SOUTH FLORIDA RESEARCH CENTER

Report SFRC-83/06 Mowry Canal (C-103): Water Quality and Discharge into Biscayne Bay, Florida, 1975-1981

NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR

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Mowry Canal (C-103): Water Quality and Discharge into Biscayne Bay, Florida, 1975-1981

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INTRODUCTION

The Mowry Canal (C-103) is located on the lower east coast of Florida approximately 25 miles south of Miami. Because of its location, it plays an important role in both flood protection and the salt water intrusion control network of southern Dade County (Fig. 1).

The Mowry Canal is of special interest to Biscayne National Park because its annual discharge is generally the greatest of the three major water management canals that discharge into southern Biscayne Bay (Fig. 2). Mean annual discharges for water-years 1975-1980 (Oct 1 - Sep 30) were recorded as 162,234 acre-feet for the Mowry Canal, 137,731 acre-feet for the Snapper Creek Canal (C-2), and 106,584 acre-feet for the Black Creek Canal (C-1) (WY 1978 is omitted since discharge data for that year are not available for the Black Creek Canal). Typically, the combined discharge from these three canals was greater than 400,000 acre-feet per year during the period of this study.

The objectives of this report are to assess the water quality of the Mowry Canal and to quantify its freshwater discharge into Biscayne Bay. This study provides necessary groundwork for future studies designed to assess the impact of freshwater discharge on the marine habitat of the Biscayne Bay portion of Biscayne National Park.

To accomplish the above mentioned objectives this study analyzed available water quality data from county and federal networks for the period 1974-1981. Trends in water quality parameters are further related to 1980 Mowry Canal basin land use data provided by the Metropolitan Dade County Planning Department. The relationship between rainfall in the Mowry Canal basin and discharge from this canal to Biscayne Bay is also discussed.

Basin Description

The Mowry Canal is located in southern Dade County near Homestead, Florida. Its major branch, C-103, extends approximately 18.6 miles from the L-31N canal east and south to Biscayne Bay where it discharges just north of Convoy Point (Fig. 3). C-103S is a 2.3 mile section extending south from C-103 between Homestead and Florida City. A second extension, C-103N, extends 6.2 miles north and west from the main branch.

The 27.1 mile Mowry Canal system drains a 49.3 square mile basin, roughly bounded on the west by the L-31N Canal, on the east by SW 137th Avenue and Homestead Air Force Base, on the north by SW 200th Street, and on the south by SW 328th Street.

Agriculture accounts for 51.5 percent of land use in the Mowry Canal basin, with 22.3 percent of the basin in vegetables or row and field crops, 20.2 percent of the basin in groves, 2.3 percent occupied by plant nurseries, and other agricultural uses accounting for 6.7 percent of the basin land use. Residential uses contribute 14.9 percent of basin land use, of which 11.7 percent is single family housing with 3.2 percent representing other residential uses. Seventeen point seven percent of

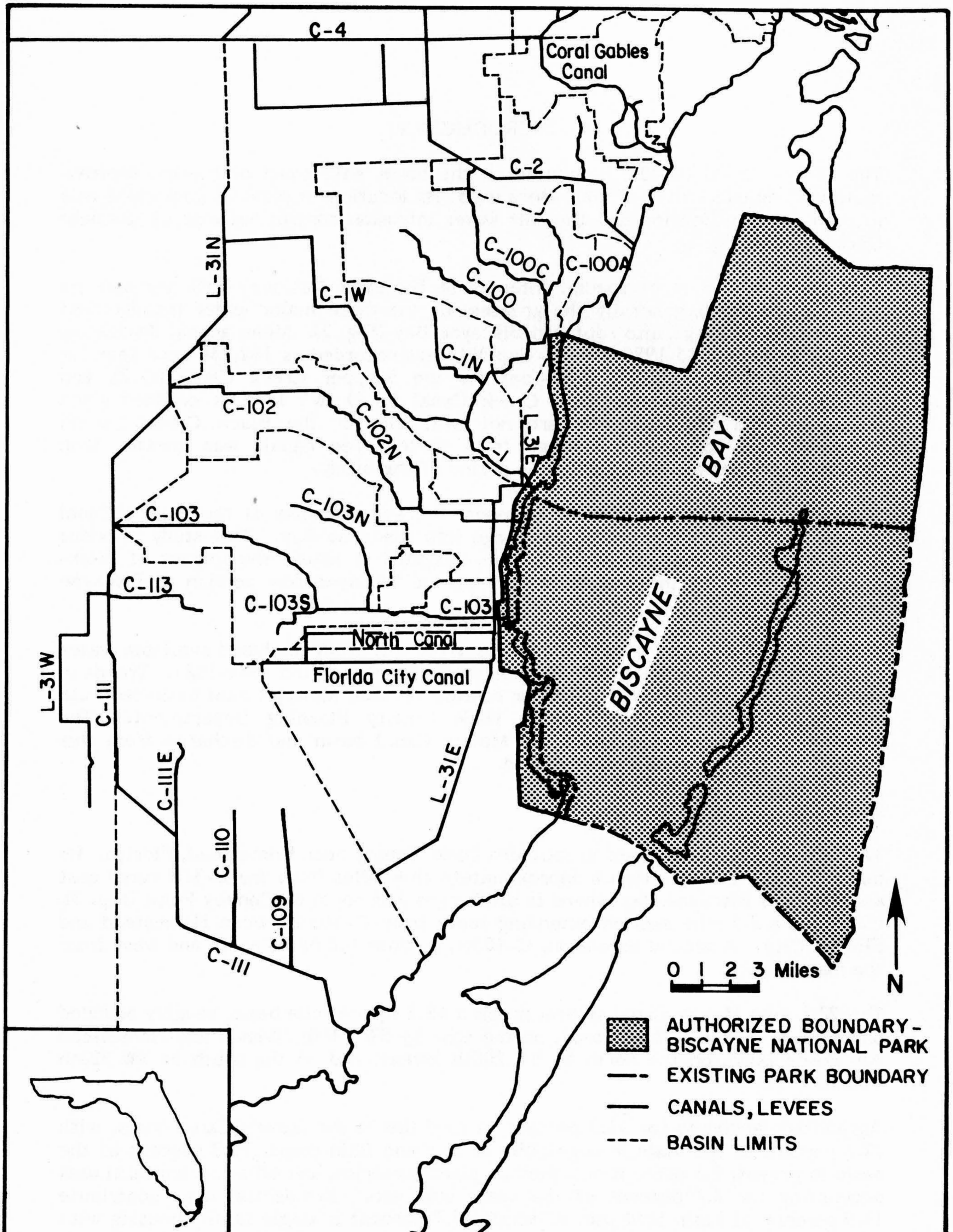

Figure 1. Major canals and canal basin delineations for southeastern Dade County, Florida.

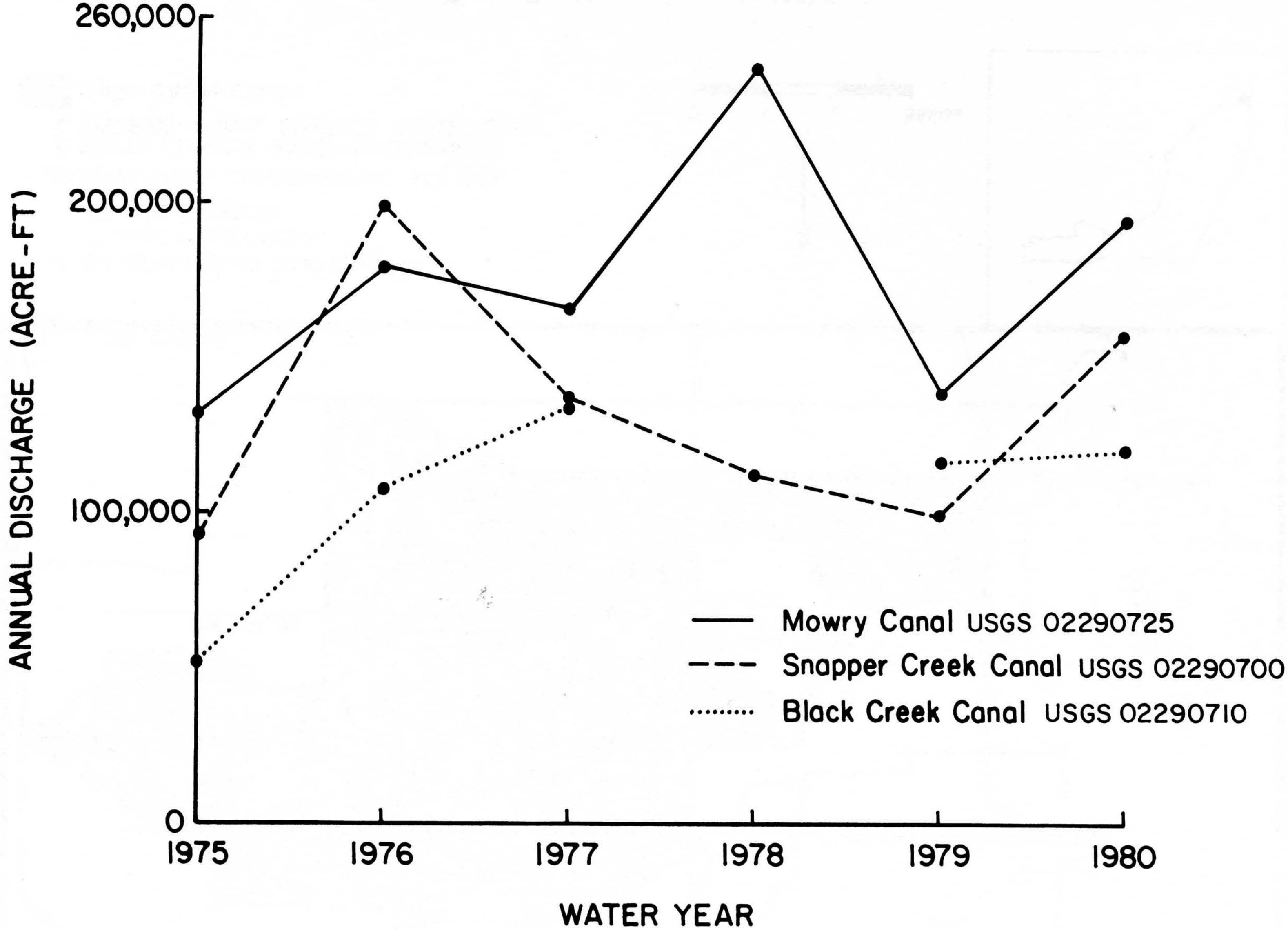

Figure 2. Annual discharge from Mowry Canal, Snapper Creek Canal, and Black Creek Canal for water years 1975-1980.

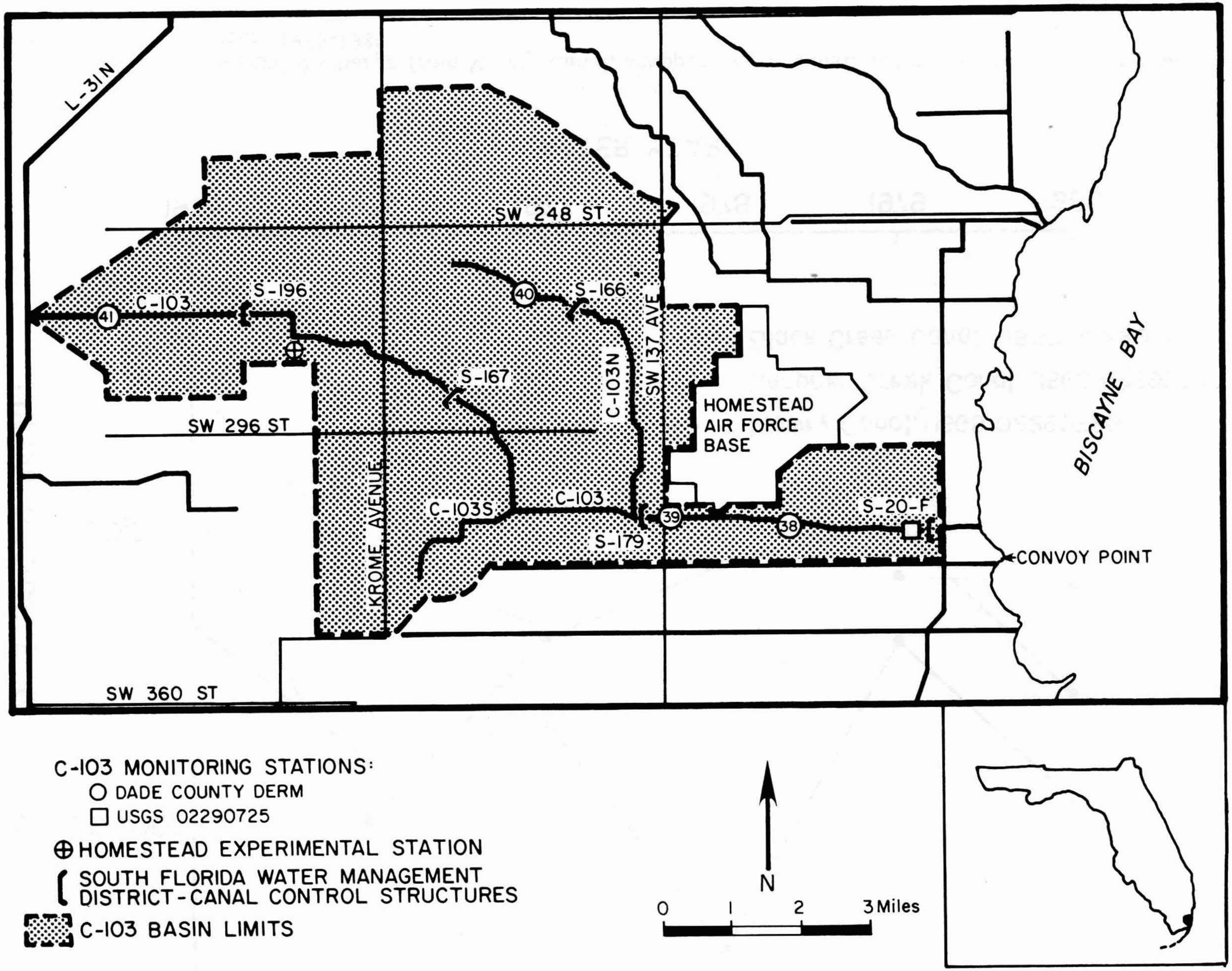

Figure 3. The Mowry Canal (C-103) Basin.

the basin is undeveloped; transportation, communication, and utilities together account for 9.1 percent; and the remaining 6.8 percent of the basin land use is divided among parks and open space, inland water, and commercial, industrial, and institutional uses (Table 1).

