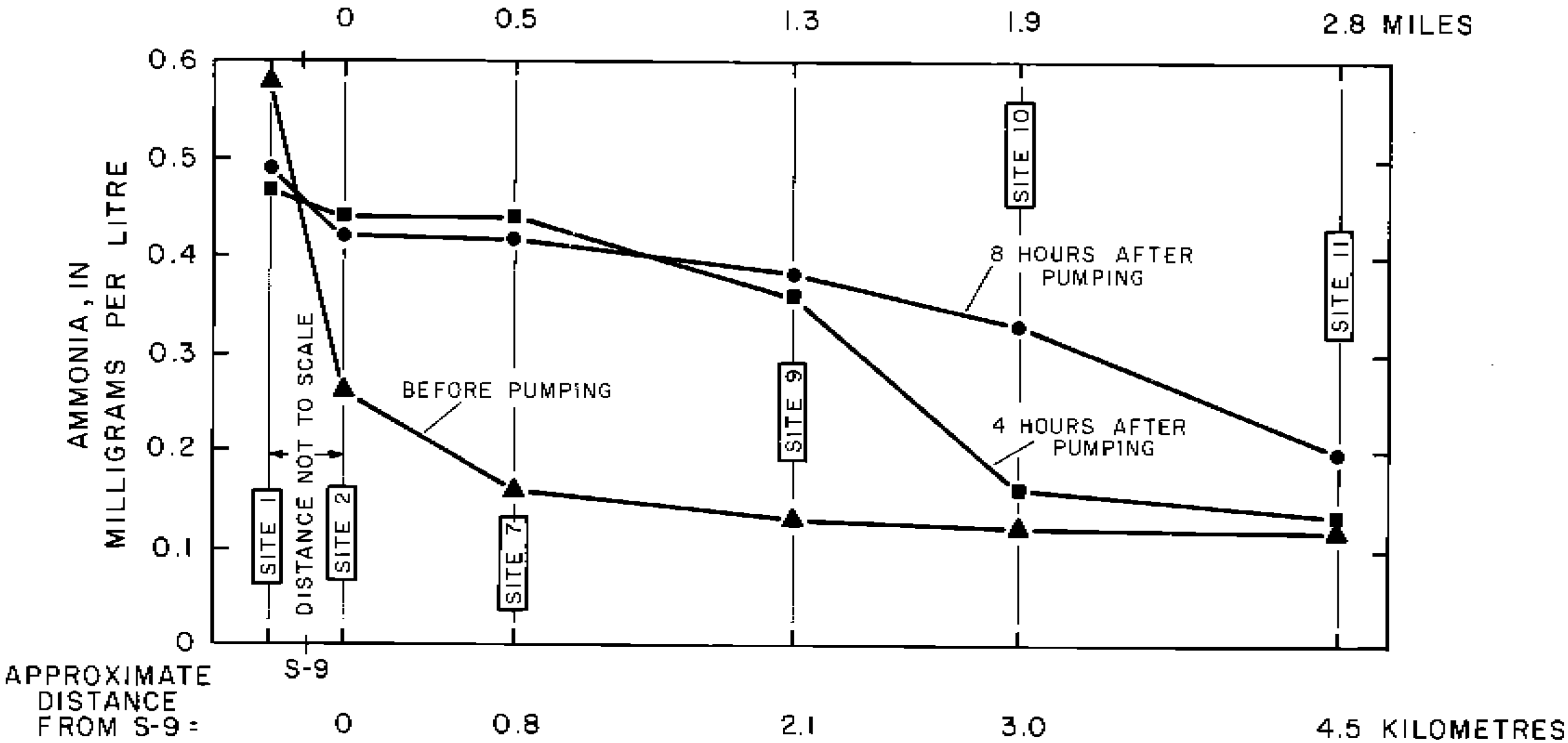

Figure 17.--Changes in concentration of ammonia (NH_3-N) at six sampling sites near S-9, January 16-17, 1973. Concentrations are those before backpumping began, four hours after backpumping began, and eight hours after backpumping. (For site locations see figure 5).

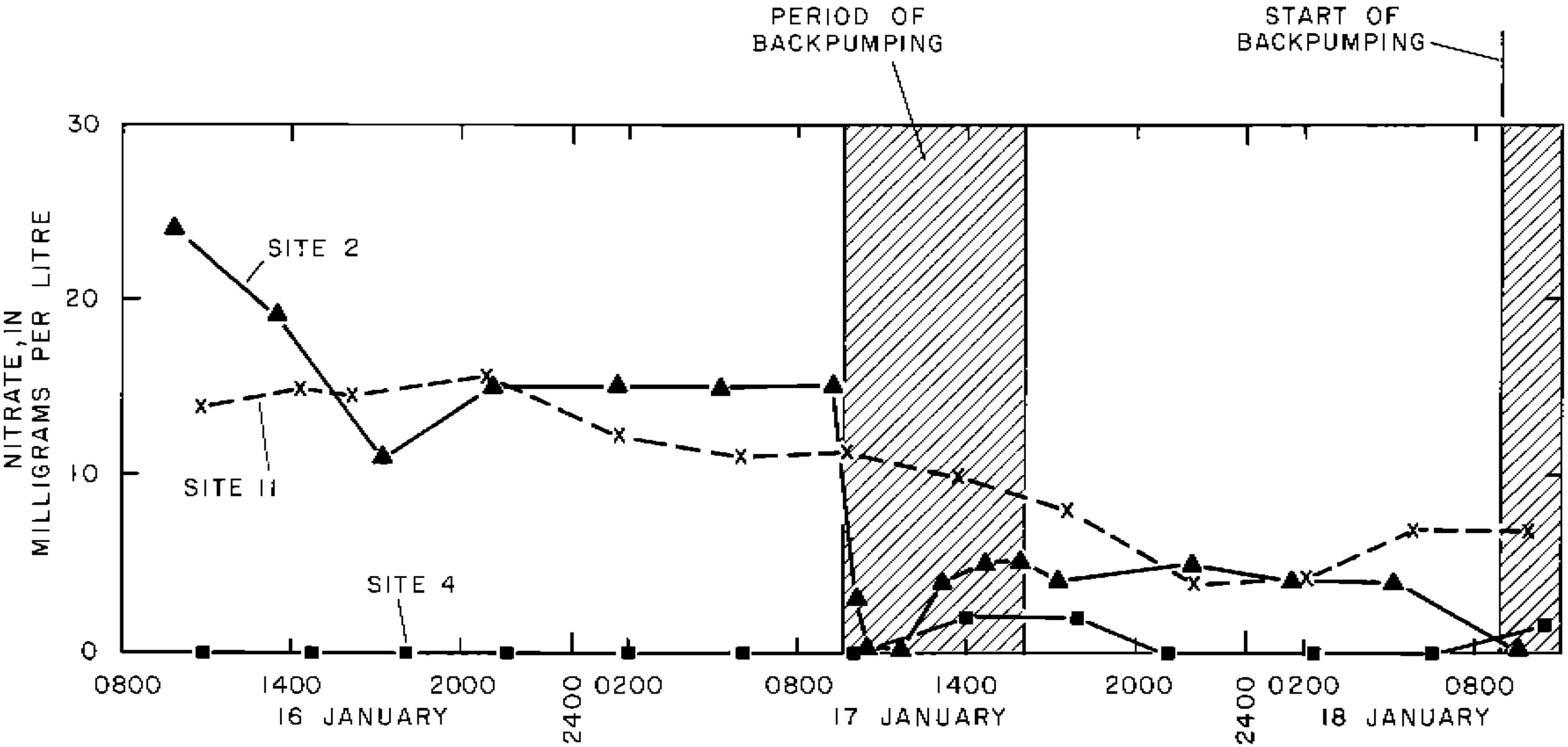

Figure 18.--Changes in concentration of nitrate (NO_3-N) at three sampling sites near S-9, January 16-18, 1973. Sites 2 and 11 are in canals; site 4 is in the marsh. (For locations see figure 5).

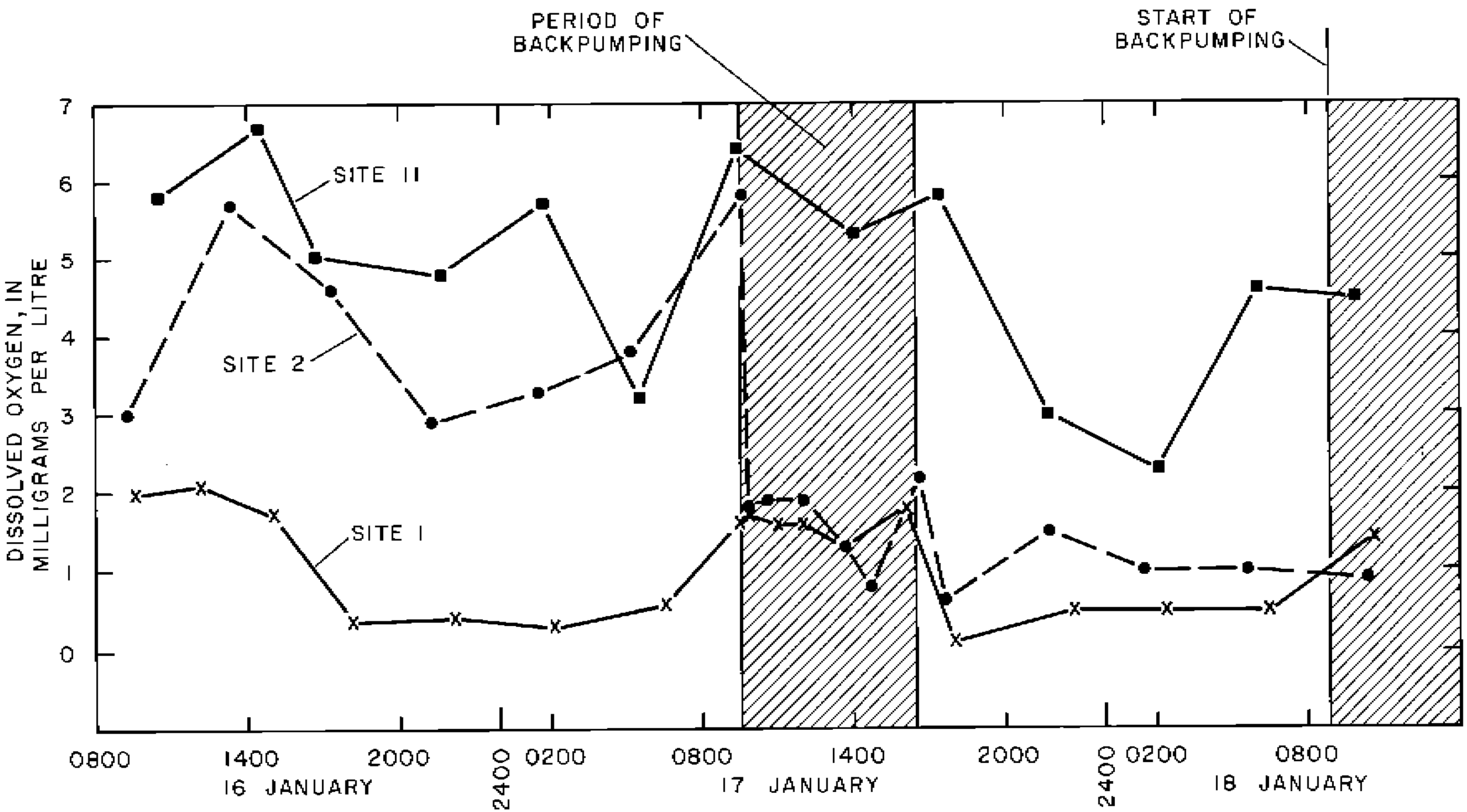

Figure 19.--Changes in dissolved oxygen at three sampling sites near S-9, January 16-18, 1973. (For site locations see figure 5).

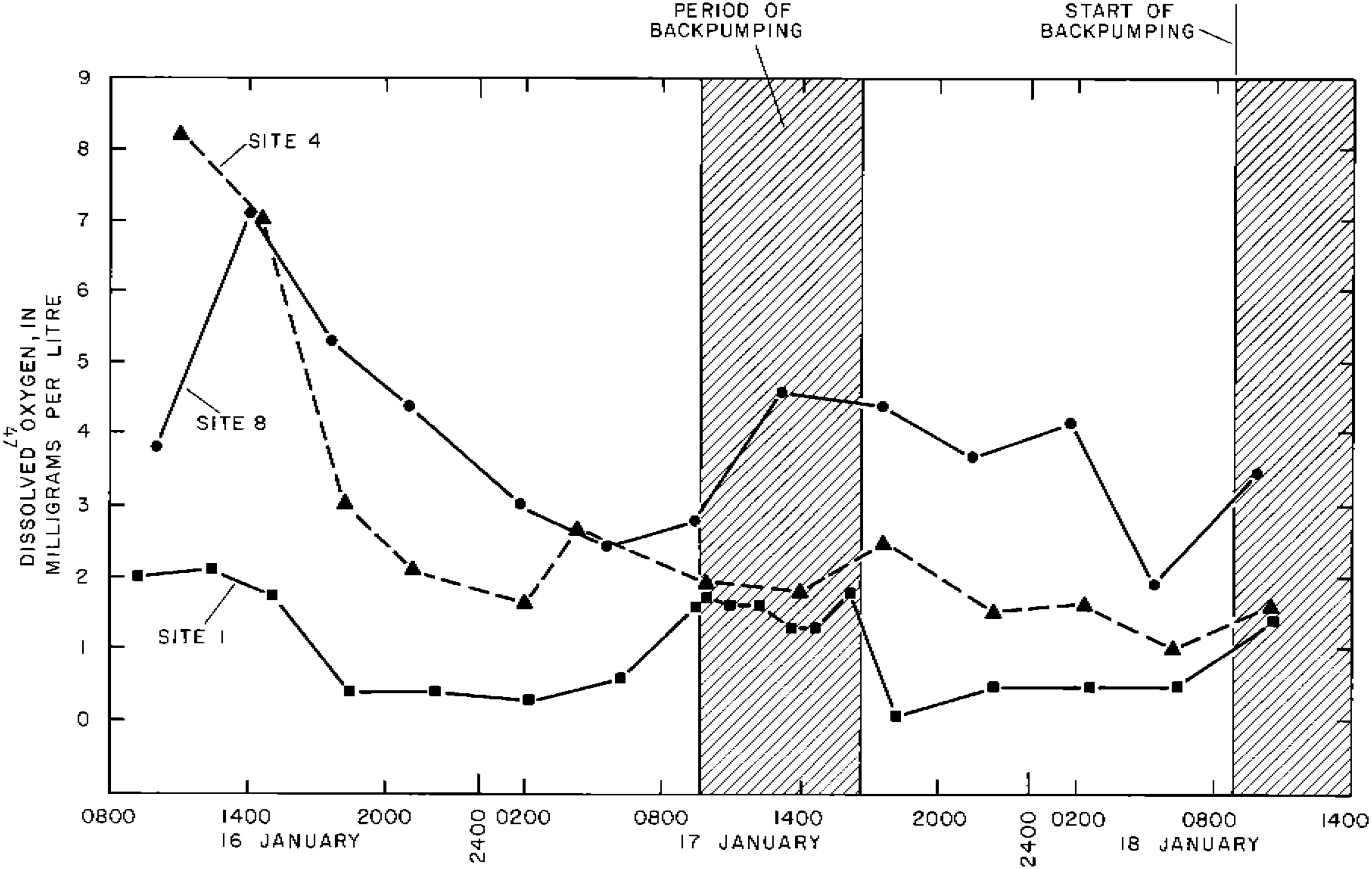

Figure 20.--Changes in dissolved oxygen at three sampling sites near S-9, January 16-18, 1973. (For site locations see figure 5).

ammonia. Phosphorus occurs either in organic form, derived from plants and animals, or inorganic form, derived from clays and minerals.

Nitrogen in bottom material is usually unavailable to the overlying water. Under anaerobic conditions, however, ammonia may be released from the sediments. Also, ammonia may be released when the sediment is agitated, when urea is excreted from benthic organisms, or when organic cells break down. The bottom materials act as a nitrogen sink by accumulating organics that have settled, by adsorbing ammonia onto clays, metal oxides, hydroxides, and organic colloids, and by the process of denitrification under anaerobic conditions.

Phosphorus in bottom sediments may be derived from many sources. The organic fraction, usually proteins or enzymes, may come from bottom organisms or from organisms that sink from the water above. The inorganic fraction may come from the breakdown of organic material or from minerals in runoff and rainfall. The common inorganic form, phosphate, is often sorbed on organic colloids, associated with carbonates or precipitated by aluminum, iron, or manganese. Phosphate minerals release little soluble phosphate to the water.

Phosphorus uptake and release from bottom materials are controlled mainly by pH and redox potential at the water-sediment interface, by concentrations of oxygen, calcium, iron, aluminum, and manganese, and by sediment mixing and agitation. Under anaerobic conditions, which result in low redox potential, phosphorus is released from the sediment. Under aerobic conditions, however, it is bound in the sediments with iron, aluminum, and manganese hydroxides and oxides. The release of phosphorus from sediments is also facilitated by high (greater than 7) or low (less than 5) pH. High concentrations of calcium will scavenge inorganic phosphorus from the water column by forming precipitates.

Chemical analyses of bottom sediments from the Everglades marshes and canals are shown in Table 6. The average concentration of organic material in the bottom sediment at 11 long-term sites ranged from 2.5 to 87 percent. The average marsh concentrations ranged from 62 to 87 percent, and the average in canals from 2.5 to 49 percent. Because the amount of organic material determines to a large degree the concentrations of nitrogen and phosphorus as well as metals, the average concentration of these elements also varied widely in the sediment. For example, the average nitrogen concentration ranged from 1.9 to 46 g/kg, and phosphorus ranged from 7.5 to 640 mg/kg.

To compare elemental composition of sediment samples with different amounts of organic matter, it is necessary to normalize the samples. This can be done by calculating the amount of nitrogen and phosphorus present in the sediment for each 100 grams of organic carbon. For example, if one sample has twice as much organic matter as another, one would expect, under comparable environmental conditions, twice as much phosphorus, nitrogen, and metals in the organically rich sample as in the organically poor sample. Once normalized, differences in elemental concentrations may be attributed to factors other than organic content. For example, sediments may be enriched in a particular element because of contamination from an outside source.

Table 6.--Average concentrations of macronutrients and selected metals and percent organic material in bottom sediments at selected canals and marshes in the Everglades. (For locations see figures 2A, 3 and 5B.)

	Organic Carbon	Total Nitrogen	Total Phosphorus	Percent Organic	Iron	Manganese	Copper	Lead
	(milligram per kilogram)				(microgram per gram)			
Agricultural Canals								
S-5	50,000	3,700	125	15.9	3,850	47	14	35
S-6	257,000	14,000	83	49.1	3,250	67	38	28
S-7	90,000	10,000	87	23.6	5,650	97	18	128
S-8	8,300	1,900	490	2.5	2,440	16	5	12
S-9	6,500	4,400	640	3.1	652	11	11	59
Average								
Non Agricultural Canals								
S-11C	94,000	5,500	180	28.3	4,300	131	13	39
L-67A	67,000	6,600	7.5	16.0	5,170	137	21	69
L-28 East	82,000	15,000	110	22.3	7,700	97	10	46
Average								
Marshes								
1-15	420,000	38,000	167	86.6	2,370	98	4	31
2-17	282,000	23,000	235	67.9	1,310	97	8	20
3-28	366,000	46,000	250	62.4	6,620	126	8	48
Average								

When the chemical data from Table 6 were normalized to organic carbon, the average concentrations of nitrogen, phosphorus, iron, copper, and lead were generally highest in the canals near pumping stations, somewhat lower in the canals remote from pumping, and lowest in the interior marshes (table 7). Average concentrations for a specific element in the marsh were relatively uniform, but concentrations in the canals varied greatly. This suggests that the elemental sediment composition in each canal may be controlled by complex factors not accounted for by the simple categorization of canals into those near pumping stations and those remote from pumping stations.

The chemical composition of the sediment in canals may be dynamic, compared with that of the sediment in marshes, because the sediment in canals is exposed to relatively rapid water flow, turbulence, and resuspension, particularly near the pumping stations. Resuspension may release soluble nitrogen and phosphorus buried in the sediment and also increase the exposure of sediment surface area to biological and chemical activity.

A synoptic sampling in the peripheral canals and adjacent marshes of Conservation Area 1 was made to determine the nitrogen and phosphorus concentrations in sediments. (see Figure 5A for site locations). The analyses of organic carbon, nitrogen, phosphorus and 5 trace metals are given in Table 8.

There was considerable variation in elemental composition among the samples from canals and also among those from the marsh. In general, however, the average concentrations of carbon, nitrogen, and normalized phosphorus differed between these environments. The average organic carbon was about twice as high in the marshes, 307 g/kg, as it was in the canals, 149 g/kg. Nitrogen concentrations were about three times higher in marsh sediments than in the canal sediments, averaging 27 g/kg and 10 g/kg respectively. However, normalized nitrogen concentrations were about the same in the two environments. Average phosphorus concentrations were about the same in the two environments (183 and 187 mg/kg). However, when the phosphorus concentrations were normalized to account for differences in organic matter, phosphorus was higher in the canal sediments, 200 mg/kg, than in the marsh sediments, 62 mg/kg (table 9).

Ratios of carbon to nitrogen to phosphorus (C:N:P), based on the average values for canal and marsh sediments given in Table 8, further illustrate the phosphorus enrichment in canal sediments with respect to carbon and nitrogen. The C:N:P ratio in canal sediments was 810:55:1 as compared with 1610:145:1 in the marsh sediments, indicating phosphorus in canal sediments is enriched by a factor of 2 to 2.6.

The concentration of iron, manganese, copper, lead, and mercury in the bottom sediments varied widely and no areal pattern was evident (Table 8). There were differences, however, between the average concentrations in canals and marshes. When normalized to the amount of organic carbon in the sediment, the 15 canal samples were slightly enriched, on the average, in manganese, iron, copper, and lead compared with the 7 marsh samples.

At selected sites within the Everglades, aquatic marsh plants and bottom sediments were collected and analyzed for nitrogen, phosphorus, and

Table 7.--Average normalized concentrations of macronutrients and selected trace elements in bottom sediments at selected canal and marsh sites in the Everglades. (Averages of 4 samples collected quarterly, October 1972, April and October 1973 and April 1974. Data are normalized to 100 grams per kilogram organic carbon.)

		Organic Carbon grams per kilogram	factor	Total Nitrogen grams per kilogram	Total Phosphorus milligram per kilogram	Iron	Manganese	Copper	Lead
							micrograms per gram		
Agricultural Canals									
near pumping stations	S-5A	100	0.2	7.4	230	6,700	94	28	70
	S-6	100	.4	5.6	33	1,300	27	15	11
	S-7	100	1.1	11.0	96	6,215	107	20	141
	S-8	100	12	22.8	5,880	29,280	192	60	144
	S-9	100	15	66	9,600	9,780	165	165	885
Average				22.6	1,440	9,094	117	58	250
Non-Agricultural	S-11C	100	1.06	5.8	191	4,558	139	14	41
Canals	L-67A	100	1.5	9.9	11	7,755	206	32	104
	L-28 East	100	1.2	18.0	132	9,240	116	12	55
Average				11.2	111	7,194	154	19	66
Marshes	1-15	100	.24	9.0	40	589	23	1	7
	2-17	100	.35	8.0	82	486	34	3	7
	3-28	100	.27	12.4	68	1,787	34	2	13
Average				9.8	63	954	30	2	9

Table 8.--Chemical analyses of bottom sediments collected in Conservation Area 1 in February 1974. (Location of sampling sites shown on figure 5A.)

Canal Sites	Organic Carbon (grams per kilogram)	Total Nitrogen (grams per kilogram)	Total Phosphorus (milligram per kilogram)	Mercury (microgram per gram)	Manganese (microgram per gram)	Iron (microgram per gram)	Copper (microgram per gram	Lead (microgram per gram)
0	110	11	260	0.00				
4	70	.62	150	.01	26	1900	4	10
8	140	1.7	270	.05				
12	86	13	180	.05	47	2700	5	20
16	54	9.2	150	.02				
20	28	4.6	130	.03				
24	130	10	97	.03				
28	240	20	150	.03				
32	220	2.5	140	.00				
26	250	23	200	.00				
40	290	23	180	.23				
41	230	.75	190	.00	140	8200	24	25
44	210	17	230	.00	120	3200	19	25
48	150	11	270	.00				
52	22	2.4	150	.00	6	1300	2	10
Average	149	9.98	183	.03	68	3460	11	18
Std. dev.	87	7.95	53	.06	59	2748	10	8
Marsh sites								
4	410	29	130	.03	29	1400	6	13
12	190	23	80	.14	29	1900	5	25
20	350	22	230	.10				
28	290	17	50	.07				
36	340	39	260	.00				
44	260	30	330	.06	70	8800	31	38
52	310	31	230	.14	25	2500	12	33
Average	307	27	187	.08	38	3650	14	27
Std. dev.	70	7	102	.05	21	3463	12	11

Table 9.--Concentrations of nitrogen and phosphorus in bottom sediments normalized to 100 grams per kilogram organic carbon, February 1974. (Locations shown on figure 5A).

Canal sites	N	P
0	10.	.236
4	.89	.215
8	1.2	.193
12	15.	.209
16	17.	.278
20	16.	.464
24	7.7	.075
28	8.3	.063
32	1.1	.064
36	9.2	.080
40	7.9	.062
41	.33	.083
44	8.1	.110
48	7.3	.180
52	11.	.682
Average	8.07	.200
Std. dev.	5.43	.173
Marsh sites		
4	7.1	.032
12	12.1	.042
20	6.3	.066
28	5.9	.017
36	11.5	.076
44	11.5	.127
52	10.0	.074
Average	9.20	.062
Std. dev.	2.69	.036

carbon content. The concentration of nitrogen in bottom sediment was about 1,000 times greater than the concentration in the plants, and the concentration of phosphorus in the sediment was more than 100 times greater than in aquatic plants (fig. 21). The carbon concentration of both the plants and sediments was similar indicating the organic origin of the sediments.

The chemical composition of the bottom sediments within the Everglades indicate that a variety of factors are controlling the nitrogen and phosphorus content of these sediments. In general, the sediments are a sink for nitrogen and phosphorus. Waller (1975) estimated that 74 percent of the total nitrogen and 96 percent of the total phosphorus that enter the conservation areas were retained.

Under anaerobic conditions or when sediments are resuspended due to flow and turbulence, bottom sediments may also be a source of nitrogen and phosphorus to the water. For example, the increased concentration of ammonia nitrogen, in the canal waters near S-5A during pumping is probably due, in part, to the release of ammonia from bottom sediments due to mixing and resuspension of these sediments.

CHARACTERISTICS OF VEGETATION IN THE EVERGLADES MARSH AND IN CANALS NEAR PUMPING STATIONS

Introduction

Most of the Everglades is saw grass marsh interspersed with sloughs, wet prairies, and tree islands. Saw grass is the dominant plant; it comprises about 65 to 70 percent of the total vegetation cover (Loveless, 1959).

Changes in Everglades vegetative communities may be attributed to a number of causes - some related to man and some not. Under ideal conditions, vegetation undergoes orderly, successional changes. One community replaces another until a relatively stable situation is reached in which the final community is in equilibrium with its climatic environment and is capable of self-perpetuation as long as the climate does not change radically. The stable community is called climax; previous ones are sub-climax. Each community in this successional change has its own species, organization, and conditions. Environmental factors other than climate may control and maintain subclimax communities; saw grass marsh, for example, is maintained by periodic seasonal fires. Lightning has always caused some wildfires, particularly during the summer when thunderstorms are common. Wildfires during the rainy season are usually less severe than fires during the winter dry season. Fires during the dry season are often man-caused.