The South Florida Water Management District operates five control structures in the Mowry Canal system. Control structures 20 F, 166, 167, and 179 are reinforced-concrete, U-shaped spillways provided with vertical gates installed on crests of trapezoidal weirs. These structures are operated by automatic controls with opening and closing determined by headwater elevation. All are located on the major branch of C-103, except S-166 which is located on C-103N (Fig. 3). Their function is to maintain water level control in C-103 and C-103N. Control structure 196 is a gated concrete culvert near the western end of C-103 which is operated manually. It controls water flow to the east when required. S-20F, located near the Mowry Canal mouth, helps to maintain salinity control for the system.

Rainfall - Discharge Analysis

Monthly rainfall in the Mowry Canal basin is represented by rainfall at the Homestead Experiment Station (NOAA 1975-1981) (Fig. 4). Monthly rainfall for water-years 1975-1981 ranges from a low of 0.12 inches in April of 1975 to a high of 27.3 inches (associated with Tropical Storm Dennis) in August 1981. Mean monthly rainfall for the period of study (Fig. 5a) indicates that August is the wettest month with a seven-year monthly mean of 12.4 inches, followed by September, May, and June with means of 11.6 inches, 8.9 inches, and 8.6 inches, respectively. The driest month was March, with a seven-year monthly mean of only 1.2 inches, followed by January, December, and November with means of 1.4 inches, 1.9 inches, and 2.6 inches, respectively. Annual rainfall measurements range from a low of 49.6 inches in water-year 1975 to 81.0 inches in water-year 1981 (Fig. 6).

Discharge data were collected at a United States Geological Survey (USGS) continuous monitoring station, USGS 02290725, located near the Mowry Canal mouth. Monthly discharge (Fig. 4) from water-year 1975 through water-year 1981 ranged from zero, occurring 10 times, to 54,650 acre-feet, associated with Tropical Storm Dennis in August of 1981. September was the month with the greatest mean monthly discharge (29,882 acre-feet), followed by August, October, and June with seven-year mean monthly discharges of 26,278 acre-feet, 21,855 acre-feet, and 19,929 acre-feet, respectively (Fig. 5b). The lowest mean monthly discharge occurred in April with a seven-year monthly mean of 4,042 acre-feet, followed by March, February, and January with means of 4,875 acre-feet, 7,434 acre-feet, and 8,403 acre-feet, respectively. Annual discharge ranged from a minimum of 131,792 acre-feet in water-year 1975 to a maximum of 243,250 acre-feet in water-year 1978 (Fig. 6).

A positive relationship between rainfall and discharge is suggested by monthly, mean monthly, and annual measurements. Correlation coefficients were computed by the least-squares method to determine the strength of the relationship between rainfall within the Mowry Canal basin and discharge from the Mowry Canal. Analysis between mean monthly rainfall at Homestead Experimental Station and

Table 1. Land use in the Mowry Canal (C-103) Basin.

Land Use	Percent of Canal Basin		Acreage	
Agriculture	51.5		16,274.5	
Row and field crops, vegetables		22.3		7,055.4
Groves		20.2		6,380.5
Pland nursery		2.3		728.6
Other agriculture		6.7		2,110.0
Undeveloped	17.7		5,582.5	
Residential	14.9		4,683.7	
Single family		11.7		3,680.7
Other residential		3.2		1,003.0
Transportation, communication, and utilities	9.1		2,863.8	
Inland water	2.2		684.4	
Commercial and industrial	1.8		580.3	
Parks and open space	1.8		555.1	
Institutional	1.0		315.3	
Total	100.0		31,539.6	

Compiled from 1980 land use information provided by the Metropolitan Dade County Planning Department.

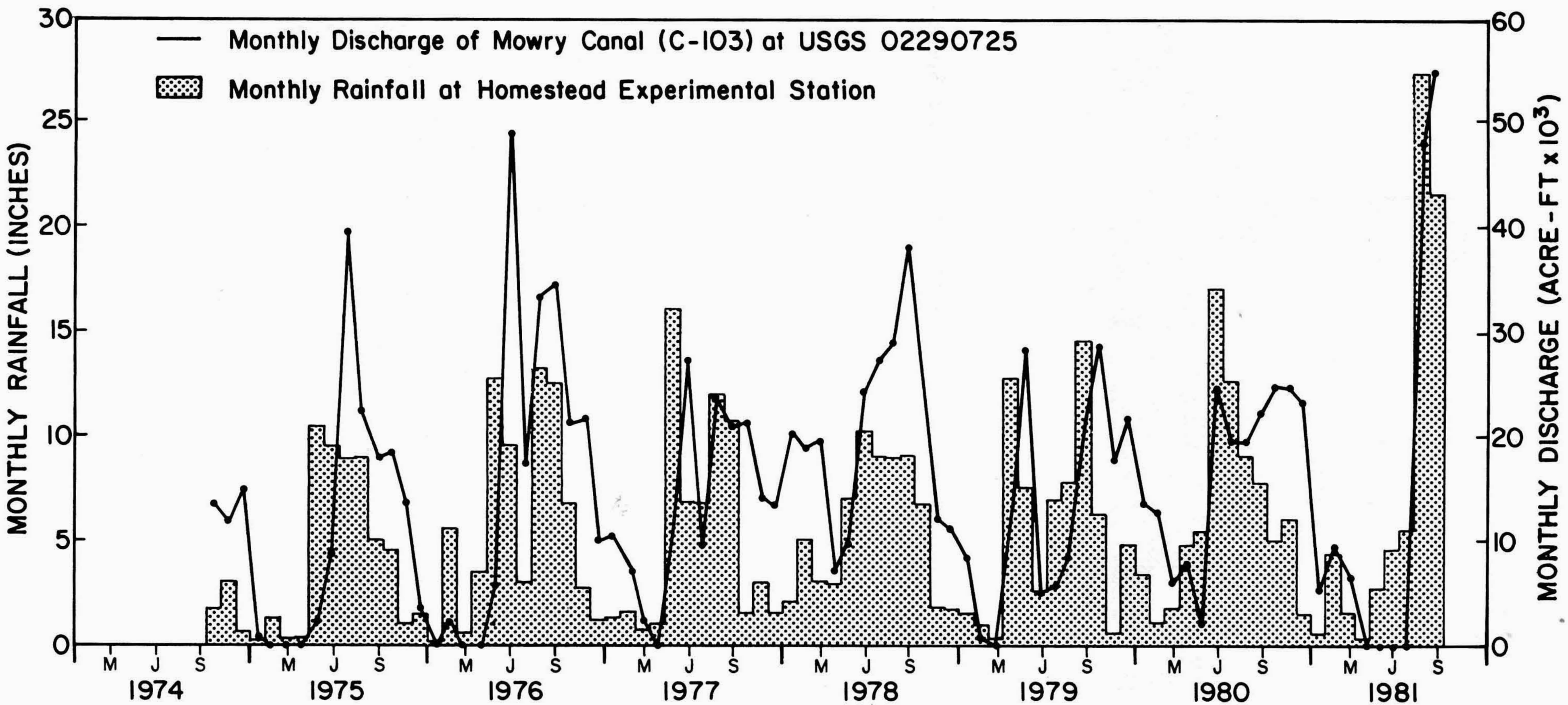

Figure 4. Monthly discharge from the Mowry Canal and monthly rainfall within the Mowry Canal Basin.

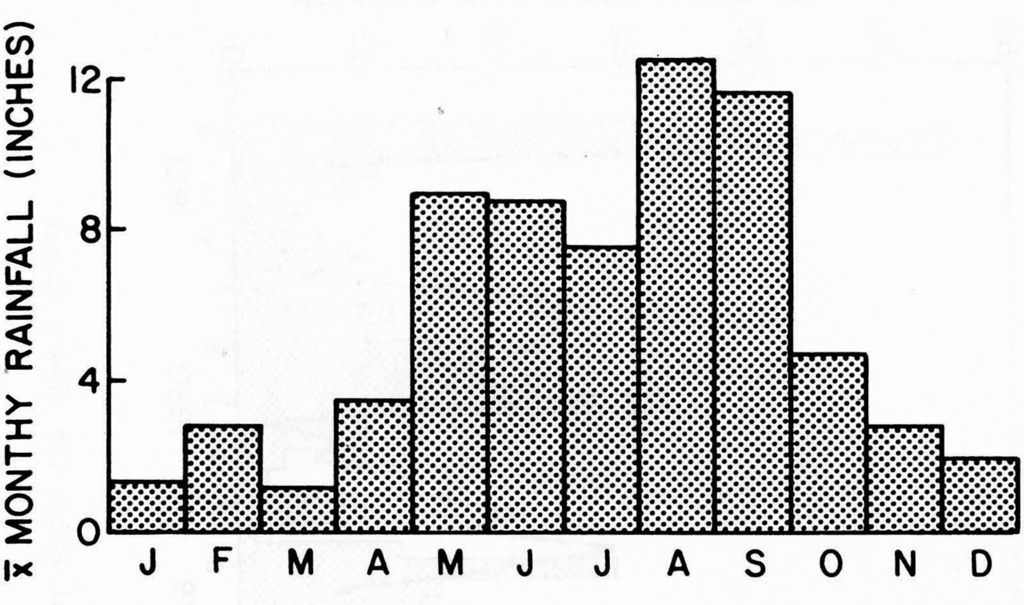

Figure 5a. Mean monthly rainfall at Homestead Experimental Station from water years 1975-1981.

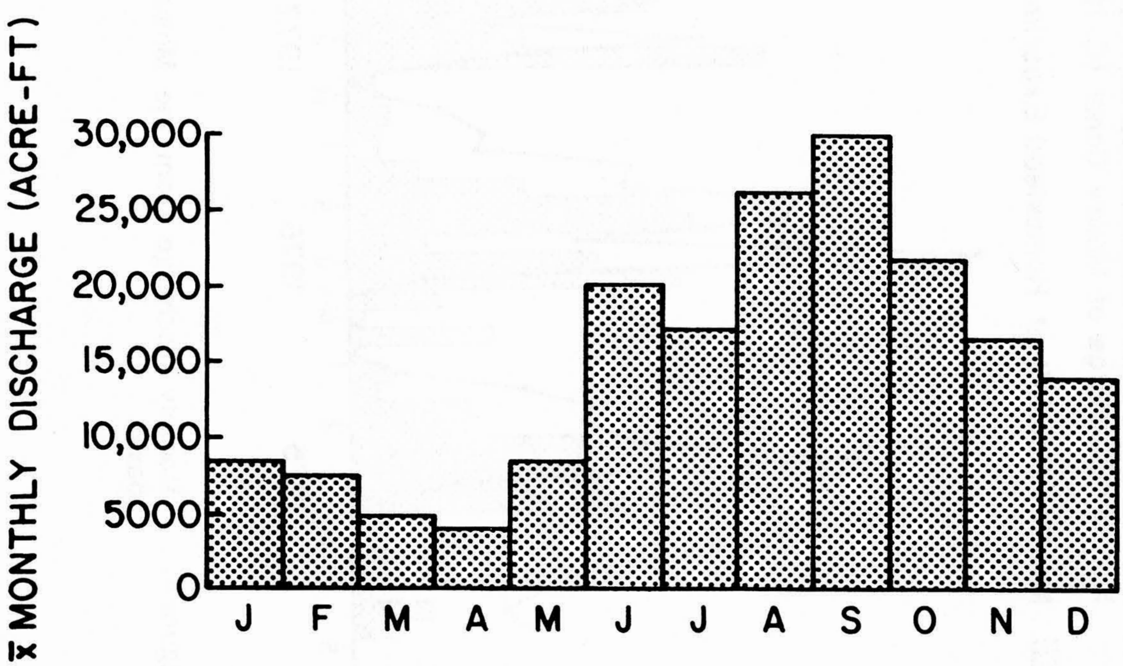

Figure 5b. Mean monthly discharge at Mowry Canal (USGS 02290725) from water years 1975-1981.