The northern Everglades has been mostly drained for farming so that little natural vegetation remains except in Conservation Area 1 (Loxahatchee National Wildlife Refuge). In the southern Everglades two other conservation areas and Everglades National Park contain most of what is left of the natural vegetation. The vegetation within the conservation areas and the Everglades National Park,

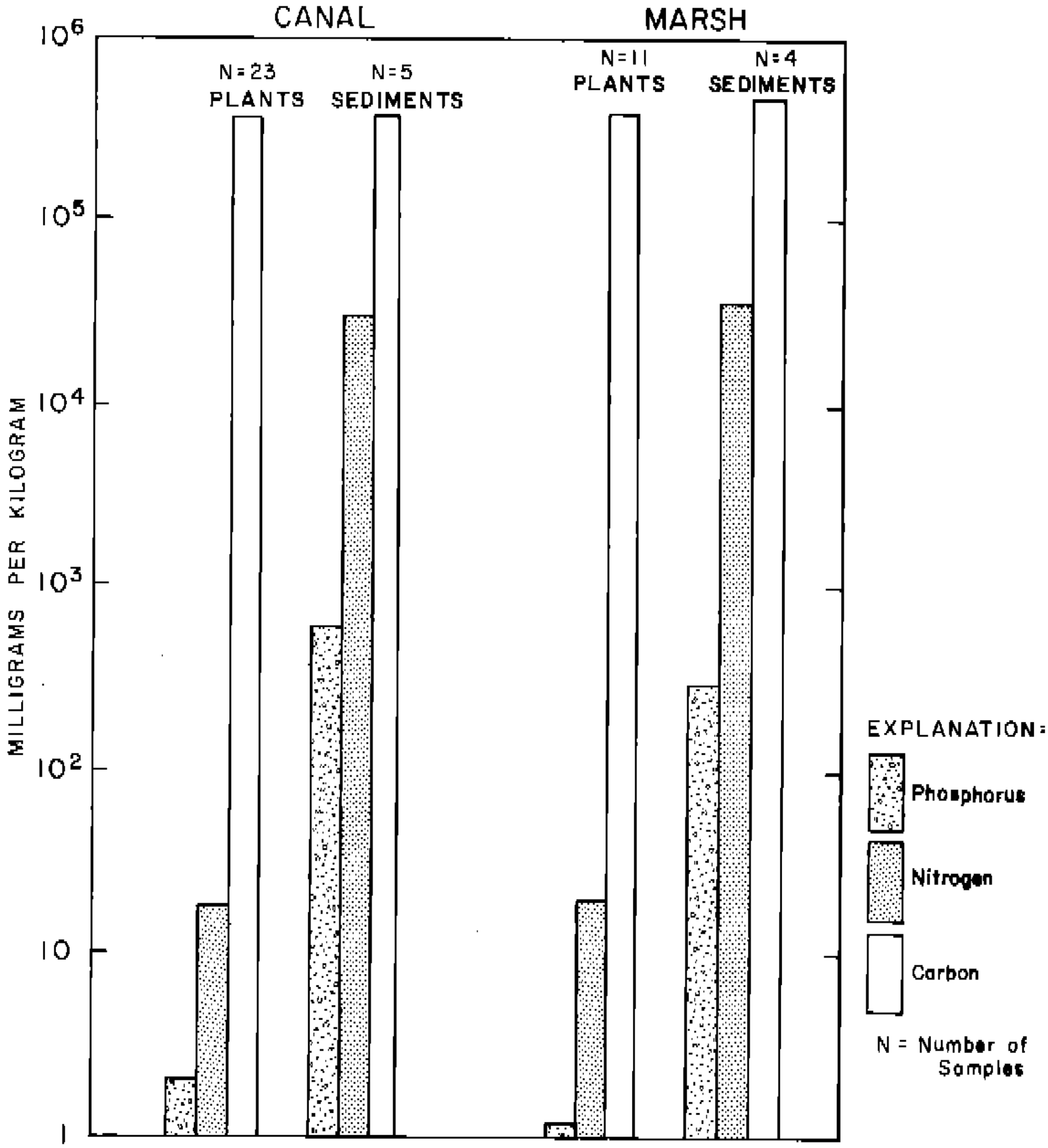

Figure 21.--Carbon, nitrogen, and phosphorus concentrations of aquatic plants and bottom sediments collected in the Everglades, in January 1973. (For locations see figures 3 and 5B).

however, has also been subjected to man-caused environmental changes. Water impoundment, for example, has altered hydroperiods and affected plant communities (Alexander and Crook, 1974; Hagenbuck and others, 1974). Canals have not only dewatered land but have created new environments favorable to submerged and floating aquatic plants. Draining and channelization have encouraged the spread of exotic plant species some of which are becoming dominants in parts of the Everglades.

In addition to changes in water inundation, vegetative communities may be affected by changes in water quality. Increased input of nutrients into lakes, for example, often accelerates the process of eutrophication. Steward and Ornes (1974a, 1974b) found that saw grass has a low nutrient requirement and probably a limited capacity for removing nutrients from water. Ornes and Steward (1974a) also found that enrichment of a saw grass community with phosphorus and potassium resulted in phytoplankton blooms, dynamic shifts in phytoplankton genera, and the disappearance of aquatic macrophytes _Chara_ sp and _Utricularia_ sp. Gleason and Spackman (1974) reported that periphyton composition and biomass in Area 1 changed in relation to a chemical gradient from perimeter canals into the interior marshes. Calcareous, blue green algae of high biomass dominated the periphyton near the perimeter canals where concentration of dissolved solids was high as a result of agricultural runoff and ground water influx. This flora changed to a green, non-calcareous algal periphyton of lower biomass in the interior of Area 1.

Survey and Sampling

Water of relatively poor quality has been pumped into the Everglades at S-5A and S-6 for a number of years. Any effects of altered water quality on vegetation should be most obvious at these places. For this reason we surveyed or sampled the plant communities in the vicinity of S-5A and the Hillsboro Canal below S-6, and for comparison, the communities in the vicinity of S-9, and the interior marshes of the Everglades.

Results

The canals near S-5A are heavily infested with the submerged exotic hydrilla, _Hydrilla verticillata_. The large reed, _Phragmites australis_, is dominant at the canal edge. The nearby marsh has dense cattail stands (_Typha_ sp) and ponded areas with floating and submerged exotic plants. Plants such as _Pistia stratiotes_, _Lemna_, _Salvinia_, _Azolla_, _Alternanthera philoxeroides_, and filimentous green algae are locally abundant.

Cattail is the dominant emergent plant in the marshes near the Hillsboro Canal, in both Areas 1 and 2; dense growth of this plant extends up to several kilometres from the canal. Other large plants are virtually absent over large areas. North of the Hillsboro Canal there are also large ponded areas of open water with predominantly submerged plants.

At pumping station S-9 canal banks are also characterized by heavy and intermixed stands of cattail and _Phragmites australis_. Interspersed are patches of yellow water lily _Nuphar luteum_. _Hydrilla_, bladderwort, _Najas_, and *Cabomba caroliniana* are abundant. The peripheral marshes have intermixed stands of cattail and sawgrass.

Dense stands of cattail occur in the Everglades near canals, along airboat trails, or around tree islands. In the interior Everglades cattails are not usually abundant except for large stands around some tree islands and near the mangrove fringe. The dense stands of cattail in the conservation areas are probably good indicators of disruption and stress on sawgrass. Many ponded areas, near the large canals in the northern conservation areas are infested with exotic submerged or floating plants that are also indicative of disruption. Disruption of the Everglades plant communities may reflect one or a combination of factors including altered water levels, altered water quality, destruction of existing communities, or opening routes of access by channelization.

Aquatic plant biomass was sampled at four slough locations in Conservation Area 1 (Basic data F). Two of the locations were near pumping station S-5A; the other locations were in areas remote from pumping. Plants in the quadrats were removed whole, including roots, separated into species, and weighed wet in the field. Subsamples were returned to the laboratory, oven dried, and weighed.

Total wet weight ranged from 397 to 25,410 gm/m^2. Because of the large variation at any one location no significant differences in biomass between the locations were evident. Species composition differences were obvious however. Floating and submerged plants, including *Hydrilla verticillata* *Alternanthera philoxeroides* and *Najas quadalupensis*, were dominant in biomass at locations near S-5A. Cattail was the dominant emergent plant. In the quadrats in the interior of Area 1 the dominant emergent vegetation included *Nymphaea odorata*, *Eleocharis*, *Rhynchospora tracyi* and *Pontederia lanceolata*.

Selected nutrients and trace elements were measured in a variety of marsh plants. Samples of several common plant species were collected in areas of relatively poor quality water (S-5A and S-10 structures) and in areas of relatively good quality water (the interior marshes of the conservation areas). Results for each species are given in Table 10.

Nutrients, such as nitrogen, phosphorus, and carbon, and potentially toxic metals, such as copper, lead, and zinc are often associated with agricultural or urban runoff. These might be expected to be in higher concentration in plants near S-5A and S-10C than in plants from the interior marshes. No such trends were evident, however, with the possible exception of phosphorus. Samples of cattail from S-5A had a higher average concentration of phosphorus (2.2 mg/g) than those from other locations (1.0 to 1.2 mg/g). Also, the overall average for all species was higher in this element at S-5A and at S-10C (2.2 to 2.4 mg/g) than at the other locations (0.8 to 1.4 mg/g). The highest concentration of lead (21 µg/kg) was surprisingly in a cattail sample from a remote region of Conservation Area 3A.

Table 10.--Concentrations of nutrients and trace elements (totals) in aquatic plants from the water conservation areas. (Plants were collected January 1973. Location of sampling sites shown on figure 3 and 5B.)

	PLANT SPECIES	Nitrogen	Phosphorus	Carbon	Copper	Lead	Zinc
		(milligrams per kilogram)		(percent)	(microgram per kilogram)		
S-5A	(Area 1)						
Cattail (top)	*Typha* sp.	18	2.2	39.7	4	1	16
Cattail (top)	*Typha* sp.	22	2.3	33.2	4	2	11
Cattail (roots)	*Typha* sp.	14	2.7	38.6	8	4	11
Cattail (roots)	*Typha* sp.	11	1.5	36.6	5	1	13
Water lettuce	*Pistia stratioles*	16	2.3	32.2	4	5	10
Water lettuce	*Pistia stratioles*	21	3.3	33.6	4	7	14
Hydrilla	*Hydrilla verticillata*	23	2.9	27.6	10	17	59
Hydrilla	*Hydrilla verticillata*	21	3.5	30.8	8	9	48
Water hyacinth	*Eichhornia crassipes*	16	1.2	36.8	4	8	17
Water hyacinth	*Eichhornia crassipes*	19	1.1	35.6	3	4	15
periphyton (algae)		19	1.4	32.4	4	9	12
periphyton		23	1.4	35.6	4	8	12
Duckweed	*Lema* sp.	17	2.9	36.8	7	10	29
	Average	18.5	2.2	34.6	5.3	6.5	20
S-10C							
Hydrilla	*Hydrilla verticillata*	16	1.6	26.7	5	12	44
White water lilly	*Nymphaea odorata*	23	1.8	40.9	2	2	13
Cattail (top)	*Typha* sp.	13	1.1	43.0	2	2	6
Cattail (roots)	*Typha* sp.	16	1.3	41.1	10	16	40
Pickerel weed (tops)	*Pontederia lanceolata*	22	3.0	36.6	2	4	16
Pickerel weed (roots)	*Pontederia lanceolata*	12	5.5	36.6	8	6	32
	Average	17	2.4	37.5	4.8	7	25
5 Miles So. of S-10C (Area 2)							
Cattail (tops)	*Typha* sp.	17	1.4	43.0	3	2	12
Bladderwort	*Ultricularia* sp.	21	1.7	38.0	5	9	24
White water lilly	*N. odorata*	23	1.1	40.1	1	2	15
	Average	20.5	1.4	40.4	3	4	17

Table 10.--Continued - Concentrations of nutrients and trace elements (totals) in aquatic plants from the water conservation areas. (Plants were collected January 1973. Location of sampling sites shown on figure 3 and 5B.)

PLANT SPECIES (Area 2)		Nitrogen (milligrams per kilogram)	Phosphorus (milligrams per kilogram)	Carbon (percent)	Copper (microgram per kilogram)	Lead (microgram per kilogram)	Zinc (microgram per kilogram)
2-17 (Center of Area 2)							
White water lilly	*N. odorata*	24	1.1	41.7	2	2	17
Interior of Area 1							
Bladderwort	*Ultricularia* sp.	15	.77	37.9	8	5	56
Cattail (top)	*Typha* sp.	18	1.1	41.6	2	3	11
Arrowhead	*Sagittaria lancifolia*	26	1.8	40.6	2	3	32
Pickerelweed (tops)	*Pontederia lanceolata*	18	1.3	41.3	1	3	18
White water lilly	*N. odorata*	24	1.3	38.5	1	3	31
	Average	20.5	1.2	40.	2.8	3.4	29
L-28 (Area 3)							
Cattail (top)	*Typha* sp.	15	.99	44.2	2	2	9
Cattail (roots)	*Typha* sp.	11	.96	36.5	9	21	19
Pickerelweed (tops)	*P. lanceolata*	21	1.5	40.0	1	3	13
Pickerelweed (roots)	*P. lanceolata*	11	1.6	38.8	3	7	26
	Average	14	1.3	39.8	3.7	8	17
3-28							
White water lilly	*N. odorata*	21	.91	41.7	1	3	29
Bacopa	*Bacopa caroliniana*	11	.64	36.1	7	7	27
	Average	16	.77	39.1	7	5	28

SUMMARY AND CONCLUSIONS

Water to sustain the marshes of the conservation areas and Everglades National Park is from direct rainfall and from canals which convey water from Lake Okeechobee and from agricultural lands in the north. Water flows southward in the canals by gravity or is pumped southward into the conservation areas. The three conservation areas are connected by spillway structures that enable water to be transferred directly from Lake Okeechobee through Conservation Area 3 and thence to Everglades National Park or, during drought, to the Miami area. In addition, water can be backpumped from the east into Conservation Area 3A at pumping station S-9.

Plans for further water management in southeast Florida include reduction of storm runoff to the coastal areas by large increases in backpumping to the conservation areas. Such backpumping would alter water levels and introduce additional nutrients and pollutants into the Everglades environment. The degree of change in water chemistry in the conservation areas would depend mainly on the quality and quantity of the water backpumped. With additional backpumping, the conservation areas would become wetter and this would tend to increase aquatic plant communities in relation to semi-aquatic communities. Such changes have already been recorded in parts of the conservation areas where water levels have been increased by impoundment. Land to the east of the conservation areas would become drier with backpumping, and this would tend to increase the development potential of this land.

Water pumped into the conservation areas is now largely confined to canals and peripheral marshes of Area 1 and 3. In area 2, however, canal water extends into the interior marshes.

Water pumped into the northern Everglades often has relatively high concentrations of inorganic nitrogen and phosphorus which are transported in the canals or move into the peripheral marshes. Concentrations of nitrogen and phosphorus decrease sharply within 100 metres or less of the canals, whereas specific conductance remains essentially unchanged within that distance. The sharp decrease in inorganic nitrogen and phosphorus along the canal edge indicates net uptake in these shallow waters.

Concentrations of total phosphorus and inorganic nitrogen decreased an average of 3 percent and 4 percent per kilometre respectively downstream in canals in the conservation areas. This decrease is due partly to dilution by rainfall and runoff, and partly to net uptake in the canals and peripheral marsh.

Measurements of dissolved oxygen suggest that nutrient uptake from canal water by aquatic biota occurs mainly near the edge of the canal and in nearby marshes. First, diel fluctuations of dissolved oxygen in the large canals in January 1973 and 1974 and September 1973 were relatively small, indicating a low biological metabolism with little uptake or release of nutrients. Second, dissolved oxygen decreased with depth, often to near anaerobic levels near the bottom of the canals. This suggests that the dominant metabolic process was respiration which would release nutrients to the water. Third, concentrations of dissolved oxygen tended to increase near the canal bank and in the nearby marshes. Low-flow or stagnant conditions, however, would probably allow plankton to bloom resulting in increased photosynthesis and nutrient uptake.

Pumping water into the conservation areas has several local effects on water chemistry in canals near the pumping stations. First, it introduces new water, often of a different quality, into the conservation area canals. At pumping station S-9, for example, water backpumped into Conservation Area 3A is usually rich in ammonia and virtually devoid of dissolved oxygen, apparently because it is partly of ground-water origin. After backpumping, concentrations of dissolved oxygen are depressed and concentrations of ammonia are elevated at least several kilometres downstream from the pump. Second, pumping breaks up stratification and mixes the different waters. At pumping station S-5A dissolved oxygen became almost uniform with depth after pumping began. Also, concentrations of ammonia increased sharply downstream with pumping, possibly because of a mixing effect that released ammonia from bottom sediments. The high concentrations of ammonia and low concentrations of dissolved oxygen associated with pumping are, under present water-level conditions, confined primarily to canals in the conservation areas.

Backpumping from the east coast canals, which now occurs only at station S-9, added 230 tonnes (253 tons) of nitrogen and 1.8 tonnes (2 tons) of phosphorus to Conservation Area 3 from July 1972 through June 1973 (Waller, 1975). Additional pumping stations will allow as much as 50 percent of total annual canal runoff in southeast Florida to be backpumped. Annually this would add from 900 to 5,600 tonnes (990 to 6,160 tons) of nitrogen and from 9 to 56 tonnes (10 to 62 tons) of phosphorus to the conservation areas. For comparison, rainfall and dry fallout contributed 5,200 tonnes (5,700 tons) of nitrogen and 207 tonnes (228 tons) of phosphorus to the conservation areas from July 1972 through June 1973 (Waller, 1975).

Direct rainfall and dry fallout are the major contributors of nitrogen and phosphorus to the conservation areas. Practically all this falls on the marsh environment where it is subject to biological uptake. The marsh sediments are a sink for these elements. Bottom sediments can also be a source of nitrogen and phosphorus when anaerobic conditions exist at the water-sediment interface or when resuspension of the bottom material occurs.

With respect to organic carbon and nitrogen, phosphorus is enriched in canal sediments compared with marsh sediments. Also there is some indication that nitrogen and phosphorus and several trace metals are enriched in canal sediments near pumping stations that drain agricultural land compared with canal sediments remote from pumping stations.

The plant communities of the Everglades are often disrupted in the vicinity of large canals. Saw grass marsh, sloughs, and wet prairies have been altered or replaced by cattails or by submerged, floating, and exotic plants. The disruption of the original plant communities may reflect altered water levels, altered water quality or a combination of the two.

The plant communities near the large canals in the northern Everglades are often exposed to agricultural runoff and to water of poor quality compared with the water quality in the interior marshes. Thirty-four samples of aquatic plant species collected in these canals and the interior marshes were analyzed for nitrogen, phosphorus, carbon, copper, lead, and zinc. Except for slightly higher concentrations of phosphorus in plant tissue from two locations where water quality is poor, no differences in nutrient and metal concentrations were evident in aquatic plants collected either from remote, relatively undisturbed areas or from areas receiving agricultural runoff.

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BASIC DATA A

Nutrient Transects, September 10-11, 1973 and January 16-17, 1974.

Transects from canals into the marshes of the Conservation Areas on September 10-11, 1973. Locations of transects shown on Figure 3.

Transects B, C, D, E cross canals.

Distance in metres from canal(s)	Temp °C	DO mg/l	Specific Conductance micromhos/cm at 25°C	mg/l PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
			Transect A				
0	28.5	3.4	1015	0.008	0.18	0.000	0.00
100	28.0	1.5	1015	-	-	-	-
800	27.5	1.1	1025	-	-	-	-
2,400	26.5	0.7	900	.010	.22	.000	.00
			Transect B (East to West)				
0	28.0	0.8	940	.008	.18	.000	.00
0	27.5	1.3	1175	.010	.42	.012	.00
0	28.0	1.1	1015	-	-	-	-
1,600	27.5	2.0	1130	-	-	-	-
4,000	27.5	2.0	875	.006	.19	.000	.00
			Transect C (South to North)				
3,200	27.0	3.5	910	.005	.12	.000	.00
0	28.5	2.5	1020	.004	.16	.000	.00
0	29.0	6.8	1010	-	-	-	-
2,400	28.5	3.8	1020	-	-	-	-
7,200	28.0	2.6	1015	-	-	-	-
13,600	28.5	1.8	1255	.003	.13	.000	.01
15,000	29.0	2.8	1020	-	-	-	-
			Transect D (southwest to northeast)				
-	30.0	2.4	1020	.006	.17	.000	.00
0	28.0	1.5	1335	.037	.43	.000	.21
0	28.0	1.6	1345	.032	.40	.048	.15
400	28.0	0.9	1315	.010	.20	.000	.00
2,000	28.0	6.5	705	.005	.12	.000	.00
3,600	28.0	5.7	660	.010	.12	.000	.01
5,200	28.0	6.4	245	.005	.16	.000	.00
6,800	31.0	9.4	105	.004	.11	.000	.00

Continued - Transects from canals into the marshes of the Conservation Areas on September 10-11, 1973. Locations of transects shown on figure 3.

Transects B, C, D, E cross canals.

Distance in metres from canal(s)	Temp °C	DO mg/1	Specific Conductance micromhos/cm at 25°C	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
			Transect E				
-	28.0	.05	920	.026	.20	.000	.00
0	28.5	2.2	885	.036	.30	.000	.01
0	29.0	4.4	920	.005	.13	.000	.03
100	30.0	7.6	830	.010	.13	.000	.00
500	28.5	1.2	540	.007	.07	.000	.00
1300	29.0	6.1	180	.008	.16	.000	.00
2900	30.0	6.1	110	.006	.15	.000	.00
			Transect F (West to east)				
0	28.5	1.7	1080	.036	.62	.100	.41
100	26.5	1.0	850	.012	.21	.000	.00
500	26.0	3.2	445	.015	.21	.000	.00
1700	27.0	6.4	130	.012	.23	.000	.00
			Transect G				
0	26.0	1.6	1040	.050	.92	.048	.14
100	28.0	1.0	400	.012	.32	.000	.00
500	29.0	7.0	200	.025	.33	.000	.00
2100	30.0	8.1	115	.025	.38	.000	.00
			Transect H				
0	28.0	0.9	820	.042	.40	.000	.00
100	28.0	1.4	780	.023	.20	.000	.00
500	28.5	7.0	370	.006	.15	.000	.00
1300	28.0	7.2	270	.009	.17	.000	.00
2100	29.0	7.1	180	.007	.19	.000	.00
2900	29.5	6.8	150	.012	.42	.005	.00

Continued - Transects from canals into the marshes of the conservation areas on September 10-11, 1973. Locations of transects shown on figure 3.

Transects B, C, D, E cross canals.

Distance in metres from canal(s)	Temp °C	DO mg/l	Specific Conductance micromhos/cm at 25°C	mg/l PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
			Area 1 near center				
north center	31.0	8.7	110	.015	.35	.000	.06
south center	31.0	5.8	110	.005	.15	.000	.00
			Transect I				
0	28.5	-	810	.002	.18	.000	.13
200	29.0	-	653	.003	.07	.000	.00
500	29.0	-	440	.004	.14	.000	.00
1000	28.0	4.0	252	.002	.11	.000	.00
16000	28.0	-	199	.003	.11	.000	.00
			Transect J				
0	28.0	-	696	.006	.17	.000	.16
200	29.0	-	442	.003	.08	.014	.00
500	29.0	-	377	.007	.08	.000	.00
1000	28.5	-	289	.003	.13	.000	.01
4800	28.0	-	199	.003	.11	.000	.00
			Transect K				
0	30.0	-	407	.004	.14	.000	.00
200	29.0	-	295	.000	.10	.000	.00
1200	29.0	-	223	.005	.08	.000	.00
1600	29.5	-	198	.001	.09	.000	.01
8000	30.0	-	200	.005	.12	.000	.01

-Transects from canals into the marshes of Conservation Area 1 on 16-17 January 1974. Distance from canal is in meters (approximate). Transect locations are shown on Figure 3.

Distance in meters	Time	Temp °C	D.O. mg/l	Specific Conductance micromhos/cm	mg/l PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
			Transect L					
0	1300	21.5	2.1	1180	0.14	0.73	0.09	0.51
10	1303	22.0	6.4	1300	0.09	0.51	0.15	0.51
20	1306	22.0	2.0	1300	0.09	0.56	0.15	0.46
100	1309	22.1	4.2	800	0.01	0.11	0.00	0.00
500	1312	23.5	6.8	210	0.01	0.18	0.00	0.00
2000	1315	25.0	6.9	100				
			Transect M					
0	1320	21.0	2.2	1240	0.14	0.65	0.07	0.51
10	1325	22.9	2.3	1310	0.12	0.57	0.11	0.52
20	1328	24.0	4.5	1390	0.04	0.37	0.15	0.37
100	1330	23.2	4.1	1480	0.01	0.35	0.08	0.07
400	1335	22.2	7.5	280	0.01	0.11	0.00	0.00
1500	1337	24.5	7.1	140	0.01	0.19	0.00	0.00
			Transect N					
0	1410	24.0	4.4	490	0.02	0.21	0.00	0.14
10	1412	24.0	4.7	570	0.02	0.17	0.00	0.03
20	1414	23.0	4.1	580	0.02	0.20	0.00	0.04
100	1416	24.0	8.0	355	0.00	0.09	0.00	0.00
400	1418	24.0	6.7	180	0.00	0.11	0.00	0.00
1000	1420	24.5	7.3	105	0.00	0.12	0.00	0.00
			Transect O					
0	1010	21.0	3.9	420	0.01	0.14	0.00	0.01
10	1012	21.0	3.6	440	0.02	0.36	0.00	0.00
20	1014	21.0	3.3	420	0.01	0.18	0.00	0.00
100	1016	21.0	3.6	190	0.00	0.13	0.00	0.00
500	1018	20.5	4.3	110	0.00	0.11	0.00	0.00
2500	1020	20.5	3.4	52	0.01	0.18	0.00	0.00
			Transect P					
0	1045	21.5	2.2	1280	0.03	0.44	0.06	0.24
10	1048	21.5	2.8	1250	0.02	0.29	0.03	0.28
20	1050	21.5	3.5	1280	0.01	0.20	0.03	0.25
100	1052	22.0	4.8	1310	0.00	0.28	0.04	0.16
500	1054	20.0	3.1	1100	0.00	0.13	0.00	0.00
1500	1056	20.5	4.5	980	0.00	0.12	0.00	0.00
3000	1058	20.5	4.6	500	0.00	0.08	0.00	0.00
4500	1100	21.5	5.0	200	0.00	0.12	0.00	0.00

Distance in meters	Time	Temp °C	D.O. mg/l	Specific Conductance microhome	mg/l PO_4 as P	mg/l NH_3 as N	mg/l NO_2 as N	mg/l NO_3 as N
			Transect Q					
0	1120	-	-	-	0.01	0.16	0.00	0.03
20	1122	22.0	5.2	720	0.01	0.11	0.00	0.02
100	1124	22.0	5.8	800	0.00	0.12	0.00	0.00
500	1126	20.5	5.3	620	0.01	0.13	0.00	0.00
1200	1128	21.0	5.8	500	0.00	0.10	0.00	0.00
2500	1130	20.5	6.3	450	0.00	0.08	0.00	0.00
4500	1135	22.0	7.5	240	0.00	0.10	0.00	0.00
			Center of Conservation Area 1					
North	1345	23.6	6.5	110	0.01	0.17	0.00	0.00
South	1430	23.2	8.5	95	0.00	0.16	0.00	0.00

Transects from canals into the marshes of Conservation Areas 2 and 3 on 16-17 January 1974. Distance from canal is in meters (approximate). Transect locations shown on Figure 3.

Distance	Time	Temp °C	D.O. mg/l	Specific Cond. micromho	PO_4 as P (mg/l)	NH_3 as N (mg/l)	NO_2 as N (mg/l)	NO_3 as N (mg/l)
				Transect R				
0	1230	22.2	2.8	800	0.00	0.44	0.00	0.06
10 (1)	1235	21.5	2.0	780	0.00	0.13	0.00	0.00
20	1240	21.0	1.0	780	0.00	0.12	0.00	0.00
200	1240	20.0	1.5	750				
4000	1246	220	3.0	750	0.00	0.13	0.00	0.00
				Transect S				
0	1345	22.0	1.7	1200	0.04	0.35	0.00	0.12
10	1350	22.0	2.9	1100	0.00	0.16	0.00	0.00
100	1352	19.5	1.7	600	0.00	0.12	0.00	0.00
2500	1355	21.5	3.4	820	0.00	0.13	0.00	0.00
				Transect T				
0 (2)	1355	23.0	1.6	1050	0.00	0.64	0.00	0.01
20	1357	22.5	2.8	1100	0.01	0.32	0.00	0.02
				Transect U (Area 3A to 2B)				
2500	1405	20.0	2.6	860	0.01	0.16	0.00	0.00
0 (west)	1410	22.0	4.4	1000	0.01	0.18	0.00	0.04
0 (east)	1418	24.0	6.9	910	0.00	0.20	0.00	0.24
200	1420	24.5	2.6	980	0.00	0.14	0.00	0.00
center of 2B	1425	26.0	5.3	890	0.00	0.10	0.00	0.00
				Center of Area 2A (2-17)				
	1310	21.5	4.4	1080	-	-	-	-

(1) The second sample site, Transect R, in the marsh west of levee. There was no canal west of levee. Canal on the east.