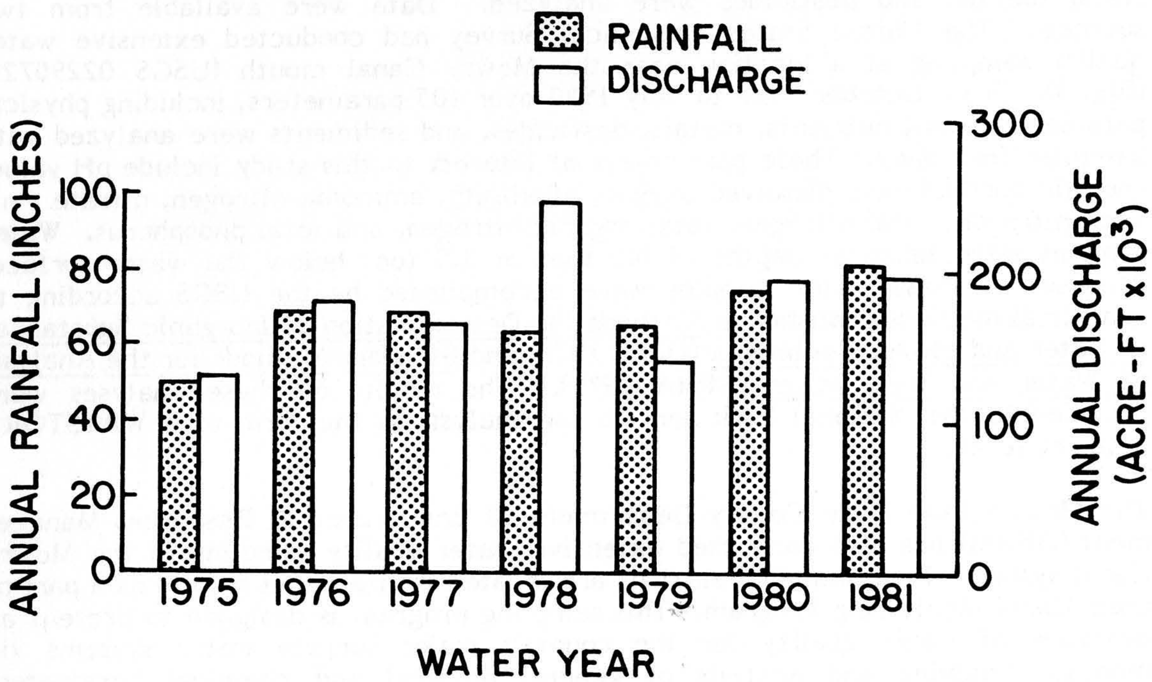

Figure 6. Annual rainfall at Homestead Experimental Station and annual discharge (USGS 02290725) from Mowry Canal (water years 1975-1981).

mean monthly discharge at USGS 02290725 (Fig. 7a) gave a correlation coefficient of 0.72, which is significant ($p < .005$). A better fit is obtained if mean monthly discharge is lagged one month after mean monthly rainfall (Fig. 7b). This analysis results in a correlation coefficient of 0.89, which is also significant ($p < .0005$). The stronger relationship between rainfall and runoff with a lag time is likely the result of water management detention practices within the Dade County canal system.

METHODS AND ANALYSIS

Water Quality Evaluation

Mowry Canal water quality data for various physical parameters, nutrients, bacteria, metals, and pesticides were analyzed. Data were available from two sources. The United States Geological Survey had conducted extensive water quality sampling at a location near the Mowry Canal mouth (USGS 02290725) (Fig. 3). From October 1975 to July 1980 over 105 parameters, including physical parameters, ions, nutrients, metals, pesticides, and sediments were analyzed with irregular frequency. Those parameters of interest to this study include pH value, specific conductance, dissolved oxygen, alkalinity, ammonia nitrogen, nitrate + nitrite nitrogen, total nitrogen, total organic nitrogen, and total phosphorus. Water samples were taken at depths of 0.5 foot or 1.0 foot below the water surface. Analyses of these water samples were accomplished by the USGS according to analytical methods published in Methods for Determination of Inorganic Substances in Water and Fluvial Sediments (USGS 1979) and Standard Methods for the Analysis of Water and Wastewater (APHA 1979). The results of these analyses were provided to the National Park Service for analysis in the form of a WATSTORE data retrieval.

The Metropolitan Dade County Department of Environmental Resources Management (DERM) has also conducted extensive water quality sampling in the Mowry Canal system. Four sampling stations are located in this canal system as a part of their Canal Monitoring Program. This sampling program is designed to present an overview of water quality for the county's major surface water systems via monthly sampling and analysis of general physical and chemical parameters (Labowski 1982). Samples taken at station 41 (Fig. 3), located in the western reach of C-103, are intended to represent background conditions. Samples from station 40, located on C-103N, and station 39, located just downstream from the junction of C-103N and C-103, are intended to be representative of mid-canal conditions. Samples from station 38, located about two miles upstream from the Mowry Canal mouth, are intended to be representative of the quality of inland water discharged to Biscayne Bay.

From January 1980 through December 1981 Dade County DERM sampled monthly nine general physical and chemical parameters. The parameters of interest to this study include water temperature, dissolved oxygen, conductivity, Secchi disc transparency, nitrite + nitrate nitrogen, total coliform bacteria, fecal coliform bacteria, and fecal streptococcus bacteria. All samples were taken at mid-depth in the water column. Over the 24-month period this corresponds to an average sampling depth of 5.9 feet at station 38, 5.0 feet at station 39, 3.5 feet at station 40, and 3.5 feet at station 41. Bacteriological analyses were performed by the

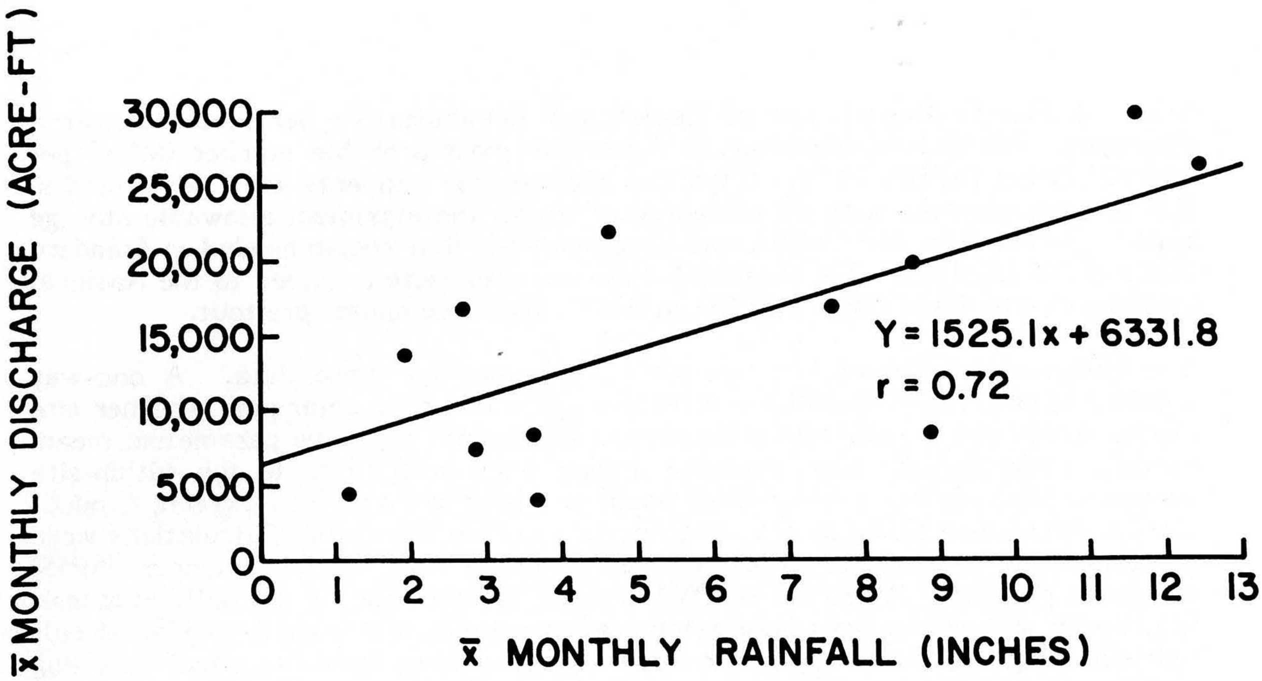

Figure 7a. Relationship between mean monthly rainfall at Homestead Experimental Station and mean monthly discharge from Mowry Canal (USGS 02290725).

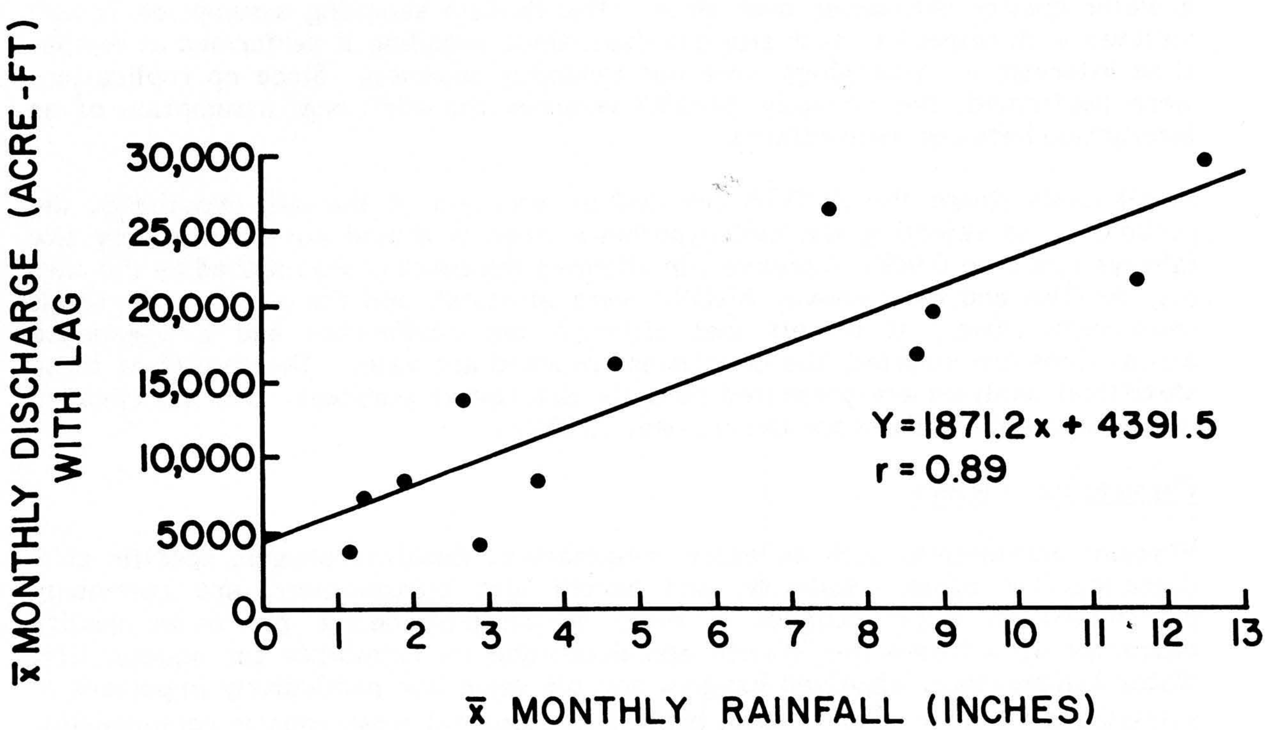

Figure 7b. Relationship between mean monthly rainfall at Homestead Experimental Station and mean discharge from Mowry Canal (USGS 02290725) one month later.

State of Florida Department of Health and Rehabilitative Services laboratory, employing standard methodology to determine most probable number (MPN) per 100 milliliters (APHA 1979). Chemical analyses for nutrients were performed in the DERM laboratory with an autoanalyzer within the maximum allowable storage time established by the USEPA and using methods that recommended in Standard Methods (APHA 1979). The results of these analyses were provided to the National Park Service by Dade County DERM in the form of a computer printout.

Two different statistical analyses were performed on these data. A one-way analysis of variance (ANOVA) was performed in order to determine whether site means could have been obtained from populations with the same parametric mean. Stated differently, is there variance among sites in addition to the within-site variance? Parameters evaluated included: temperature, dissolved oxygen, conductivity, secchi disc transparency, and nitrite + nitrate nitrogen. Calculations were performed by a standard Statistical Package for the Social Sciences (SPSS) computer program. When the ANOVA resulted in rejection of the null hypothesis (therefore, site does affect parameter concentration), the Student-Newman-Keuls multiple range test was applied in order to determine between which sampling stations the significant difference existed (Zar 1974; Sokal and Rohlf 1969). The second statistical analysis performed was a two-way ANOVA with site and date being the two main effects. Calculations were performed by an SPSS computer package program.

ANOVA assumes independent observations which are random samples from normally distributed populations with equal variances. In the present situation the assumption of independence is violated, as is typically the case in the monitoring of a water quality parameter over time. The random sampling assumption is also violated with respect to both site and date, since sampling is performed at regular time intervals at sites which were not randomly selected. Since no replications were performed, the two-way ANOVA requires the additional assumption of no interaction between main effects.

In all cases where the ANOVA resulted in rejection of the null hypothesis, the probability of rejecting the null hypothesis when it should not be was very low (always less than 0.001). Moreover, in all cases the conclusions reached by the one-way ANOVA and the two-way ANOVA were identical, and the significance levels were very close. It is felt that although the randomness and independence assumptions are violated, the conclusions reached are valid. The results of these statistical analyses are presented here for descriptive purposes. The significance levels reported are those for the one-way ANOVA.