(2) Transect run due west into Conservation Area 3 from S-11C. Water was flowing west through S-11C. Transect stopped because of dry conditions.

Transect from S-39 southwest along airboat trail into the marshes of area 2. 16-17 January 1974. Distance from S-39 in meters (approximate)

Time EDST	Distance in meters	Temp °C	D.O. mg/l	Specific Conductance	PO_4 as P	NH_3 as N (mg/l as N)	NO_2 as N (mg/l as N)	NO_3 as N (mg/l as N)
Transect V								
January 16, 1974								
1315	10	24.5		1380	.03	.38	.04	..06
1520	100	24		1340	.01	.29	.02	.06
1530	240	24		1150	.01	.18	.00	.01
1535	300	24		1165	.01	.22	.00	.00
1545	1600	24		1360	.01	.13	.00	.00
1600	5000	24		1120	.00	.16	.00	.00
1610	8000	24		-	-	-	-	-
January 17, 1974								
0935	10	21.5	2.6	1325	.03	.58	.04	.06
0950	8000	20	1.9	1080	.00	.12	.00	.00
0955	10000	20.5	2.8	1025	.00	.12	.00	.00

BASIC DATA B

Concentrations of nutrients near S-5A on 16-17 January 1973.

Concentrations of nutrients near S-5A on 16-17 January 1973. Specific conductance in micromhos at 25° C. Acid hydrolizable P and PO_4-P, NO_3-N, NO_2-N, NH_3-N, inorganic N and dissolved oxygen (DO) in mg/l. No pumping.

Time	Specific Cond.	PO_4	NH_3	NO_2	NO_3	Total inorg.N	Temp C^o	DO	Percent saturation
				Site 1 (West Palm Beach Canal)					
0810	1280	.078	.46	.068	.43	.96	15	4.9	48
1220	1345	.072	.47	.070	.45	.99	17	6.3	64
1600	1420	.070	.46	.060	.47	.99	17	5.5	56
2200	1300	.084	.46	.060	.47	.99	16	5.2	52
0005	1260	.070	.45	.058	.47	.98	16	5.4	54
0405	1240	.070	.43	.070	.48	.98	16	5.5	55
0745	1220	.084	.42	.059	.48	.96	16	5.5	55
Avg	1295	.076	.45	.064	.46	.98	16	5.5	55
				Site 2 (Below S-5A)					
1050	1330	.042	.37	.077	.37	.82	15	6.9	67
1330	1300	.042	.35	.088	.38	.82	15	6.8	66
1705	1170	.042	.31	.094	.41	.81	16.5	6.5	65
2040	1200	.042	.31	.094	.41	.81	15.5	6.6	65
0100	1200	.045	.30	.090	.42	.81	16	6.4	64
0440	1160	.042	.30	.092	.43	.82	15.5	6.1	60
0900	1260	.040	.28	.088	.39	.76	15.5	7.0	70
Avg	1230	.042	.32	.089	.40	.81	16	6.6	65
				Site 3					
1115	1310	.042	.34	.060	.35	.75	14.5	6.7	64
1340	1320	.056	.36	.064	.36	.75	15	--	--
2020	1200	.056	.33	.068	.38	.78	16	6.3	63
0315	1230	.054	.32	.068	.36	.75	16	6.1	61
0530	1220	.042	.32	.066	.37	.76	16	5.9	59
0805	1180	.042	.33	.055	.36	.75	15.5	6.4	63
Avg.	1240	.049	.33	.064	.36	.76	16	6.3	62

Time	Specific Cond.	PO_4	NH_3	NO_2	NO_3	Total inorg. N	Temp C^o	DO	Percent saturation
					Site 4				
1040	1270	.042	.31	.086	.39	.79	14	6.9	66
1320	1370	.042	.27	.088	.45	.81	15	7.2	70
2125	1200	.042	.27	.086	.43	.79	15.5	6.7	65
0050	1190	.042	.28	.086	.45	.82	16	6.6	66
0450	1160	.042	.28	.080	.45	.81	15.5	6.3	63
0850	1230	.022	.26	.075	.44	.78	15.5	6.8	67
Avg.	1230	.042	.28	.084	.44	.80	16	6.7	66
					Site 5				
0945	--	.028	.24	.066	.60	.91	14	6.8	65
1250	1125	.050	.25	.066	.63	.95	15	7.9	78
1645	1180	.028	.23	.068	.63	.93	16.5	7.1	72
2105	1140	.028	.22	.068	.62	.91	16	7.5	75
0025	1160	.039	.23	.068	.64	.94	15.5	7.3	72
0505	1120	.022	.22	.070	.63	.92	15.5	6.8	67
0830	1130	.027	.20	.060	.59	.85	15.5	7.5	73
Avg.	1140	.031	.23	.067	.62	.92	16	7.3	72
					Site 6				
1000	--	.050	.57	.055	.28	.91	12.5	3.6	33
1300	1210	.042	.53	.053	.31	.89	15.5	7.7	76
1635	1350	.000	.48	.055	.22	.76	18	8.2	96
0035	1150	.028	.30	.080	.54	.92	16	6.7	78
0510	1140	.042	.50	.086	.39	.98	15.5	3.3	33
0840	1230	.042	.42	.000	.47	.89	15.5	6.8	77
Avg	1200	.034	.47	.066	.37	.89	16	6.2	66

Concentrations of nutrients in Hillsboro Canal
Upstream of S-10C Spillway in Water Conservation Area 1

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
					mg/l				
January 16, 1974									
	Surface	22.0	805	59	5.2	.03	.12	.00	.02
	1	22.0	795	56	5.0	.01	.12	.00	.02
1035	2	22.0	800	58	5.2	.02	.17	.00	.02
	3	22.0	800	45	4.0	.01	.12	.00	.02
	Surface	24.0	820	68	5.8	.01	.12	.00	.02
	1	22.5		56	4.9				
1430	2	22.0		52	4.6				
	3	22.0	845	51	4.5	.01	.11	.00	.02
	Surface	23.5	692	67	5.7	.01	.16	.00	.03
	1	23.0		61	5.3				
1815	2.	22.0	730	48	4.2				
	3	22.0		48	4.2	.01	.15	.00	.04
	Surface	22.5	845	60	5.3	.01	.11	.00	.03
	1	22.5		60	5.3				
2315	2	22.0	860	54	4.8	.01	.11	.00	.03
January 17, 1974									
	Surface	22.0	800	54	4.8	.01	.10	.00	.03
	1	22.0		53	4.7				
0755	2	22.0	840	46	4.1	.01	.12	.00	.03

Concentrations of nutrients in the Hillsboro Canal
Upstream of S-10D Spillway in Water Conservation Area 1

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	mg/l DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
January 16, 1974									
	Surface	22.5	1070	62	5.4	.01	.12	.00	.04
	1	22.0	1050	47	4.2	.01	.11	.00	.05
1140	2	22.0	1050	41	3.6	.01	.13	.00	.06
	Surface	25.0	1100	97	8.9	.01	.12	.00	.04
	1	22.0		49	4.3				
1530	2	22.0	1140	47	4.2	.01	.13	.00	.06
	Surface	23.0	1050	75	6.5	.01	.13	.00	.06
	1	22.0		40	3.5				
1900	2	22.0	1170	37	3.3	.01	.26	.01	.11
	Surface	22.0	1120	53	4.7	.01	.19	.00	.10
	1	22.0		37	3.3				
2300	2	22.0	1260	35	3.2	.01	.36	.03	.17
January 17, 1974									
	Surface	21.5	1340	28	2.5	.01	.45	.04	.27
	1	21.5		25	2.3				
0810	2	21.5	1340	25	2.3	.01	.38	.05	.23

BASIC DATA C

Diel study at 3 sampling sites in the Hillsboro Canal, at one canal location just south of S-10C and in the nearby marshes of Conservation Area 2A on January 16-17, 1974.

Concentrations of nutrients in Hillsboro Canal
Upstream of S-10A Spillway in Water Conservation Area 1

Time EDST	Depth metres	Temp C°	Specific Cond. micromhos/cm at 25°C	Percent saturation DO	mg/l DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
January 16, 1974									
0830	Surface	22.0	680	62	5.5	.01	.15	.00	.01
	1	21.5	680	64	5.8	.01	.15	.00	.02
	2	21.5	680	57	5.0	.01	.14	.00	.02
	3	21.5	680	22	2.0	.00	.12	.00	.02
1210	Surface	22.0	680	62	5.6	.00	.11	.00	.02
	1	22.0	690	48	4.3	.01	.11	.00	.02
	2	21.5	690	47	4.2	.01	.15	.00	.00
1600	Surface	24.0	670	71	6.1	.01	.10	.00	.02
	1	22.5		71	5.0				
	2	22.0	660	52	4.6	.01	.12	.00	.03
1915	Surface	22.5	635	60	5.3				
	1	22.5		57	5.0				
	2	22.0	635	46	4.0	.00	.12	.00	.02.
2335	Surface	22.0	675	62	5.5	.00	.11	.00	.02
	1	22.0		60	5.3				
	2	22.0	690	60	5.3	.00	.14	.00	.02
January 17, 1974									
0835	Surface	22.0	642	58	5.1	.01	.15	.00	.02
	1	22.0		57	5.0				
	2	22.0	645	57	5.0	.00	.13	.00	.02

Concentrations of nutrients in a canal and nearby marshes of Area 2 just south of L-39 near S-10C on January 16-17, 1974

Location approx. (in metres)	Dist. south of canal	Time	Temp	Specific Cond.	Percent saturation DO	DO	PO_4 as P	NO_3 as N	NO_2 as N	NH_4 as N
Canal	16 Jan	1005	22	1,430	19	1.7	.02	.07	.03	.91
		1400	26	1,460	43	1.7	.01	.11	.03	.96
		1705	24	1,550	47	4.0	.01	.11	.04	.90
		2000	23.5	1,450	44	3.8	.01	.11	.05	.88
		2255	23	1,380	35	3.1				
	17 Jan	0615	22.2	1,418	9	1.4	.02	.10	.05	.82
		0800	22.0	1,400	10	1.5	.01	.10	.04	.94
15 m in Marsh	16 Jan	1010	21.5	2,250	12	1.1	.01	.00	.00	.24
		1405	25.2	2,290	48	4.0	.01	.00	.00	.32
		1710	26	2,380	65	5.4	.01	.00	.00	.32
		2005	24	2,340	44	3.8	.01	.00	.00	.37
		2300	23	2,240	19	1.7	.01	.00	.00	.57
	17 Jan	0620	21.8	2,330	0	0.2	.01	.00	.00	.60
		0810	21.0	2,300	3	0.4	.02	.00	.00	.70
30 m in Marsh	16 Jan	1015	20	1,300	6	0.6	-	-	-	-
		1410	22	1,470	20	1.9	.11	.00	.00	.66
		2010	21	1,420	12	1.1	.08	.00	.00	.52
		2305	20.3	1,380	4	0.4	.08	.00	.00	.45
	17 Jan	0625	19.1	1,400	4	0.4	.08	.00	.00	.49
		0815	18.8	1,420	4	0.4	.11	.00	.00	.62
800 m	16 Jan	1050	20	970	30	2.7	.01	.00	.00	.14
		1720	23	1,220	55	4.8	.01	.00	.00	.18
		2020	20	1,250	9	0.9	.01	.00	.00	.20
		2310	19	1,140	7	0.7	.02	.00	.00	.18
	17 Jan	0630	18.5	1,180	3	0.3				
		0820	18.2	1,780	3	0.3				

Concentrations of nutrients in a canal and nearby marshes of Area 2 just south of L-39 near S-10C on January 16-17, 1974

Location approx. (in metres)	Dist. south of canal	Time	Temp	Specific Cond.	Percent saturation DO	DO	PO_4 as P	NO_3 as N	NO_2 as N	NH_4 as N
1000 m		1105	22	1,300	38	3.4	.01	.00	.00	.24
		2025	19.8	1,220	9	0.9	.01	.00	.00	.21
		0640	18.4	1,140	4	0.4	.01	.00	.00	.20

BASIC DATA D

Diel study at 11 sampling sites near pumping station S-9 on January 16-18, 1973. All measurements at approximately 0.3 metres Backpumping began about 9:30 A.M. on January 17 and ended just after 4:00 P.M. on the same day. Dissolved oxygen (DO), PO_4-P, NH_3-N, NO_2-N, NO_3-N in mg/l. Specific conductance (K) in micromhos/cm at 25°C.