Physical Parameters

Physical parameters, such as water temperature, dissolved oxygen, specific conductance, pH value, alkalinity, and Secchi disc transparency, are commonly determined on water samples in order to partially define the water quality character of a freshwater system and determine its suitability for aquatic life. Water temperature, dissolved oxygen, and pH value are particularly important in assessing the ability of an aquatic habitat to support diverse aquatic communities. High water temperatures, low dissolved oxygen concentrations, low pH value, or abnormally extreme fluctuations in any of these parameters have been shown to cause decreased species diversity, signaling an unhealthy aquatic environment.

Specific conductance is a measure of the resistance of a solution to electrical current and, therefore, an indicator of the ionic content of water. Previously, this parameter has been shown to be an early indicator of changes in water management practice and water quality in non-urban areas of southern Florida (Flora and Rosendahl 1981). Large fluctuations in specific conductance that cannot be accounted for by seasonal variability may indicate movements of agriculturally influenced water through the southern Florida system and a need for expanded water quality monitoring.

Alkalinity is a measure of the buffering capacity of a water system to resist wide scale variations in pH value. This capacity is especially important in areas where acid precipitation presents a major threat to aquatic resources.

Secchi disc transparency is defined as the mean depth where a weighted white disc of standard diameter (20 cm) disappears when viewed from the shaded side of a vessel, and that point where it reappears upon raising it after it has been lowered beyond visability (Wetzel 1975). As such, it is an indicator of water clarity and is influenced directly and indirectly by many factors, including algal productivity, turbidity, water color, and visual acuity of the observer.

Monthly mid-depth water temperature measurements from January 1980 through December 1981 were available for the four DERM stations located in the Mowry Canal system (Fig. 8). Water temperature over this two year period ranged from 16.0°C to 31.5°C and displayed a seasonal trend. Lowest water temperatures generally occurred in December or January, and highest water temperatures usually were recorded in June or July.

Monthly water temperatures did not display significant ($p > 0.75$) variability among the four stations and were similar to those occurring in other canal systems throughout Dade County. No point source thermal discharges are known to occur in the Mowry Canal system, and the water temperatures are within the tolerances of fish species commonly found in southern waters.

Dissolved oxygen data from the four DERM stations and the USGS station at the mouth of the Mowry Canal are presented in Table 2 and Figure 9. Dissolved oxygen concentrations in natural systems have been described by a number of mathematical models generally based upon the equation of continuity and the conservation of mass (Waite and Freeman 1977). One common dissolved oxygen model states that dissolved oxygen concentration in an open channel flow system depends upon the initial concentration of dissolved oxygen, the rate of atmospheric reaeration, the biochemical oxygen demand, and plant photosynthesis and respiration.

In the Mowry Canal system, low dissolved oxygen concentrations were found to occur at the westernmost station, DERM station 41 ($p < 0.0001$). Dissolved oxygen concentrations at this station ranged from 1.0 mg l^{-1} to 6.8 mg l^{-1} with a mean of

Table 2. Mean, standard deviation and range of selected physical parameters in the Mowry Canal during period of study.

Station	Period of record	n	$\bar{x}$	SD	Min	Max
		Dissolved oxygen (mg l^{-1})				
DERM 38	1980-1981	21	5.7	1.6	2.8	8.1
DERM 39	1980-1981	21	8.0	2.2	4.1	12.5
DERM 40	1980-1981	21	5.4	1.6	3.5	10.8
DERM 41	1980-1981	20	3.4	1.5	1.0	6.8
USGS 02290725	1975-1980	29	6.4	1.8	3.1	10.1
		Specific conductance (umhos cm^{-1})				
DERM 38	1980-1981	23	959	547	575	3200
DERM 39	1980-1981	23	581	95	375	800
DERM 40	1980-1981	23	645	85	450	825
DERM 41	1980-1981	23	661	107	440	850
USGS 02290725	1975-1980	28	843	255	575	1580
		pH (units)				
USGS 02990725	1975-1980	30	7.4	-	7.0	8.1
		Alkalinity (mg l^{-1} as $CaCO_3$)				
USGS 02990725	1975-1980	24	200	18	166	233
		Secchi disc transparency (m)				
DERM 38	1980-1981	21	2.1	0.7	0.9	3.4
DERM 39	1980-1981	21	2.5	0.8	1.0	3.8
DERM 40	1980-1981	20	2.1	0.5	1.5	3.5
DERM 41	1980-1981	20	1.1	0.4	0.1	1.8

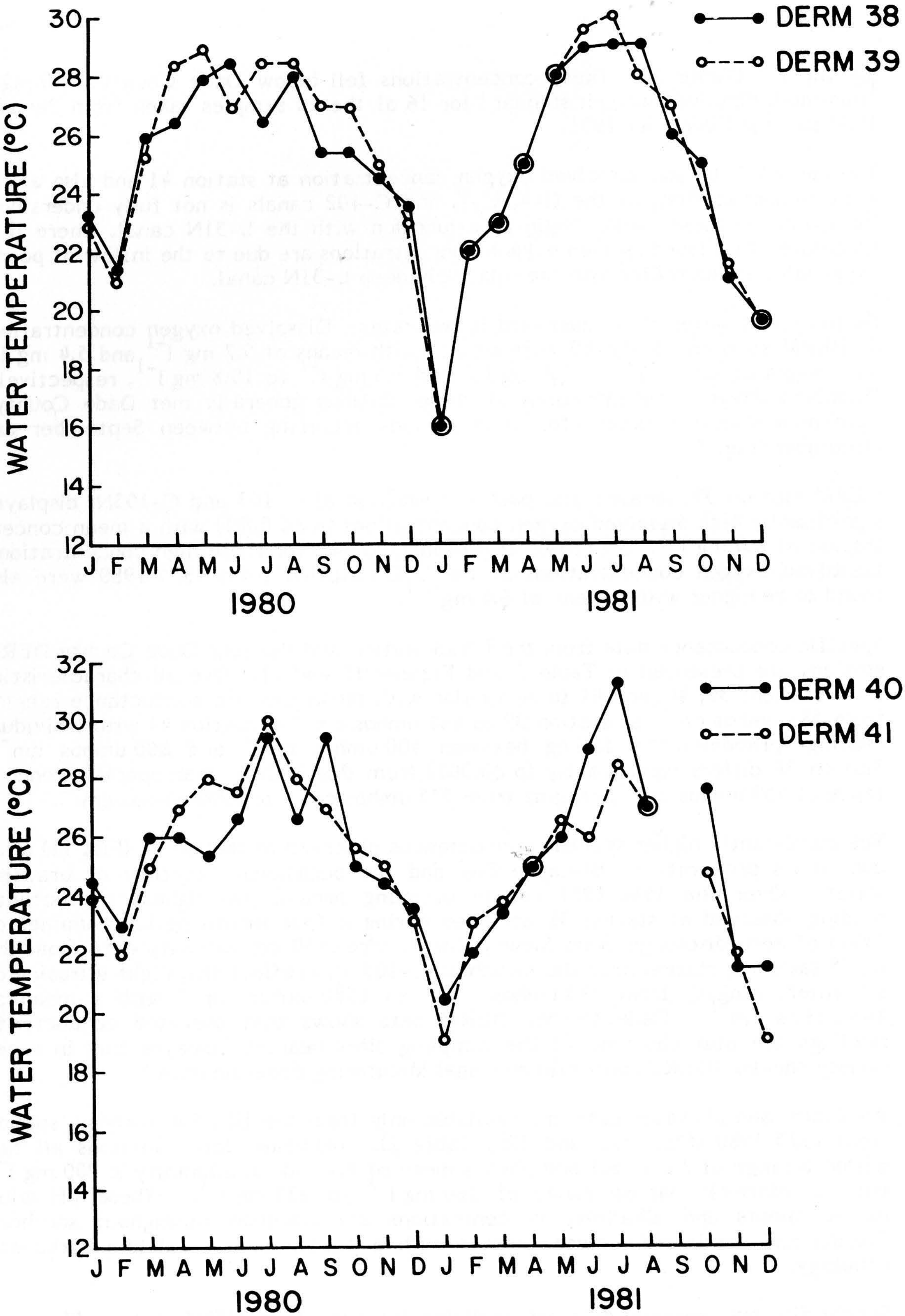

Figure 8. Water temperature (°C) at sampling depth at DERM Mowry Canal stations 38-41 (1980-1981).

3.4 mg l^{-1} (Table 2). These concentrations fell below Dade County's 4.0 mg l^{-1} minimum dissolved oxygen standard for 16 of the 20 samples taken from January 1980 through December 1981.

The cause of the low dissolved oxygen concentration at station 41 and also at the westernmost stations of the C-4, C-1, and C-102 canals is not fully understood. However, all these canals begin at a junction with the L-31N canal, where it is speculated that low dissolved oxygen concentrations are due to the inflow of poorly oxygenated groundwater into the relatively deep L-31N canal.

As the canal water flows eastward it reaerates. Dissolved oxygen concentrations at DERM stations 38 and 40 were similar with means of 5.7 mg l^{-1} and 5.4 mg l^{-1} and ranges of 2.8 mg l^{-1} to 8.1 mg l^{-1} and 3.5 mg l^{-1} to 10.8 mg l^{-1}, respectively. Dissolved oxygen concentrations at these stations generally met Dade County's mimimum standard except for brief periods occurring between September and December (Fig. 9).

DERM station 39, located just past the junction of C-103 and C-103N, displayed significantly high dissolved oxygen concentrations ($p < 0.0001$) with a mean concentration of 8.0 mg l^{-1}. No reason is presently known for these high concentrations. Dissolved oxygen concentrations at the USGS station from 1975-1980 were also found to be higher with a mean of 6.4 mg l^{-1}.

Specific conductance data from the USGS station and the four Dade County DERM stations are presented in Table 2 and Figures 10 and 11. Overall characteristics show stations 39, 40, and 41 to be similar with mean specific conductance ranging from 581 umhos cm^{-1} at station 39 to 661 umhos cm^{-1} at station 41 with individual readings predominantly falling between 400 umhos cm^{-1} and 800 umhos cm^{-1}. Station 38 differs significantly ($p < 0.001$) from this with a mean specific conductance of 959 umhos cm^{-1}, ranging from 575 umhos cm^{-1} to 3200 umhos cm^{-1}.

The consistantly higher specific conductances observed at station 38 (Fig. 11) were due to its proximity to Biscayne Bay and the occasional backflow of brackish water. Over the 1980-1981 county sampling period, the highest conductivity reading observed at station 38 occurred during a four month period (summer of 1981) of zero discharge from Mowry Canal. Pre-1980 conductivity data from the USGS sampling station near the mouth of C-103 also reflect the slight intrusion of saltwater, ranging from 575 umhos cm^{-1} to 1580 umhos cm^{-1} with a mean of 843 umhos cm^{-1}. Dade County DERM data shows that elevated conductivity readings are also observed at the sampling sites nearest Biscayne Bay in other county canals. (DERM, unpublished Canal Monitoring Program data.)

Alkalinity and pH value data are available only from the USGS monitoring station from 1975-1980 (Fig. 12a and 12b, Table 2). pH value determinations all fall within a range of 7.0 to 8.1 and have a mean of 7.4. Mean alkalinity is 200 mg l^{-1} with a relatively narrow range of 166 mg l^{-1} to 233 mg l^{-1}. These pH value measurements and alkalinity concentrations are common throughout southern Florida and result from close contact with a predominantly calcium carbonate lithology.

Secchi disc transparency data are available from the four DERM stations (Table 2, Fig. 13). Secchi disc depths at stations 38, 39, and 40 were all similar, ranging

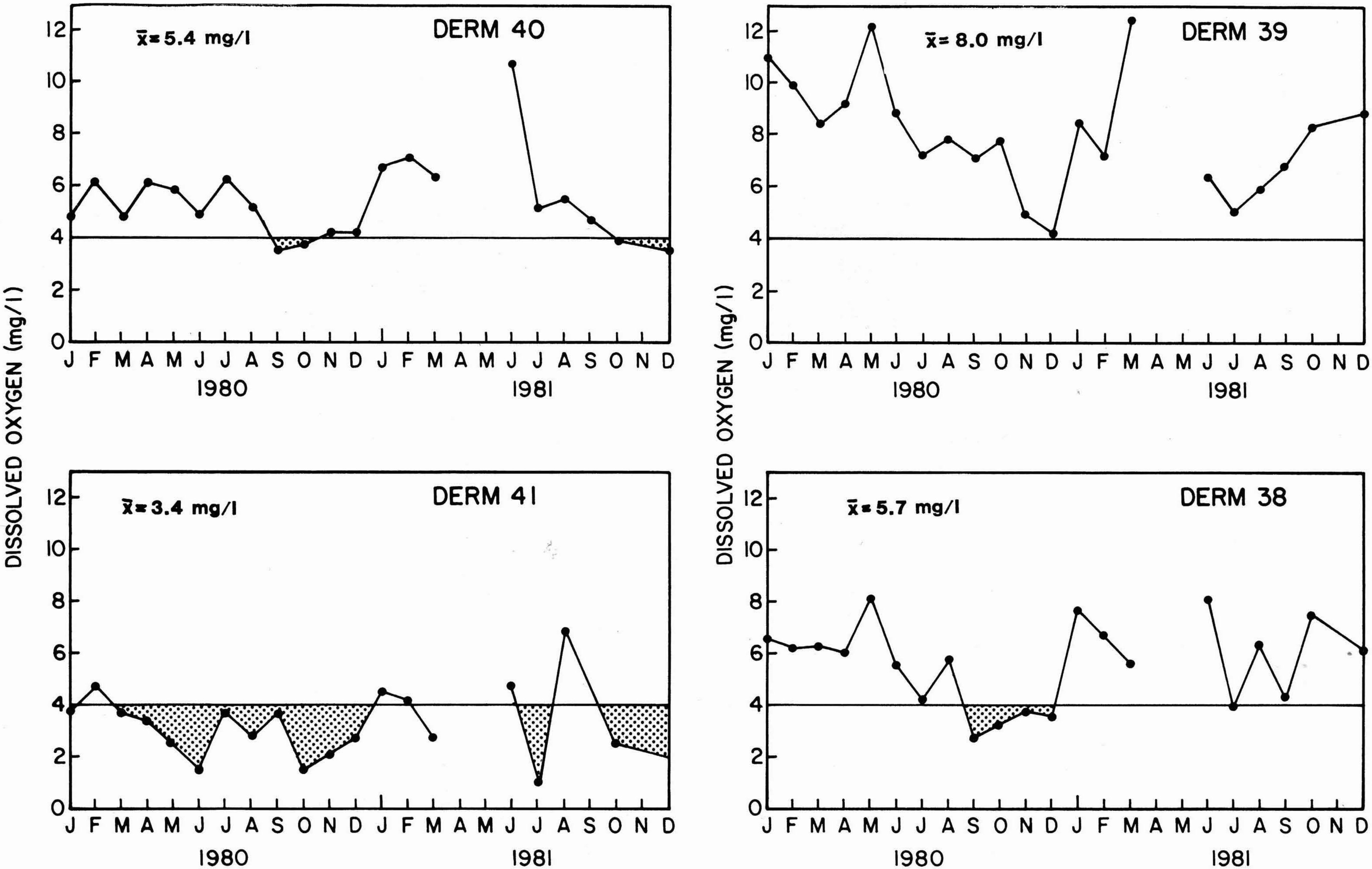

Figure 9. Dissolved oxygen concentration (mg l^{-1}) at DERM Mowry Canal sampling stations 38-41 (1980-1981). Note: Shaded areas indicate those times when dissolved oxygen concentration fell below the 4.0 mg l^{-1} Dade County standard.

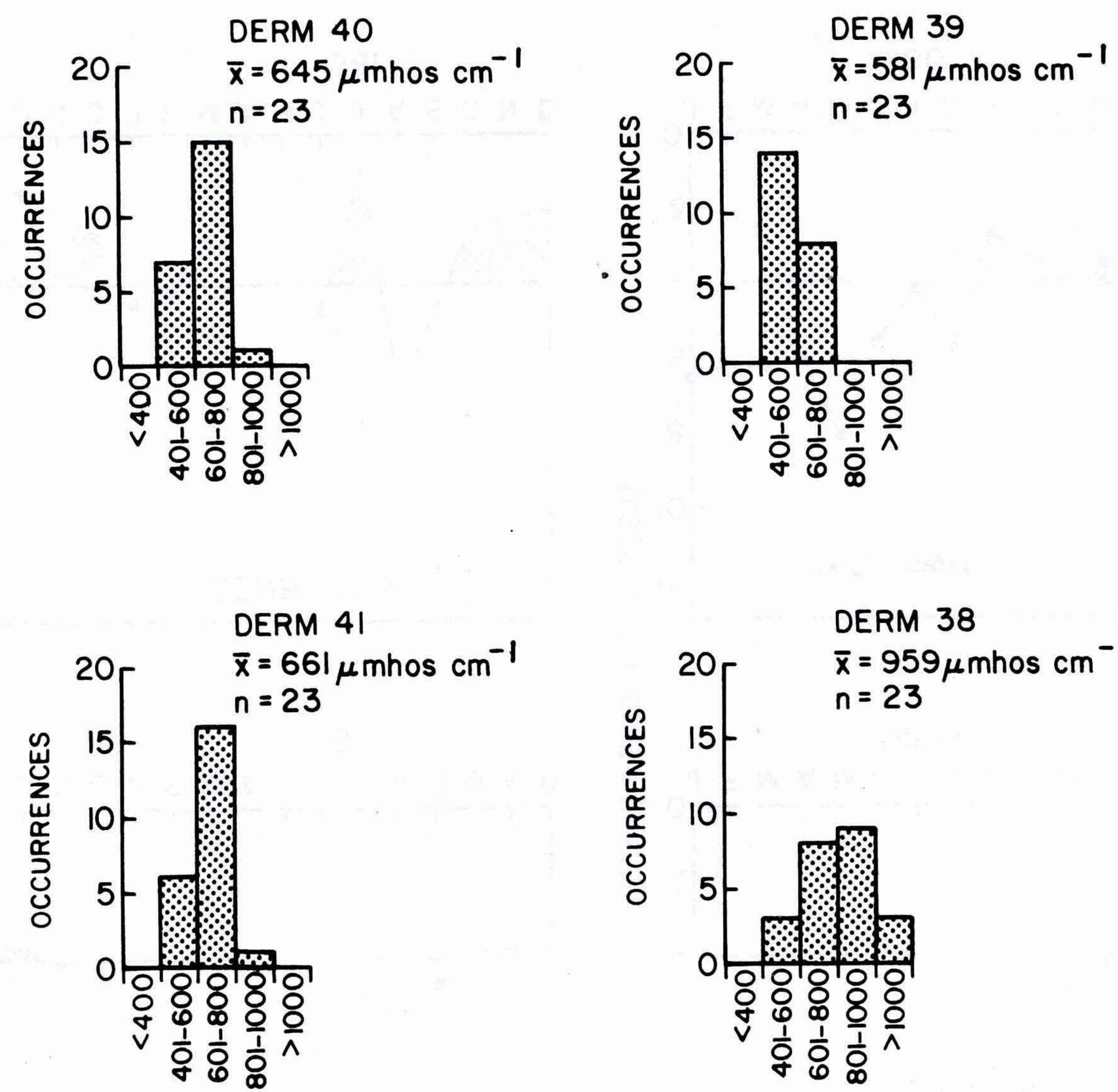

Figure 10. Specific conductance distribution (μmhos cm^{-1}) at DERM Mowry Canal sampling stations 38-41 (1980-1981).

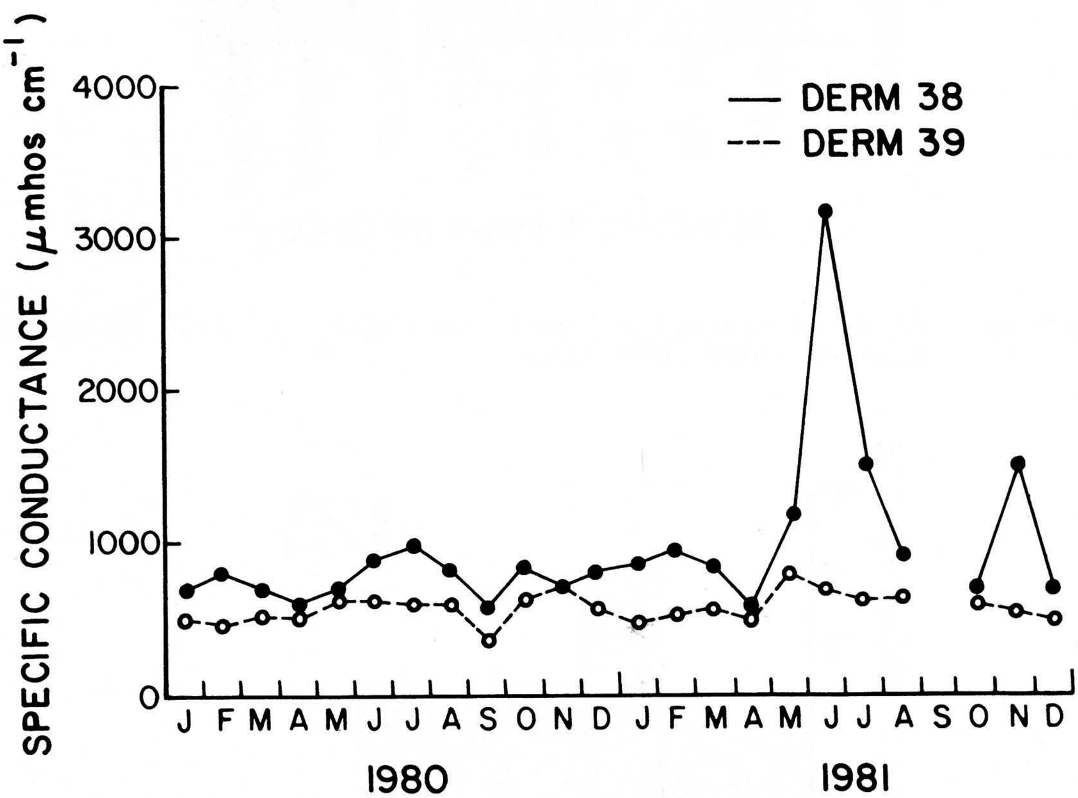

Figure 11. Specific conductance distribution (μmhos cm^{-1}) at DERM Mowry Canal sampling stations 38 and 39 (1980-1981).

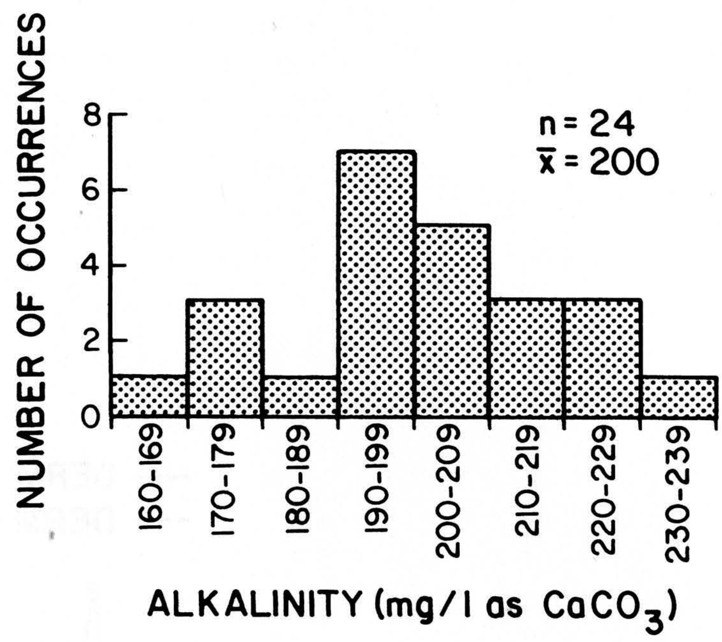

Figure 12a. Alkalinity distribution (mg l^{-1} as $CaCO_3$) at USGS Mowry Canal station 02290725 (1975-1980).

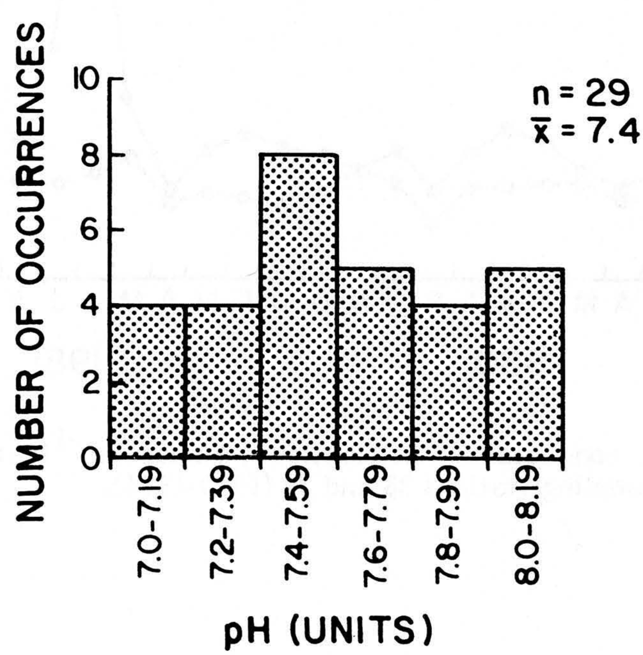

Figure 12b. pH distribution at USGS Mowry Canal station 02290725 (1975-1980).