Sampling Site I near S-9

Time	Temp C^o	Specific Cond.	Percent saturation DO	mg/l DO	mg/l PO_4-P	mg/l NH_3-N	mg/l NO_2-N	mg/l NO_3-N
January 16, 1973								
0930				2.0	.031	0.54	.018	.04
1200	27.0	590	26	2.1				
1500	23.0		13	1.7	.035	0.56	.025	.02
1820	23.0	705	4	0.4	.000	0.53	.025	.00
2200	22.0	700	4	0.4	.000	0.57	.020	.00
January 17, 1973								
0210	22.0	695	3	0.3	.000	0.55	.013	.00
0620	20.0	710	6	0.6	.000	0.56	.013	.00
0925	22.0		18	1.6	.000	0.58	.006	.00
0955	22.0		18	1.7	.000	0.58	.000	.00
1055	21.0		17	1.6	.000	0.49	.000	.00
1150	21.0	760	17	1.7	.000	0.47	.000	.01
1330	20.5	770	13	1.3	.000	0.47	.005	.02
1440	21.0		13	1.3	.000	0.46	.000	.05
1600	21.0		19	1.8	.000	0.48	.002	.05
1805	21.5	810	1	0.1	.000	0.48	.000	.00
2225	22.0	800	5	0.5	.000	0.53	.006	.01
January 18, 1973								
0225	21.5	750	5	0.5	.000	0.53	.016	.00
0630	22.0	710	5	0.5	.000	0.54	.012	.00
1015	21.0	760	15	1.4	.000	0.47	.005	.00

Sampling Site 2 near S-9

Time	Temp C^o	Specific Cond.	Percent saturation DO	mg/l DO	PO_4-P	NH_3-N	NO_2-N	NO_3-N
January 16, 1973								
0915	22.0	630	34	3.0	.046	0.38	.015	.24
1310	19.0	770	61	5.7	.000	0.31	.010	.19
1720	18.0	880	48	4.6	.029	0.15	.006	.11
2115	18.0	690	30	2.9	.000	0.28	.010	.15
January 17, 1973								
0130	17.5	745	34	3.3	.000	0.29	.012	.15
0520	17.0	755	38	3.8	.000	0.28	.000	.15
0720	17.5	785	35	3.4	.000	0.27	.011	.15
0945	17.5		60	5.8				
1005	21.0		19	1.8	.000	0.42	.004	.03
1045	21.0	775	20	1.9	.000	0.46	.006	.00
1205	21.0	735	20	1.9	.000	0.49	.005	.00
1315	21.5	760	14	1.3	.000	0.44	.010	.04
1455	21.0		8	0.8	.000	0.45	.000	.05
1610	21.0		24	2.2	.000	0.48	.000	.05
1720	21.0	735	8	0.6	.000	0.42	.002	.04
2140	20.0	835	16	1.5	.000	0.41	.002	.05
January 18, 1973								
0140	20.0	740	11	1.0	.000	0.54	.003	.04
0525	20.0	735	11	1.0	.000	0.40	.002	.04
0930	22.0	745	9	0.9	.000	0.50	.012	.00

Sampling Site 3 near S-9

Time	Temp C°	Specific Cond.	Percent saturation DO	mg/l DO	PO_4-P	NH_3-N	NO_2-N	NO_3-N
January 16, 1973								
0935	17.0	680	93	9.1	.000	.02	.000	.00
1320	17.0	760	98	9.7	.000	.03	.000	.00
1730	17.0	780	105	10.3	.000	.01	.000	.00
2126	16.0	710	103	10.2	.000	.02	.000	.00
January 17, 1973								
0128	15.5	750	101	10.2	.000	.02	.000	.00
0525	15.0	730	78	8.0	.000	.02	.000	.00
0925	16.0	730	87	8.7	.000	.02	.000	.00
1320	19.0	745	103	9.7	.000	.01	.000	.00
1730	19.5	690	117	10.8	.000	.02	.000	.00
2145	18.5	820	108	10.2	.000	.02	.000	.00
January 18, 1973								
0145	17.5	725	87	8.4	.000	.02	.000	.00
0535	17.5	725	87	8.4	.000	.01	.000	.00
0935	18.0	765	70	6.7	.000	.02	.000	.00

Sampling Site 4 near S-9

Time	Temp C°	Specific Cond.	Percent saturation DO	mg/l DO	mg/l PO_4-P	mg/l NH_3-N	mg/l NO_2-N	mg/l NO_3-N
January 16, 1973								
1100	18.5	709	87	8.2	.000	.05	.000	.00
1445	15.0	800	68	7.0	.000	.06	.000	.00
1815	14.0	760	28	3.0	.000	.04	.000	.00
2150	15.0	725	20	2.1	.000	.11	.000	.00
January 17, 1973								
0200	15.0	740	15	1.6	.000	.08	.000	.00
0605	15.0	740	26	2.7	.000	.12	.000	.00
0955	15.5	800	18	1.9	.000	.10	.000	.00
1400	17.5	770	16	1.8	.000	.16	.000	.02
1755	17.5	735	25	2.5	.000	.15	.002	.02
2215	16.5	805	15	1.5	.000	.16	.000	.00
January 18, 1973								
0215	16.5	690	16	1.6	.000	.15	.000	.00
0615	16.0	740	10	1.0	.000	.17	.000	.00
1003	17.0	755	16	1.6	.000	.16	.000	.02

Sampling Site 5 near S-9

Time	Temp C^o	Specific Cond.	Percent saturation DO	mg/1				
				DO	PO_4-P	NH_3-N	NO_2-N	NO_3-N
January 16, 1973								
0945	19.5	870	73	6.8	.000	0.10	.000	.12
1335	16.0	960	73	7.3	.000	0.10	.002	.12
1735	17.0	930	63	6.1	.029	0.12	.000	.11
2125	17.0	870	60	5.9	.000	0.12	.002	.11
January 17, 1973								
0132	16.5	855	67	6.6	.000	0.10	.000	.10
0530	16.5	885	65	6.4	.000	0.09	.001	.10
0926	16.5	885	67	6.6	.000	0.10	.000	.09
1325	21.0	810	31	2.9	.000	0.42	.003	.02
1730	21.0	795	17	1.6	.000	0.41	.008	.01
2150	19.5	835	16	1.5	.000	0.37	.005	.02
January 18, 1973								
0148	19.5	770	19	1.8	.000	0.35	.005	.02
0535	18.5	800	19	1.9	.000	0.27	.006	.03
0936	18.0	820	40	3.9	.000	0.22	.000	.05

Sampling Site 6 near S-9

Time	Temp C°	Specific Cond.	Percent saturation DO	mg/l DO	PO_4-P	NH_3-N	NO_2-N	NO_3-N
January 16, 1973								
0955	19.0	829	88	8.3	.000	0.11	.000	0.11
1340	16.0	940	84	8.4	.000	0.12	.050	0.06
1750	17.0	910	63	6.2	.000	0.11	.000	.09
2127	17.0	870	60	5.9	.000	0.10	.000	.09
January 17, 1973								
0135	16.5	855	65	6.4	.000	0.11	.004	.08
0535	16.0	870	65	6.5	.000	0.11	.000	.07
0928	16.5	875	68	6.75	.000	0.11	.000	.08
1330	17.5	890	68	6.65	.000	0.10	.000	.10
1735	19.5	840	47	4.3	.000	0.26	.000	.07
2152	16.0	960	63	6.3	.000	0.09	.000	.07
January 18, 1973								
0150	16.0	765	67	6.7	.000	0.10	.000	.05
0540	16.0	885	60	6.0	.000	0.09	.000	.06
0930	16.5	895	64	6.3	.000	0.10	.000	.05

Sampling Site 7 near S-9

Time	Temp C°	Specific Cond.	Percent saturation DO	mg/l DO	mg/l PO_4-P	mg/l NH_3-N	mg/l NO_2-N	mg/l NO_3-N
January 16, 1973								
1050	22.5	642	29	2.6	.025	0.37	.012	.20
1435	19.0	730	50	4.7	.000	0.34	.012	.17
1610	16.0	830	36	3.6	.000	0.30	.070	.09
2145	18.0	815	40	3.8	.000	0.24	.006	.14
January 17, 1973								
0156	17.0	815	45	4.4	.000	0.10	.006	.13
0600	16.0	865	28	2.8	.000	0.17	.003	.13
0952	17.0	885	58	5.8	.000	0.16	.005	.13
1357	21.0	750	18	1.7	.000	0.45	.005	.02
1750	20.5	735	24	2.3	.000	0.42	.004	.04
2213	20.0	810	11	1.6	.000	0.41	.000	.05
January 18, 1973								
0210	18.5	740	14	1.4	.000	0.42	.002	.05
0610	20.0	765	8	0.8	.000	0.51	.004	.03
1000	19.0	810	33	3.2	.000	0.27	.000	.04

Sampling Site 8 near S-9

Time	Temp C°	Specific Cond.	Percent saturation DO	mg/l				
				DO	PO_4-P	NH_3-N	NO_2-N	NO_3-N
January 16, 1973								
1010	17.0	770	38	3.8	.000	.04	.000	.04
1400	16.5	738	72	7.1	.000	.03	.000	.00
1745	17.0	810	54	5.3	.000	.03	.000	.04
2130	16.0	785	44	4.4	.000	.04	.000	.04
January 17, 1973								
0140	15.5	785	30	3.0	.000	.06	.004	.03
0540	15.0	800	24	2.5	.000	.04	.000	.04
0933	17.0	805	28	2.8	.000	.05	.000	.05
1335	18.5	835	48	4.6	.000	.05	.002	.06
1740	18.0	815	46	4.4	.000	.04	.000	.04
2157	17.0	880	37	3.7	.000	.04	.000	.05
January 18, 1973								
0155	17.5	700	43	4.2	.000	.04	.000	.06
0545	16.0	815	19	1.9	.000	.05	.000	.05
0945	17.5	830	36	3.5	.000	.05	.000	.07

<u>Sampling Site 9 near S-9</u>

Time	Temp C°	Specific Cond.	Percent saturation DO	mg/l				
				DO	PO_4-P	NH_3-N	NO_2-N	NO_3-N
January 16, 1973								
1020	20.0	755	65	6.0	.000	.23	.010	.17
1410	17.5	855	68	6.7	.000	.19	.006	.14
1750	17.5	860	49	4.7	.000	.21	.008	.12
2135	17.5	850	48	4.6	.000	.19	.005	.11
January 17, 1973								
0144	17.0	860	60	5.9	.000	.14	.003	.11
0545	16.5	850	31	3.1	.000	.14	.002	.11
0940	17.0	890	53	5.2	.000	.13	.000	.10
1340	20.5	800	53	3.4	.000	.36	.004	.05
1740	20.5	750	37	3.1	.000	.39	.004	.04
2200	19.0	855	33	3.8	.000	.30	.000	.05
January 18, 1973								
0200	19.0	755	50	4.7	.000	.32	.000	.06
0550	18.5	770	30	3.0	---	--	---	--
0950	18.0	840	39	3.8	.000	.26	.000	.05

Sampling Site 10 near S-9

Time	Temp C^o	Specific Cond.	Percent saturation DO	mg/l				
				DO	PO_4-P	NH_3-N	NO_2-N	NO_3-N
January 16, 1973								
1030	20.0	798	63	5.8	.000	0.14	.000	.15
1415	16.5	910	68	6.8				
1800	17.5	880	53	5.1	.000	0.16	.002	.14
2137	17.0	865	54	5.3	.000	0.15	.004	.11
January 17, 1973								
0146	17.0	855	64	6.2	.000	0.14	.003	.12
0550	16.5	870	62	6.1	.000	0.13	.002	.11
0943	17.0	890	65	6.4	.000	0.12	.000	.10
1345	17.5	875	64	6.2	.000	0.14	.000	.11
1745	20.0	780	42	3.9	.000	0.33	.008	.03
2203	19.0	860	39	3.7	.000	0.29	.002	.05
January 18, 1973								
0205	18.5	805	51	4.7	.000	0.22	.000	.06
0600	17.5	790	45	4.4	.000	0.21	.000	.07
0950	18.0	850	53	5.1	.000	0.17	.000	.06

Sampling Site 11 near S-9

Time	Temp C°	Specific Cond.	Percent saturation DO	mg/l DO	mg/l PO_4-P	mg/l NH_3-N	mg/l NO_2-N	mg/l NO_3-N
January 16, 1973								
1040	20.0	780	63	5.8	.000	.17	.004	.14
1425	17.0	885	68	6.7	.000	.17	.004	.15
1605	17.0	890	51	5.0	.000	.15	.004	.14
2140	17.0	865	49	4.8	.000	.16	.004	.15
January 17, 1973								
0150	17.0	855	58	5.7	.000	.15	.003	.12
0555	16.5	865	32	3.2	.000	.14	.000	.11
0946	17.5	885	65	6.4	.000	.12	.005	.11
1350	17.5	870	54	5.3	.000	.12	.003	.10
1745	18.5	850	61	5.8	.000	.20	.002	.08
2207	19.0	870	31	3.0	.000	.34	.000	.04
January 18, 1973								
0205	18.0	790	23	2.3	.000	.24	.002	.05
0605	17.5	825	47	4.6	.000	.18	.000	.07
0955	18.0	850	47	4.5	.000	.16	.000	.07

BASIC DATA E

Diel study at 7 sampling sites near S-5A and at 2 sampling points on L-28 on September 10-12, 1973. Pumping into Area 1 occurred from about 1:00 P.M. to 3:00 P.M. on September 10 and from 4:00 P.M. to 6:00 P.M. on September 11. Specific conductance (K) in micromhos/cm at 25°C. Dissolved oxygen (DO) in mg/l.

Sampling Site 1, Above Pump Station S 5-A

Time EDST	Depth metres	Temp C^o	Specific Cond.	Percent saturation DO	mg/l DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
September 10, 1973									
	0.3	29.5	540	32	2.5	0.015	0.32	0.010	0.28
1000	1.2	29.0		28	2.2				
	1.8	29.0	1400	2	0.2	.060	1.4	.090	.33
	0.3	29.8	550	59	3.0	.015	.30	.020	.28
1230	1.2	29.0		28	2.2				
	1.8	28.0	630	3	0.3	.022	.39	.020	.30
	0.3	30.5	450	67	5.1	.012	.13	.010	.24
1600	1.2	30.0		52	4.0				
	1.8	29.5	940	42	3.3	.020	.80	.055	.28
	1.3	30.0		55	4.2	.010	.17	.000	.25
1830	1.2	29.5		52	4.0				
	1.8	29.0		11	.9	.025	1.1	.055	.30
	.3	29.0	480	59	4.6	.018	.22	.010	.24
2200	1.2	29.0		49	3.9				
	1.8	29.0	840	10	1.8	.030	.82	.047	.28
September 11, 1973									
	.3	28.0	480	57	4.5	.016	.23	.011	.24
0800	1.2	28.0		50	4.0				
	1.8	28.0	500	31	2.5	.015	.22	.010	.24

Sampling Site 1, Above Pump Station S 5-A (continued)

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	mg/l DO	mg/l PO_4 as P	mg/l NH_3 as N	mg/l NO_2 as N	mg/l NO_3 as N
September 11, 1973 (continued)									
	.3	28.5	480	40	3.2	.005	.20	.005	.24
1100	1.2	28.5		37	2.9				
	1.8	28.5	480	32	2.6	.008	.15	.003	.25
	.3	31.0	460	57	4.3	.030	.20	.000	.23
1450	1.2	31.0		54	4.2				
	1.8	31.0	460	54	4.1	.010	.20	.005	.24
	1.3	29.0	450	65	5.[illegible]	.012	.15	.000	.23
1600	1.2	29.0							
	1.8	29.0	740	54	4.3	.015	.61	.025	.25
	1.3	29.0	490	65	5.0	.006	.22	.000	.23
2130	1.2	29.0							
	1.8	29.0	595	32	2.5	.010	.42	.013	.26
September 12, 1973									
	.3	29.5	580	45	3.5	.015	.46	.006	.25
0805	1.2	29.5			3.1				
	1.8	29.3	640	15	1.2	.015	.50	.015	.27