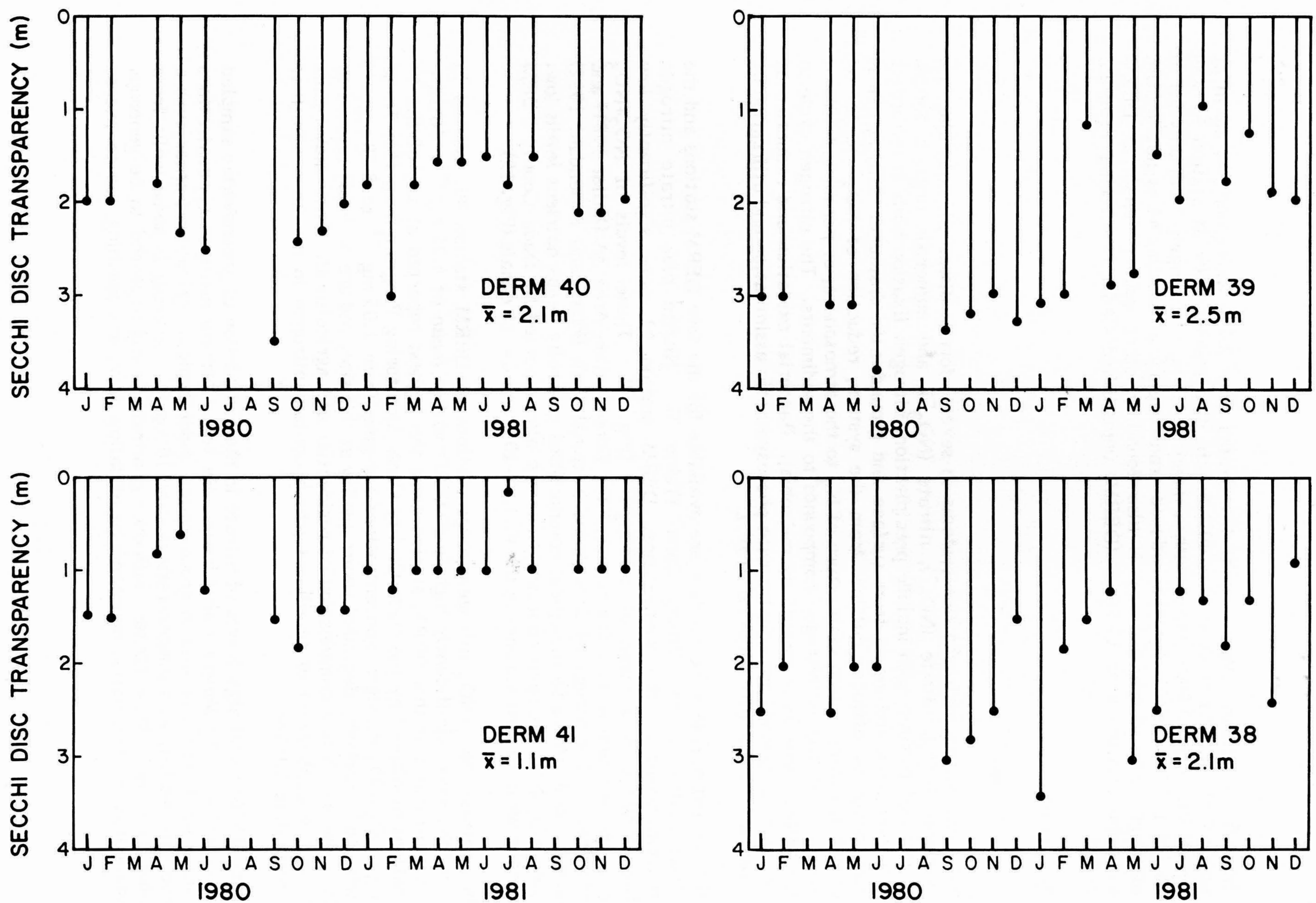

Figure 13. Secchi disc transparency (m) at DERM Mowry Canal sampling stations 38-41 (1980-1981).

from 0.9 to 3.8 m. Mean secchi disc depths were 2.1 m at station 38, 2.5 m at station 39, and 2.1 m at station 40. Secchi disc transparency at station 41 was significantly ($p < 0.0001$) lower with a mean of 1.1 m, and ranging from only 0.1 m to 1.8 m. The reason for the reduced transparency at station 41 is not known, although reduced transparency is also found in other county canals at DERM sampling stations near L-31N. (DERM, unpublished Canal Monitoring Program data.)

Nutrients

Nitrogen

Nitrogen occurs in freshwater systems in several forms: dissolved molecular N_2, ammonia (NH_3), nitrite (NO_2^-), nitrate (NO_3^-), and numerous organic forms. Sources of this nitrogen include precipitation, nitrogen fixation both in the water and sediments, and inputs from surface and groundwater drainage. Nitrogen loss may occur by effluent outflow from the system, reduction of NO_3^- to N_2 by bacterial dentrification with return of N_2 to the atmosphere, or permanent loss of inorganic or organic nitrogen compounds to the sediments. The nitrogen cycle in freshwater systems is essentially microbial. Bacterial oxidation and reduction of nitrogen compounds are coupled with photosynthetic assimilation and utilization by algae and aquatic plants (Wetzel 1975).

Nitrite and nitrate nitrogen data are available for the four DERM stations and the USGS station in the Mowry Canal (Table 3). Nitrite plus nitrate nitrogen concentrations at the westernmost DERM station 41 were significantly low ($p < 0.0001$) with a mean of 0.09 mg l^{-1} (Fig. 14). These levels of NO_2+NO_3 nitrogen are similar to those reported for Conservation Area 3A (Millar 1981) and the Shark River Slough of Everglades National Park (Flora and Rosendahl 1982) where rapid uptake by biological communities generally keeps nutrient levels low. Low NO_2+NO_3 nitrogen concentrations are also reported by Dade County DERM for the westernmost stations in the C-1, C-102, and C-111 canals (Fig. 15).

In contrast, NO_2+NO_3 nitrogen concentrations at DERM station 40, located in C-103N, were significantly high ($p < 0.0001$) with a mean of 4.25 mg l^{-1}. Nitrate concentrations at this DERM station were the highest reported at any of the 47 stations monitored by the Dade County Canal Monitoring Program (Fig. 15). These high NO_2+NO_3 nitrogen concentrations (ranging from 1.05 mg l^{-1} to 8.30 mg l^{-1}) indicate a markedly degraded water quality at this site, and are probably related to land use which is a combination of residential and agricultural. They may result from the application of fertilizers which contain nitrogen in the form of either ammonia or nitrate.

Orth (1976) found high levels of nitrate in the top portion of groundwater sampled from wells in the Mowry Canal basin. He found nitrate nitrogen concentrations averaging 3 mg l^{-1} or less in groundwater under typical agricultural areas over a two year period, with concentrations over 10 mg l^{-1} occurring in some wells from time to time. Major factors influencing nitrate levels appeared to be generous application of fertilizers, maintenance of fallow land, and leaching due to excess

Table 3. Mean, standard deviation and range of nutrients in the Mowry Canal during period of study.

Station	Period of record	n	$\bar{x}$	SD	Min	Max
		$NO_2 + NO_3$ - Nitrogen (mg l^{-1})				
DERM 38	1980-1981	20	1.13	0.41	0.33	2.01
DERM 39	1980-1981	19	1.69	0.90	0.05	3.80
DERM 40	1980-1981	20	4.25	1.80	1.05	8.30
DERM 41	1980-1981	19	0.09	0.08	0.03	0.40
USGS 02290725	1975-1980	28	0.87	0.31	0.18	1.30
		NH_3 - Nitrogen (mg l^{-1})				
USGS 02290725	1975-1980	32	0.05	0.06	0.02	0.30
		Total Organic Nitrogen (mg l^{-1})				
USGS 02290725	1975-1980	32	0.30	0.17	0.12	0.76
		Total Nitrogen (mg l^{-1})				
USGS 02290725	1975-1980	28	1.24	0.36	0.51	1.80
		Total Phosphorus (mg l^{-1})				
USGS 02290725	1975-1980	30	0.014	0.007	0.01	0.04

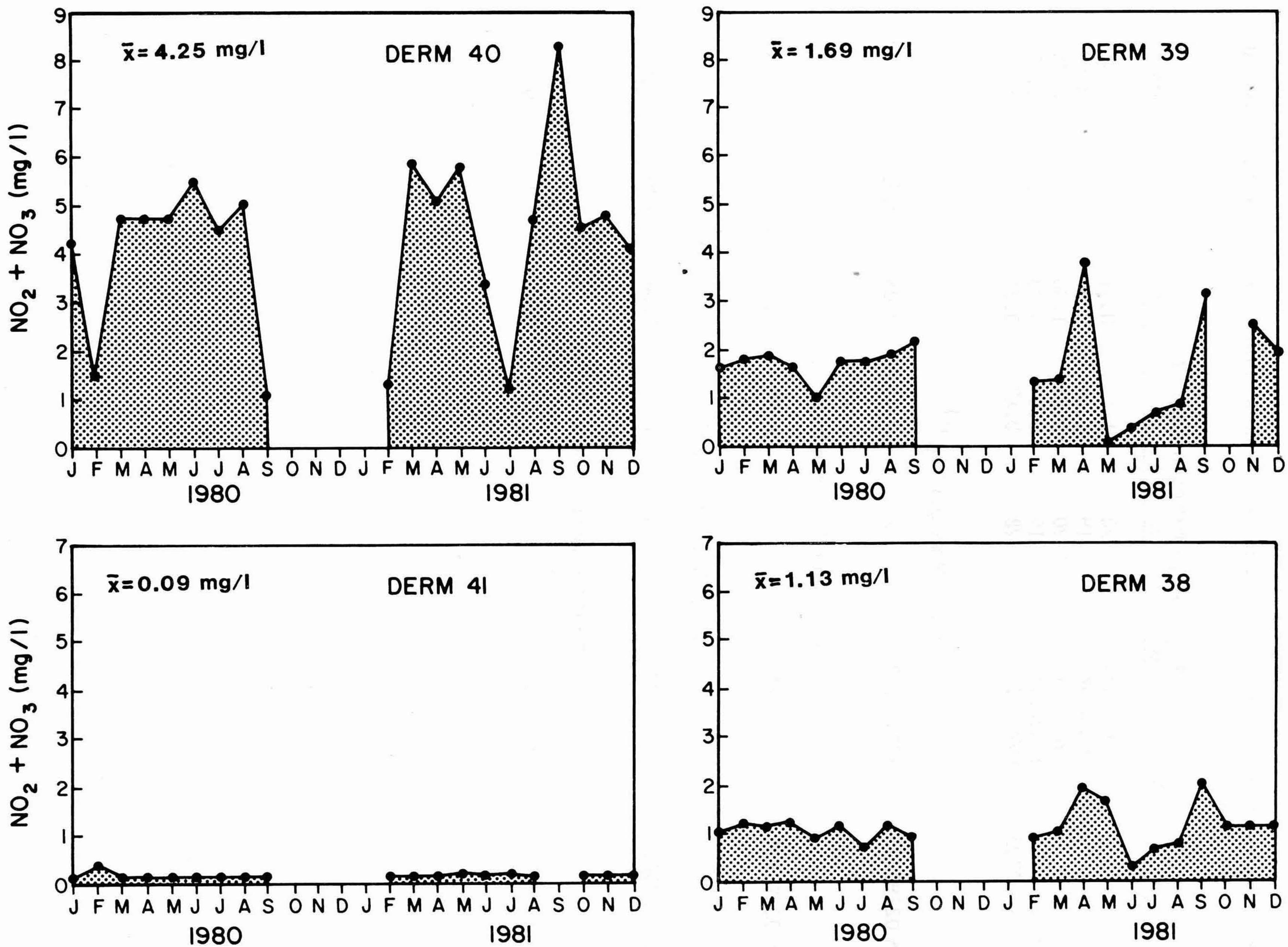

Figure 14. Nitrite plus nitrate concentration (mg l^{-1}) at DERM Mowry Canal sampling stations 38-41 (1980-1981).

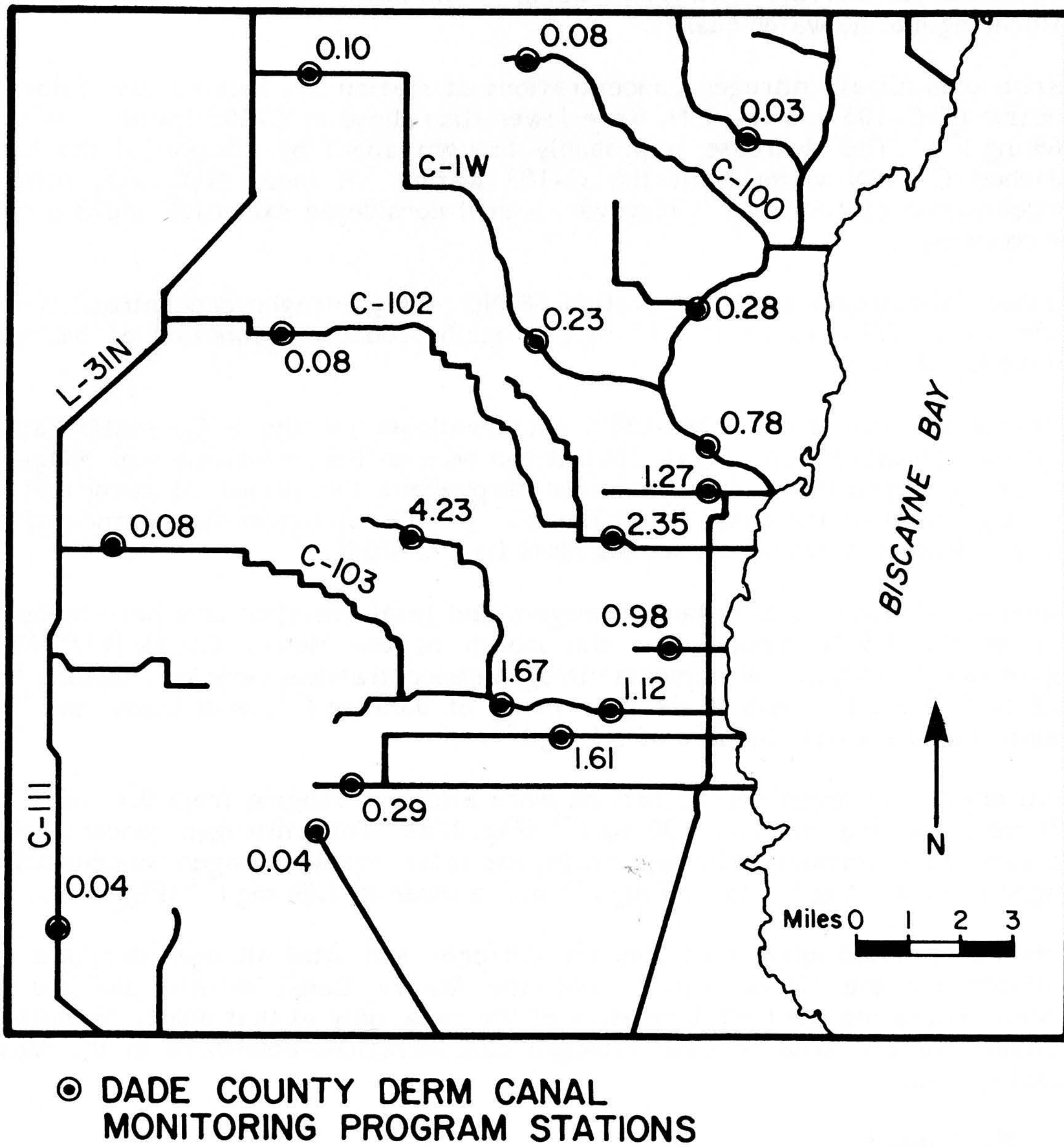

Figure 15. Mean nitrate concentration (mg l^{-1}) at selected Dade County DERM Canal Monitoring Program stations (1980-1981).

irrigation or rain. Nitrite plus nitrate nitrogen concentrations of this magnitude are a concern as they degrade canal and groundwater quality and may be responsible for increased nitrogen loading at the outfall to Biscayne Bay, possibly influencing marine water quality.

Nitrite plus nitrate nitrogen concentrations at station 39, located just below the junction of C-103 and C-103N, were lower than those in C-103N with a mean of 1.69 mg l^{-1}. This decrease is probably brought about by dilution of the highly enriched C-103N water with the C-103 water. A mean NO_2+NO_3 nitrogen concentration of 1.69 mg l^{-1}, however, is still considered excessive and is a cause for concern.

Further downstream at DERM station 38 NO_2+NO_3 nitrogen concentrations were lower still, with a mean of 1.13 mg l^{-1}, again probably a function of biological uptake and dilution.

Utilizing the long term (1975-1980) data available for the USGS station at the mouth of the Mowry Canal (Fig. 16b), it can be seen that relatively high NO_2+NO_3 nitrogen concentrations have occurred throughout the period of record at the discharge point of the canal ($\bar{x}$ = 0.87 mg l^{-1}). The biological significance of this nitrogen loading is not known but warrants further study.

Ammonia nitrogen, total organic nitrogen, and total nitrogen have been measured only at the USGS station near the mouth of the Mowry Canal (1975-1980). Figure 16a shows that the ammonia nitrogen concentrations were low, ranging from 0.02 to 0.30 mg l^{-1} with a six year mean of 0.05 mg l^{-1}, well below the Dade County surface water standard of 0.5 mg l^{-1}.

Total organic nitrogen concentrations were also low, ranging from 0.12 mg l^{-1} to 0.76 mg l^{-1} with a mean of 0.30 mg l^{-1} (Fig. 17a). Total nitrogen concentrations, the sum of the ammonia, nitrite, nitrate, and total organic nitrogen concentrations, ranged from 0.51 mg l^{-1} to 1.80 mg l^{-1} with a mean of 1.24 mg l^{-1} (Fig. 17b).

It should be noted again that ammonia-nitrogen and total nitrogen data are only available for the USGS station near the Mowry Canal mouth, and the low concentrations reported are indicative of the canal only at that point. No data are available for ammonia or total nitrogen concentrations elsewhere in the Mowry Canal system.

Phosphorus

No other element in freshwater systems has been as extensively studied as phosphorus since it is phosphorus which most commonly limits biological productivity. The chemistry of phosphorus in freshwater systems is complex, and phosphorus may occur in several different forms. Soluble orthophosphate is readily assimilated biologically. Phosphorus is also found in dissolved organic forms and suspended organic forms. Phosphorus may also be found trapped in sediments where it may be released to the water column under suitable conditions. The most important quantity, in view of the metabolic characteristics of a freshwater system, is the total phosphorus content of unfiltered water, which consists of the phosphorus suspended in particulate matter and dissolved phosphorus (Juday 1927).

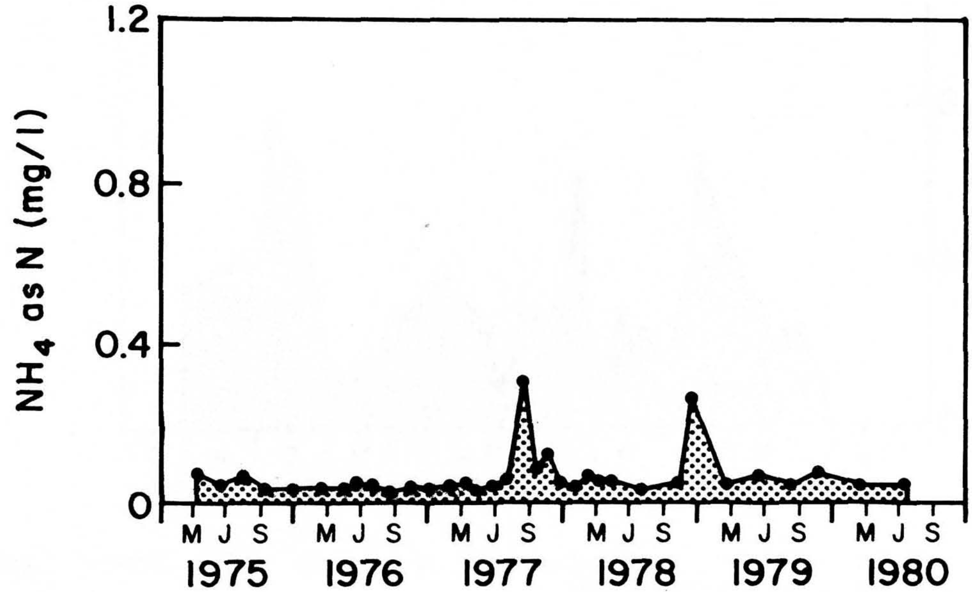

Figure 16a. Ammonia nitrogen concentration (mg l^{-1}) at USGS Mowry Canal station 02290725 (1975-1980).

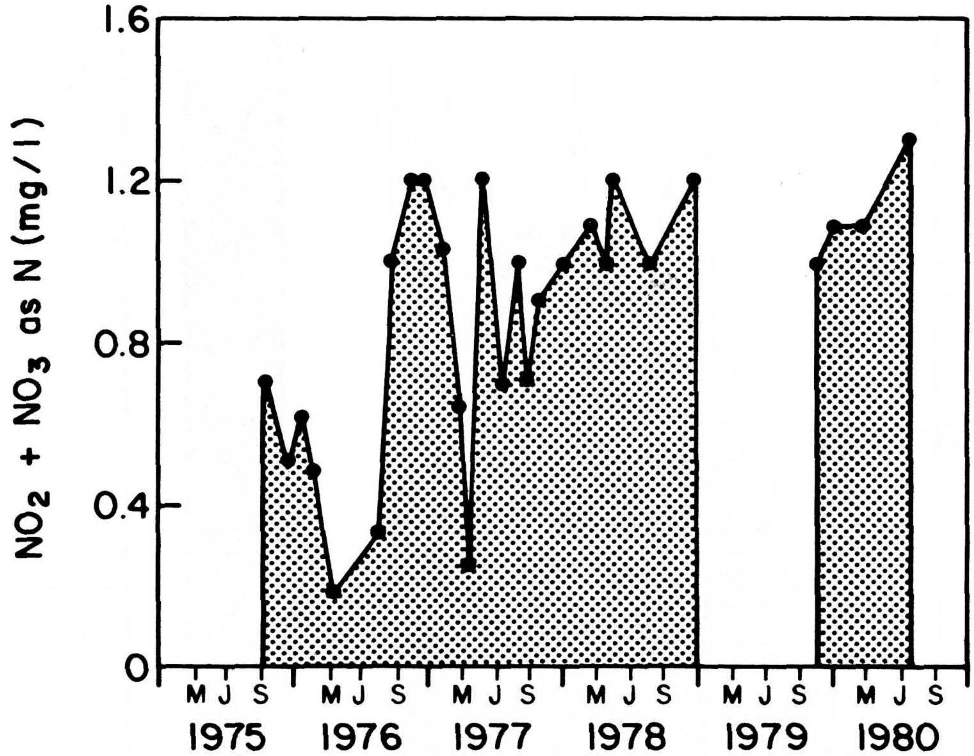

Figure 16b. Nitrite-nitrogen + nitrate-nitrogen concentration (mg l^{-1}) at USGS Mowry Canal station 02290725 (1975-1980).

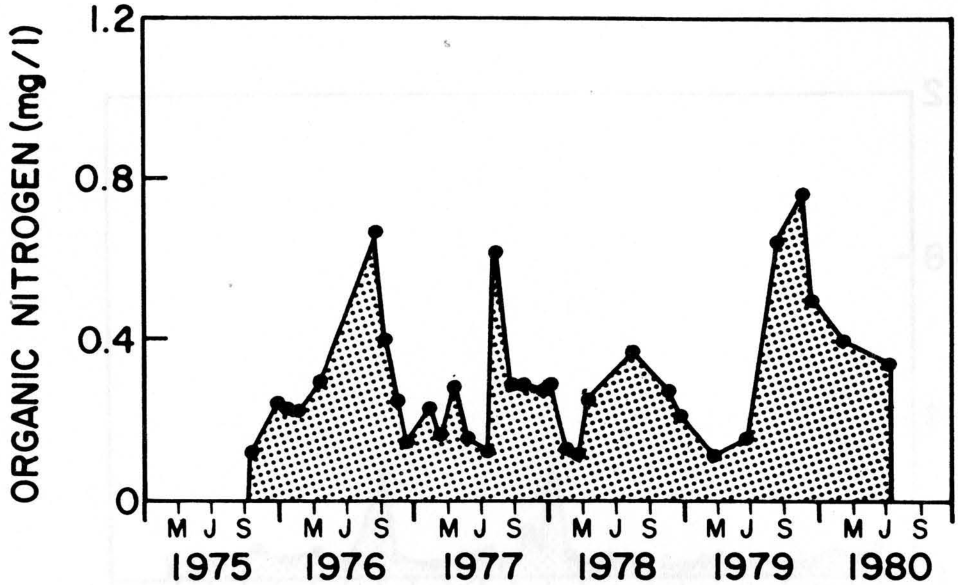

Figure 17a. Organic nitrogen concentration (mg l^{-1}) at USGS Mowry Canal station 02290725 (1975-1980).

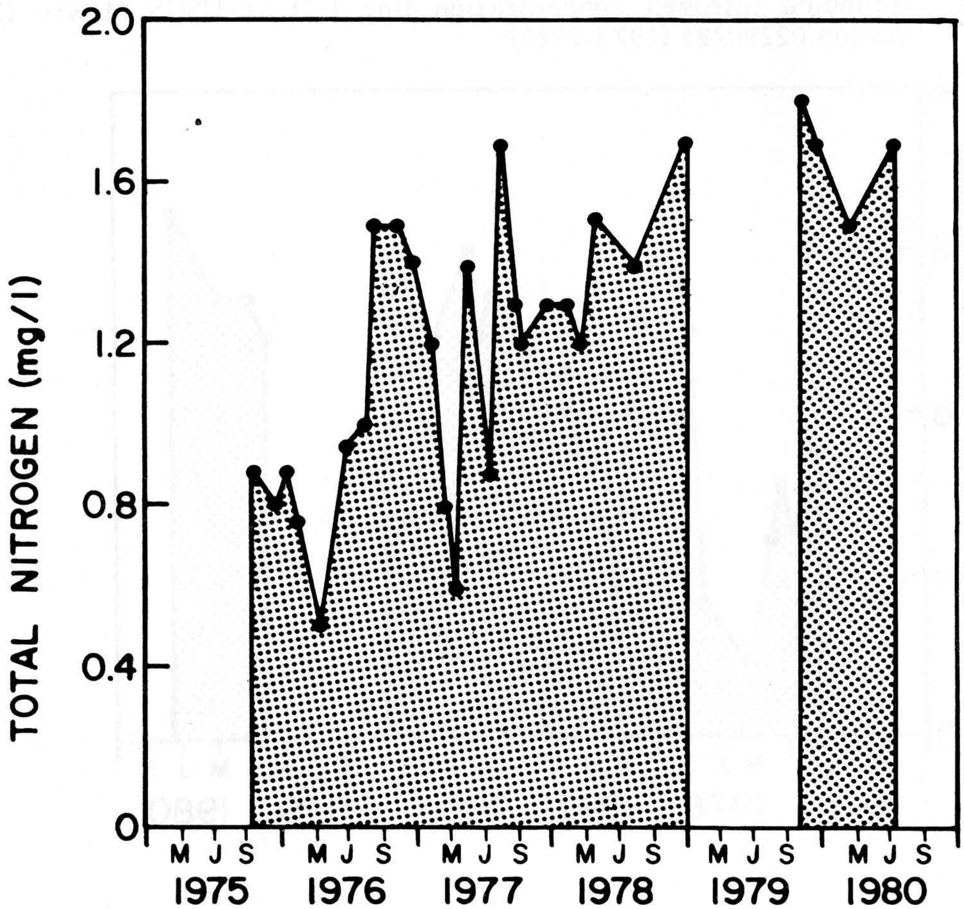

Figure 17b. Total nitrogen concentration (mg l^{-1}) at USGS Mowry Canal station 02290725 (1975-1980).

Total phosphorus data in the Mowry Canal system were available only for the USGS sampling station near the canal mouth (Fig. 18, Table 3). Concentrations were not high, ranging from 0.01 mg l^{-1} to 0.04 mg l^{-1} with a mean of 0.014 mg l^{-1}. These concentrations, generally less than 0.02 mg l^{-1}, are indicative of uncontaminated water and indicate that phosphorus enrichment is not a problem in the Mowry Canal system. Available data indicate that phosphorus concentrations throughout Dade County canals are typically low.