Sampling Site 2 near S-5A

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	mg/l DO	mg/l PO_4 as P	mg/l NH_3 as N	mg/l NO_2 as N	mg/l NO_3 as N
September 10, 1973									
	0.3	27.0	970	17	1.4	.042	.57	.120	.47
0805	1.2	26.5	1140	14	1.2	.050	.52	.100	.46
	2.4	26.0	1160	4	0.4	.050	.60	.120	.45
	3.6	26.0	1140	4	.4	.052	.62	.120	.45
	.3	29.0	1100	22	1.8	.042	.46	.095	.38
1115	1.2	28.5	1080	11	.9	.042	.42	.080	.33
	2.4	28.0	1100	4	.4	.045	.48	.090	.35
	3.6	28.0	1120	3	.3	.046	.56	.120	.38
	.3	29.0	1080	23	1.9	.032	1.2	.075	.30
1450	1.2	29.0	1080	20	1.7	.030	1.4	.077	.30
	2.4	29.0	1090	20	1.7	.035	1.4	.084	.30
	3.6	29.0	1100	20	1.7	.030	1.3	.085	.29
	.3	29.0	1160	20	1.7	.032	1.6	.085	.31
1720	1.2	29.0	1160	19	1.5	.036	1.6	.081	.30
	2.4	29.0	1160	19	1.5	.022	1.6	.081	.36
	3.6	29.0	1170	17	1.3	.035	1.6	.085	.30
	.3	29.0	1180	19	1.6	.035	1.5	.092	.31
2100	1.2	29.0	1180	17	1.4	.025	1.3	.099	.30
	2.4	29.0	1180	17	1.4	.023	1.4	.095	.30
	3.6	29.0	1160	17	1.4	.040	1.5	.095	.30

Sampling Site 2 near S-5A (continued)

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	DO (mg/l)	PO_4 as P (mg/l)	NH_3 as N (mg/l)	NO_2 as N (mg/l)	NO_3 as N (mg/l)
September 11, 1973									
	.3	29.0	1200	15	1.2	.030	1.2	.098	.30
0650	1.2	29.0	1200	13	1.1	.036	1.3	.090	.30
	2.4	29.0	1200	13	1.1	.035	1.3	.092	.31
	3.6	29.0	1200	13	1.1	.035	1.3	.095	.30
	.3	28.5	1230	12	1.0	.036	1.1	.097	.29
1000	1.2	28.5	1240	11	.9	.034	1.1	.098	.30
	2.4	28.5	1240	11	.9	.032	1.0	.095	.29
	3.6	28.0	1230	9	.8	.040	.98	.094	.29
	.3	29.0	1180	17	1.4	.030	1.0	.085	.30
1325	1.2	29.0	1220	15	1.2	.035	1.0	.080	.32
	2.4	28.8	1220	12	1.0	.032	1.0	.080	.30
	3.6	28.5	1220	11	.9	.035	.99	.082	.31
	0.3	28.8	1160	22	1.8	.020	1.5	.090	.24
1550	1.2	28.8	1160	22	1.8	.020	1.4	.091	.25
	2.4	29.0	1200	22	1.8	.022	1.6	.096	.25
	3.6	29.0	1190	20	1.6	.020	1.2	.089	.25
	0.3	29.5	1180	21	1.7	.018	1.1	.075	.28
2135	1.2	29.4	1230	21	1.7	.013	1.2	.087	.27
	2.4	29.2	1260	18	1.4	.019	1.4	.087	.27
	3.6	29.2	1260	18	1.4	.020	1.4	.088	.26

Sampling Site 2 near S-5A (continued)

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	mg/1 DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
September 12, 1973									
	0.3	29.8	1080	26	2.0	.032	1.0	.070	.28
0645	1.2	29.8	1080	20	1.6	.026	.90	.069	.27
	2.4	29.8	1080	20	1.6	.016	.97	.062	.30
	3.6	29.8	1105	11	1.4	.035	.94	.070	.27

Sampling Site 3 near S-5A

Time EDST	Depth metres	Temp C^o	Specific Cond.	Percent saturation DO	mg/l				
					DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
September 10, 1973									
0900	0.3	27.0	1100	17	1.4	0.050	0.53	0.100	0.44
	1.2	26.5		13	1.1				
	2.4	26.5	1120	3	0.3	.050	.62	.110	.45
1200	0.3	30.0	1060	33	2.6	.091	.43	.100	.41
	1.2	28.5		13	1.1				
	2.4	28.0	1080	2	.2	.049	.57	.100	.41
1610	0.3	30.0	1220	25	1.9	.035	1.4	.082	.31
	1.2	29.5		20	1.6				
	2.4	29.5	1110	18	1.4	.032	1.3	.081	.32
	3.0	29.5		18	1.4				
1815	0.3	29.0	1240	24	1.9	.032	1.3	.081	.32
	1.2	29.0		19	1.5				
	2.4	29.0	1240	14	1.2	.032	1.5	.081	.31
	3.0	29.0		14	1.2				
2150	0.3	29.0	1220	20	1.6	.030	1.2	.085	.28
	1.2	29.0		19	1.5				
	2.4	29.0	1220	18	1.4	.030	1.2	.085	.28
	3.0	29.0							

Sampling Site 3 near S-5A (continued)

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	DO (mg/l)	PO_4 as P (mg/l)	NH_3 as N (mg/l)	NO_2 as N (mg/l)	NO_3 as N (mg/l)
September 11, 1973									
	0.3	29.0	1160	21	1.7	.030	1.2	.095	.27
0635	1.2	29.0		17	1.4				
	2.4	29.0	1160	16	1.3	.036	1.3	.080	.28
	3.0	29.0		16	1.3				
	0.3	28.5	1210	20	1.6	.030	1.1	.094	.27
1050	1.2	28.5		14	1.2				
	2.4	28.0	1210	10	0.9	.026	1.1	.095	.27
	3.0	28.0		10	0.9				
	0.3	29.0	1240	26	2.1	.035	1.1	.082	.28
1425	1.2	29.4		22	1.8				
	2.4	29.0	1240	20	1.6	.039	1.1	.090	.28
	3.0	29.0		14	1.2				
	0.3	29.8	960	35	2.7	.022	.95	.060	.28
1650	1.2	29.8		32	2.5				
	2.4	29.8	1105	28	2.2	.018	1.0	.065	.28
	3.0	29.6		27	2.1				
	0.3	29.0	1260	18	1.4	.020	1.3	.088	.27
2215	1.2	29.0		15	1.3				
	2.4	29.0	1260	15	1.3	.016	1.3	.088	.27
	3.0	29.0		15	1.3				

Sampling Site 3 near S-5A (continued)

Time EDST	Depth metres	Temp C^o	Specific Cond.	Percent saturation DO	mg/l DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
September 12, 1973									
	0.3	29.0	1220	18	1.4	.030	1.0	.081	.25
0745	1.2	29.0		15	1.3				
	2.4	29.0	1120	15	1.3	.032	1.1	.070	.26
	3.0	29.0		15	1.3				

Sampling Site 4 near S-5A

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	DO	mg/l PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
September 10, 1973									
	0.3	27.0	1100	20	1.7	.042	.40	.062	.31
0822	1.2	27.0		8	0.7				
	2.4	26.5	1080	2	.2	.043	.56	.100	.36
	3.0	26.5		1	.1				
	0.3	29.0	1100	26	2.0	.041	.38	.069	.29
1130	1.2	28.5		15	1.2				
	2.4	28.0	1080	3	.3	.041	.40	.080	.28
	3.0	28.0		1	.1				
	0.3	29.0	1280	21	1.7	.030	1.5	.084	.34
1505	1.2	29.0		17	1.4				
	2.4	29.0	1360	15	1.3	.035	1.4	.086	.33
	3.0	29.0		13	1.0				
	0.3	30.0	1180	28	2.2	.035	1.1	.079	.33
1730	1.2	29.5		23	1.8				
	2.4	29.0	1240	13	1.1	.038	1.5	.081	.30
	3.0	29.0		13	1.1				
	0.3	29.0	1240	16	1.3	.034	1.2	.075	.29
2110	1.2	29.0		15	1.2				
	2.4	29.0	1220	13	1.0	.030	1.2	.084	.30
	3.0	29.0		9	.8				

Sampling Site 4 near S-5A (continued)

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	mg/l DO	mg/l PO_4 as P	mg/l NH_3 as N	mg/l NO_2 as N	mg/l NO_3 as N
September 11, 1973									
	0.3	29.0	1100	13	1.1	.046	.60	.075	.27
0700	1.2	29.0		13	1.1				
	2.4	29.0	1100	10	.9	.042	.55	.072	.27
	3.0	29.0		10	.9				
	0.3	28.5	1080	13	1.1	.040	.42	.090	.25
1015	1.2	28.0		10	0.9				
	2.4	28.0	1080	9	.8	.038	.42	.040	.29
	3.0	28.0		2	.2				
	0.3	30.0	1140	30	2.4	.043	.70	.085	.28
1340	1.2	29.0		23	1.8				
	2.4	29.0	1110	13	1.0	.041	.60	.080	.27
	3.0	28.5		7	.6				
	0.3	29.0	1100	21	1.7	.034	.98	.077	.26
1605	1.2	29.0		20	1.6				
	2.4	29.0	1140	19	1.5	.025	1.0	.082	.26
	3.0	28.8		16	1.3				
	0.3	29.2	980	24	1.9	.020	.75	.052	.26
2145	1.2	29.1		20	1.6				
	2.4	29.1	1100	19	1.5	.026	.95	.069	.27
	3.0	29.1		17	1.3				

Sampling Site 4 near S-5A (continued)

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	mg/l DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
September 12, 1973									
		29.8	1020	18	1.4	.045	.42	.050	.22
0655		29.8		15	1.2				
		29.8	1050	15	1.2	.045	.40	.069	.20
		29.8		14	1.1				

Sampling Site 5 near S-5A

Time EDST	Depth metres	Temp C^o	Specific Cond.	Percent saturation DO	mg/l				
					DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
September 18, 1973									
0832	0.3	27.0	960	10	0.9	.040	.40	.060	.24
	1.2	26.5		7	.7				
	2.4	26.0	1120	4	.4	.050	.40	.058	.26
	3.0	26.0		3	.3				
1140	0.3	29.0	1020	24	1.9	.043	.38	.058	.21
	1.2	29.0		11	.9	.043	.37	.046	.23
	2.4	28.0	1020	4	.4	.043	.36	.060	.20
	3.0	28.0	1060	2	.2	.043	.50	.100	.30
1520	0.3	29.0	950	21	1.7	.050	.47	.085	.32
	1.2	29.0	1060	16	1.3	.049	.46	.082	.32
	2.4	29.0	1060	9	.8	.046	.75	.083	.32
	3.0	28.5	1060	8	.7	.049	.47	.080	.30
1740	0.3	29.0	1100	20	1.7	.045	.62	.075	.30
	1.2	29.0		17	1.4				
	2.4	29.0	1100	10	.9	.046	.64	.081	.30
	3.0	29.0		9	.8				
2120	0.3	29.0	1040	19	1.5	.042	.40	.067	.26
	1.2	29.0		17	1.4				
	2.4	29.0	1040	16	1.3	.049	.42	.073	.26
	3.0	29.0		13	1.1				

Sampling Site 5 near S-5A (continued)

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	mg/l				
					DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
September 11, 1973									
	0.3	29.0	1020	15	1.2	.045	.38	.063	.22
0710	1.2	29.0	1020	14	1.1	.045	.38	.063	.22
	2.4	29.0	1030	14	1.1	.041	.37	.062	.21
	3.0	29.0		12	1.0				
	0.3	28.5	1020	17	1.4	.040	.30	.031	.23
1025	1.2	28.5	1040	14	1.1	.040	.30	.031	.23
	2.4	28.0	1050	12	1.0	.042	.30	.030	.23
	3.0	28.0	1040	10	.9	.042	.35	.026	.22
	0.3	29.5	1040	32	2.5	.042	.40	.060	.21
1400	1.2	29.5		17	1.4				
	2.4	28.5	1040	12	1.0	.040	.40	.058	.21
	3.0	28.5		7	.6				
	0.3	30.0		32	2.4	.035	.70	.063	.26
1625	1.2	29.8		27	2.1				
	2.4	29.5	1010	21	1.7	.038	.75	.070	.26
	3.0	29.5		21	1.7				
	0.3	29.2	1040	16	1.3	.036	.40	.056	.23
2200	1.2	29.2		16	1.3				
	2.4	29.2	1040	16	1.3	.036	.40	.050	.22
	3.0	29.0		15	1.2				

Sampling Site 5 near S-5A (continued)

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	mg/l DO	mg/l PO_4 as P	mg/l NH_3 as N	mg/l NO_2 as N	mg/l NO_3 as N
September 12, 1973									
	0.3	29.5	1020	16	1.3	.050	.43	.031	.16
0710	1.2	29.5	1020	16	1.3	.046	.40	.034	.17
	2.4	29.5	1020	16	1.3	.049	.40	.040	.16
	3.0	29.5	1005	16	1.3	.055	.44	.019	.34

Sampling Site 6 near S-5A

Time EDST	Depth metres	Temp C^o	Specific Cond.	Percent saturation DO	mg/l DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
September 10, 1973									
0840	0.3	26.0	780	5	0.5	.032	.30	.000	.00
1155	.3	29.0	850	28	2.2	.025	.32	.012	.00
1530	.3	30.5		29	2.2	.040	.35	.055	.22
1750	.3	29.0	955	7	0.6	.025	.31	.013	.01
2125		28.8	780	7	0.6	.025	.30	.013	.03
September 11, 1973									
0725	.3	28.0	900	7	0.6	.030	.30	.030	.08
1030	.3	27.0	740	5	0.5	.012	.18	.005	.00
1410	.3	31.0	970	29	2.2				
1630	.3	29.3	970	20	1.6	.030	.03	.042	.18
2205	.3	28.7	895	17	1.4	.015	.30	.013	.09
September 12, 1973									
0715	.3	29.0	995	8	0.7	.040	.41	.038	.13

Sampling Site 7 near S-5A

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	DO (mg/l)	PO_4 as P (mg/l)	NH_3 as N (mg/l)	NO_2 as N (mg/l)	NO_3 as N (mg/l)
September 10, 1973									
1540	0.3	29.5	1040	19	1.5	.045	.43	.067	.21
	1.2	29.0		15	1.2				
	2.4	29.0		7	0.6	.045	.41	.067	.21
	3.0	28.5		4					
1800	0.3	29.5	1000	19	1.5	.044	.39	.055	.22
	1.2	29.5		19	1.5				
	2.4	29.0	1020	15	1.2	.045	.41	.060	.20
	3.0	29.0		10	.9				
2135	0.3	29.0	1000	19	1.5	.045	.38	.055	.18
	1.2	29.0		16	1.3				
	2.4	29.0	1000	16	1.3	.042	.35	.050	.20
	3.0	29.0		15	1.2				
September 11, 1973									
0730	0.3	28.0	1050	12	1.0	.052	.40	.050	.13
	1.2	28.0		9	.8				
	2.4	28.0	1000	9	.8	.055	.38	.047	.14
	3.0	28.0		7	.6				
1040	0.3	28.0	1020	15	1.3	.043	.30	.025	.15
	1.2	28.0		10	.9				
	2.4	28.0	1040	8	.7	.043	.30	.025	.16
	3.0	28.0		7	.6				

Sampling Site 7 near S-5A (continued)

Time EDST	Depth metres	Temp C°	Specific Cond.	Percent saturation DO	DO	PO_4 as P (mg/l)	NH_3 as N (mg/l)	NO_2 as N (mg/l)	NO_3 as N (mg/l)
September 11, 1973 (continued)									
	0.3	29.0	1000	26	2.[illegible]	.045	.40	.040	.16
1410	1.2	29.4		18	1.4				
	2.4	28.5	1000	10	.9	.049	.40	.040	.15
	3.0	28.4		5	.5				
	0.3	29.5	1020	25	2.0	.040	.40	.050	.18
1640	1.2	29.4		25	2.0				
	2.4	29.2	1000	20	1.7	.046	.42	.051	.23
	3.0	29.2		20	1.7				
	0.3	29.1	1020	20	1.6	.050	.96	.038	.16
2205	1.2	29.1		19	1.5				
	2.4	29.0	1000	19	1.5	.045	.38	.025	.18
	3.0	29.0		19	1.5				
September 12, 1973									
	0.3	29.2	990	15	1.2	.038	.40	.025	.10
0725	1.2	29.2		15	1.2				
	2.4	29.5	990	15	1.2	.050	.37	.012	.11
	3.0	29.2		15	1.2				

Sampling Site, West Canal, L-28

Time EDST	Depth metres	Temp C°	Percent satura- tion DO	DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
				mg/1				
September 10, 1973								
1005	Surface	30.0	43	3.3	.005	.15	.000	.00
	0.3	30.0		-				
	0.6	30.0		-				
	0.9	30.0	43	3.3	.006	.12	.000	.00
	1.2	30.0	37	2.9				
	1.5	30.0	33	2.6				
	1.8	30.0		-	.003	.13	.000	.00
	2.1	30.0		-				
1415	Surface	32.0	72	5.3				
	0.3	32.0	65	4.9				
	.6	31.5	62	4.6				
	.9	31.0	62	4.6				
	1.2	29.0	50	3.9				
	1.5	29.0	31	2.4				
	1.8	29.0	30	2.3				
	2.1	29.0	29	2.2				
1615	Surface	32.5	73	5.3	.001	.15	.000	.00
	0.3	32.3	70	5.1				
	.6	32.1	68	5.0				
	.9	32.0	66	4.9	.004	.12	.000	.00
	1.2	31.0	54	4.1				
	1.5	29.3	41	3.2				
	1.8	29.2	32	2.5	.001	.17	.000	.00
	2.1	29.2	25	2.0				

Sampling Site, West Canal, L-28 (continued)

Time EDST	Depth metres	Temp C°	Percent saturation DO	mg/l DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
1905	Surface	32.2	60	4.4				
	0.3	32.2	59	4.3				
	.6	32.2	59	4.3				
	.9	32.1	60	4.4				
	1.2	32.0	60	4.4				
	1.5	32.0	56	4.1				
	1.8	29.8	32	2.5				
	2.1	29.0	21	1.7				
2200	Surface	31.0	42	3.2				
	0.3	31.0	42	3.2				
	0.6	31.0	42	3.2				
	.9	30.9	42	3.2				
	1.2	30.5	41	3.1				
	1.5	30.0	40	3.1				
	1.8	29.2	24	1.9				
	2.1	28.5	13	1.0				
September 11, 1973								
0100	Surface	30.3	36	2.8				
	0.3	30.3	36	2.8				
	.6	30.1	36	2.8				
	.9	30.1	36	2.8				
	1.2	30.0	35	2.7				
	1.5	29.8	33	2.6				
	1.8	29.0	20	1.6				
	2.1	28.5	8	0.7				

Sampling Site, West Canal, L-28 (continued)

Time EDST	Depth metres	Temp C°	Percent saturation DO	mg/l DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
0430	Surface	29.8	34	2.7				
	0.3	29.8	34	2.7				
	.6	29.7	33	2.6				
	.9	29.5	33	2.6				
	1.2	29.5	33	2.6				
	1.5	29.5	33	2.6				
	1.8	29.0	32	2.5				
	2.1	29.0	14	1.6				
0700	Surface	29.1	29	2.3	.002	.21	.000	.01
	0.3	29.1	29	2.3				
	.6	29.1	29	2.3				
	.9	29.1	27	2.2	.003	.17	.000	.00
	1.2	29.0	27	2.2				
	1.5	29.0	27	2.3				
	1.8	29.0	27	2.3	.002	.20	.000	.00
	2.1	29.0	25	2.0				

Sampling Site, East Canal, L-28

Time EDST	Depth metres	Temp C^o	Percent saturation DO	mg/l DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
September 10, 1973								
1015	Surface	31.0	53	4.0	.005	.12	.000	.00
	0.3	30.5	46	3.5				
	.6	30.5	42	3.2				
	.9	30.0	40	3.1	.003	.11	.000	.00
	1.2	30.0	42	3.3				
	1.5	30.0	44	3.4				
	1.8	30.0	44	3.4	.005	.16	.000	.00
	2.1	30.0	44	3.4				
1400	Surface	32.0	62	4.6				
	0.3	32.0	55	4.1				
	.6	32.0	48	3.5				
	.9	31.5	45	3.4				
	1.2	31.0	54	4.2				
	1.5	30.5	53	4.0				
	1.8	30.2	34	2.7				
	2.1	-	-	3.6				
1600	Surface	31.0	75	5.7	.005	.12	.000	.00
	0.3	31.0	45	3.4				
	.6	31.0	45	3.4				
	.9	30.5	44	3.4	.002	.15	.000	.00
	1.2	30.0	45	3.5				
	1.5	30.0	51	3.9				
	1.8	30.0	53	4.1	.003	.10	.000	.00
	2.1	30.0	43	3.3				

Sampling Site, East Canal, L-28 (continued)

Time EDST	Depth metres	Temp C°	Percent saturation DO	mg/l				
				DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
September 10, 1973 (continued)								
1900	Surface	30.4	52	4.0				
	0.3	30.4	48	3.7				
	0.6	30.4	47	3.6				
	.9	30.2	43	3.3				
	1.2	30.2	42	3.2				
	1.5	30.0	39	3.0				
	1.8	30.0	44	3.4				
	2.1	30.0	42	3.2				
2200	Surface	30.5	53	4.1				
	.3	30.5	50	3.8				
	.6	30.3	50	3.8				
	.9	30.3	50	3.9				
	1.2	30.1	51	4.0				
	1.5	30.1	51	4.0				
	1.8	30.0	43	3.3				
	2.1	30.0	31	2.4				
September 11, 1973								
0100	Surface	30.2	44	3.4				
	0.3	30.2	44	3.4				
	.6	30.1	42	3.3				
	.9	30.0	42	3.2				
	1.2	30.0	42	3.2				
	1.5	30.0	36	2.8				
	1.8	30.0	33	2.6				
	2.1	29.8	30	2.4				

Time EDST	Depth metres	Temp C^o	Percent saturation DO	mg/l				
				DO	PO_4 as P	NH_3 as N	NO_2 as N	NO_3 as N
September 11, 1973 (continued)								
0415	Surface	30.4	38	3.0				
	0.3	30.4	38	3.0				
	.6	30.4	38	3.0				
	.9	30.2	38	3.0				
	1.2	30.2	38	3.0				
	1.5	30.0	34	2.7				
	1.8	30.0	34	2.7				
	2.1	29.0	26	2.1				
0715	Surface	30.0	35	2.7	.002	.17	.000	.00
	0.3	30.0	36	2.8				
	.6	30.0	36	2.8				
	.9	30.0	33	2.6	.006	.12	.000	.00
	1.2	30.0	33	2.6				
	1.5	29.9	33	2.6				
	1.8	29.8	30	2.4	.006	.12	.000	.00
	2.1	29.8	27	2.1				

BASIC DATA F

Vegetative quadrats in Conservation Area 1, November 13-14, 1973.

Vegetative Quadrat Data for Conservation Area 1, 13-14 Nov. 1973

Site 1 - One and one-half miles southeast of Pump Station S-5A. Marsh adjacent to and west of Levee 40 Canal.

Approximate percent of plants on a wet weight basis.

Quadrat No.	Water Depth	Periphyton	Algal mat	Pithophora	Lemna Minor	Salvinia rotundifolia	Hydrilla verticillata	Alternanthera philoxeroides	Najas quadalupensis	Ceratophyllum demersum	Pistia stratioites	Eichhornia crassipes	Pontederia lanceolata	Typha latifolia	Phragmites communis	Panicum hemitomon	Total Wet Weight gram	Total Dry Weight gram
1	0.76m	-	-	10	<1	-	22	5	2	10	-	-	-	-	50	-	6971	572
2	.76	-	<1	10	<1	-	75	1	2	4	-	-	-	-	7	-	7771	587
3	.82	-	<1	-	-	-	33	<1	33	33	-	-	-	-	-	-	485	37
4	.79	-	10	-	9	-	36	-	36	5	-	-	-	-	2	-	5200	367
5	.64	-	<1	-	-	-	5	80	15	-	-	-	-	-	-	-	3657	318
6	.61	-	-	-	8	-	1	20	1	1	2	-	-	67	-	-	12890	1110
7	.62	-	-	-	1	-	-	16	-	1	-	-	-	82	-	-	14660	1470
8	.59	-	-	-	-	-	-	5	-	-	-	-	90	-	5	-	23600	2400

Vegetative Quadrat Data for Conservation Area 1, 13-14 Nov. 1973
Site 2 - Two and one-half miles southeast of Pump Station S-5A.
Marsh adjacent to and west of Levee 40 Canal.

Approximate percent of plants on a wet weight basis.

Quadrat No.	Water Depth	Periphyton	Algal mat	Pithophora	Lemna Minor	Salvinia rotundifolia	Hydrilla verticillata	Alternanthera philoxeroides	Najas guadalupensis	Ceratophyllum demersum	Pistia stratioites	Eichhornia crassipes	Pontederia lanccolata	Typha latifolia	Phragmites communis	Panicum hemitomon	Total Wet Weight	Total Dry Weight
I	0.66M	_	2	-	-	-	80	-	5	-	10	2	-	-	-	-	8171gm	502gm
2	.65	-	20	-	-	-	30	-	-	-	10	-	-	-	-	40	414	48
3	.62	-	30	-	1	-	18	50	-	-	1	-	-	-	-	-	397	430
4	.66	-	2	-	<1	<1	95	-	-	-	2	-	-	-	-	-	10510	670
5	.70	1	93	-	<1	-	2	1	-	-	2	-	-	-	-	-	1830	92
6	.62	-	1	-	-	-	-	1	-	1	1	-	-	96	-	-	20943	2090
7	.72	-	1	-	-	-	-	1	-	1	5	-	-	92	-	-	16700	1670
8	.66	-	4	-	-	-	-	-	-	-	16	-	-	-	-	86	10040	2231

Vegetative Quadrat Data for Conservation Area 1, 13-14 Nov. 1973
Site 3 - near barrel A-3. Approximately three and one-half miles southwest of Loxahatchee National Wildlife Refuge Headquarters.

Quadrat No.	Water Depth	Periphyton	Chara sp.	Salvinia rotundifolia	Utricularia	Nymphoides aquatica	Crinum americanum	Nymphaea odorata	Peltandra virginica	Eriocaulon compressum	Pontederia lanceolata	Typha latifolia	Eleocharis equisetoides	Rhynchospora tracyii	Panicum hemitomon	Total Wet Weight	Total Dry Weight
		Approximate percent of plants on a wet weight basis.														gm	gm
1	.76m	-	1	-	2	-	-	93	-	-	-	-	3	1	-	2357	287
2	.67	-	1	-	1	-	-	95	-	-	-	-	3	-	-	9257	619
3	.58	1	-	-	-	1	-	2	-	1	-	-	1	93	1	15260	1300
4	.56	1	-	-	1	-	-	2	-	2	-	-	-	93	1	20830	1780
5	.64	2	-	-	15	2	2	2	-	1	-	-	50	25	1	12260	226
6	.67	20	-	-	20	-	-	2	1	5	-	-	40	10	2	8800	880

Vegetative Quadrat Data for Conservation Area 1, 13-14 Nov. 1973
Site 4 - Near Edgar's Island. Approximately 5 miles southwest of Loxahatchee National Wildlife Refuge Headquarters.

Quadrat No.	Water Depth	Periphyton	Chara sp.	Salvinia rotundifolia	Utricularia	Nymphoides aquatica	Crinum americanum	Nymphaea odorata	Peltandra virginica	Piperwort	Pontederia lanceolata	Typha latifolia	Eleocharis equisetoides	Rhynchospora tracyi	Paspalidium paludivagum	Total Wet Weight	Total Dry Weight
		Approximate percent of plants on a wet weight basis.														gm	gm
1	.82m	-	-	<1	<1	-	-	17	-	-	64	18	-	-	<1	17770	1770
2	.82	-	-	1	-	-	-	-	-	-	63	31	5	-	1	25410	2540