Bacteria

Pollution of aquatic systems by the excreta of warmblooded animals creates public health problems for man and animals, and potential disease problems for aquatic life (USEPA 1976). Most freshwater systems naturally contain microbes, which may or may not be pathogenic. Pathogenic bacteria in water bodies originate from several sources, including stormwater runoff, agricultural runoff, domestic sewage, and wildlife. Certain non-pathogenic organisms, such as coliform bacteria and fecal streptococci bacteria, are used as microbiological indicators of pathogens in water in order to assess the suitability of a water for aquatic life or for drinking or swimming.

Coliform bacteria are the most commonly used microbial indicators of water quality. The total coliform group includes species of bacteria which occur in the gut of warmblooded animals as well as species which occur naturally in soils. Most species of fecal coliform bacteria, a portion of the total coliform group, are restricted to the guts of warmblooded animals. The presence of fecal coliform bacteria indicates a degradation of water quality and a relative risk of disease hazard. Fecal streptococci bacteria are found in greater numbers within the intestines of warmblooded animals other than humans.

Data for total coliform bacteria, fecal coliform bacteria, and fecal streptococci bacteria were available from the four Dade County DERM Mowry Canal sampling stations. Total coliform (TC) bacteria (Fig. 19) generally met Dade County's standard of 1000 (MPN) per 100 ml. The maximum standard was exceeded once at stations 39 and station 41, three times at station 38, and four times at station 40. The Dade County standard for fecal coliform (FC) bacteria is 200 (MPN) per 100 ml. In general, all four Mowry Canal sites met this standard as well (Fig. 20). Levels exceeding the FC standard were detected one time at station 41, and two times at stations 38, 39, and 40. Bacteriological counts for those instances where either the total coliform standard or the fecal coliform standard was exceeded are presented in Table 4.

The data do not indicate any clear differences in bacteriological counts among Mowry Canal sampling stations, and in general, bacterial contamination in this canal system does not appear to be a problem. Comparison of bacteriological counts in the Mowry Canal to bacteriological counts in other county canals monitored by the DERM Canal Monitoring Program reveal that bacteriological counts in the Mowry Canal system were the lowest of the 16 canals monitored from 1980 to 1981.

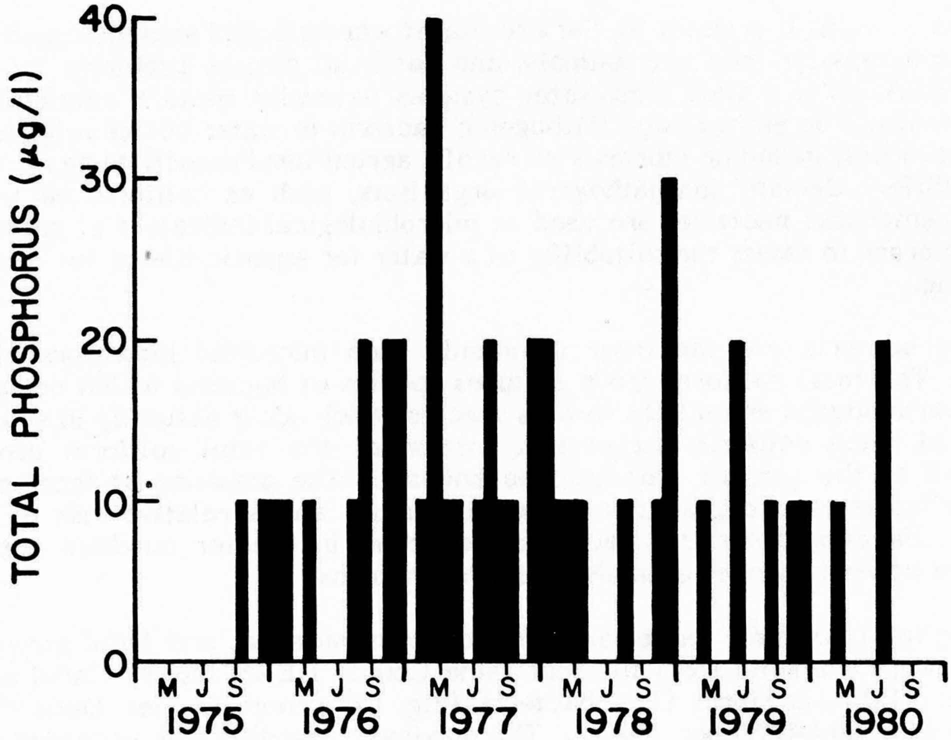

Figure 18. Total phosphorus concentration ($\mu g\ l^{-1}$) at USGS Mowry Canal station 02290725 (1975-1980).

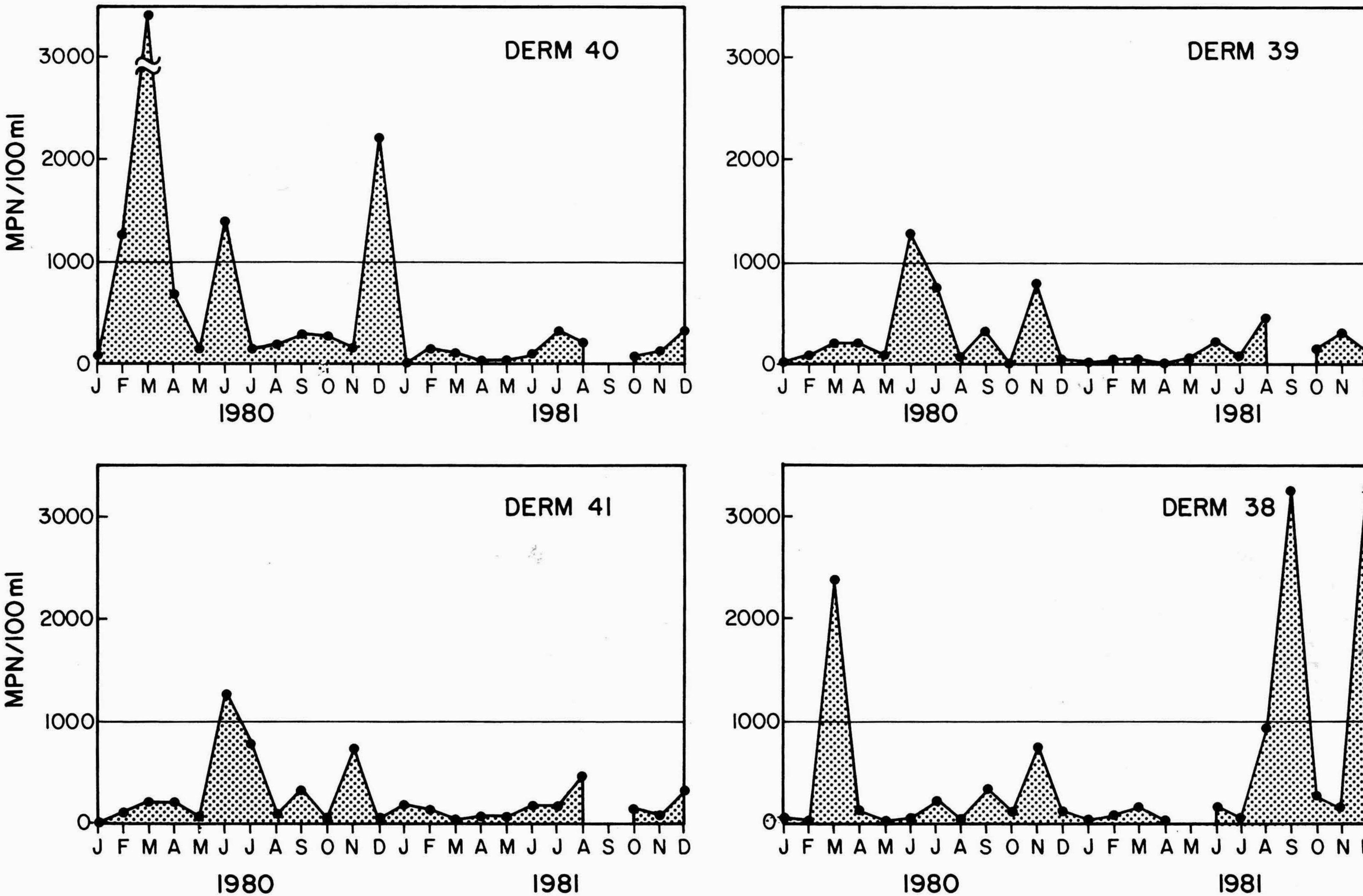

Figure 19. Total coliform bacteria (MPN 100 ml^{-1}) at DERM Mowry Canal sampling stations 38-41 (1980-1981).

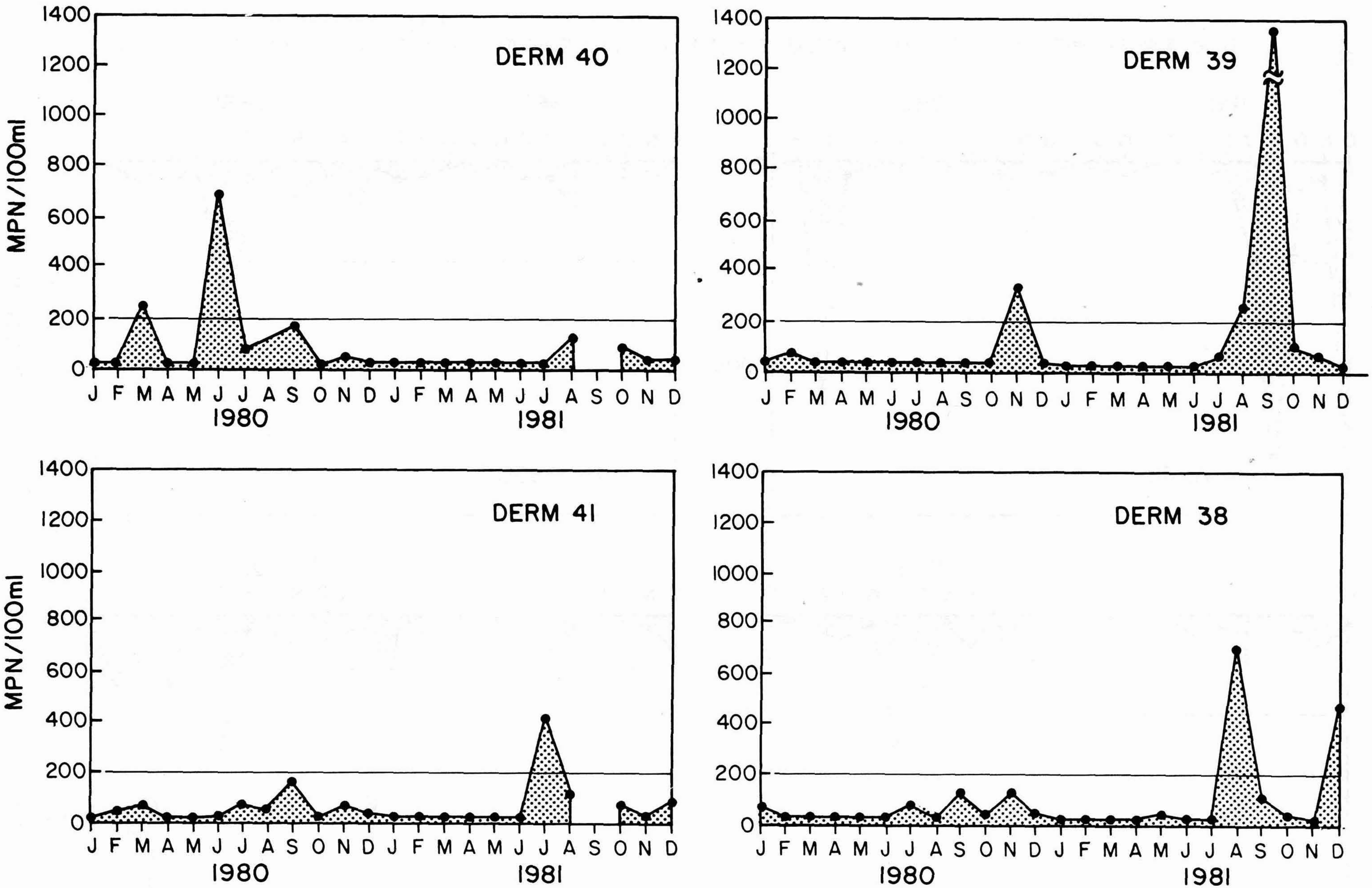

Figure 20. Fecal coliform bacteria (MPN 100 ml^{-1}) at DERM Mowry Canal sampling stations 38-41 (1980-1981).

Table 4. Bacteriological counts for DERM stations exceeding total coliform standard of 1000 MPN/100 ml or fecal coliform standard of 200 MPN/100 ml.

	Total Coliforms (MPN/100 ml)	Fecal Coliforms (MPN/100 ml)	Fecal Streptococci (MPN/100 ml)
Station 40			
March 1980	24000	270	18
June 1980	1400	700	270
December 1980	2400	18	40
Station 41			
June 1980	1700	18	18
July 1981	170	410	190
Station 39			
June 1980	1300	18	18
November 1980	790	330	18
September 1981	NA	3300	1300
Station 38			
March 1980	2400	18	18
August 1981	3300	700	20
December 1981	3300	490	20

NA = Not available

Heavy Metals and Pesticides

A limited number of heavy metal determinations in the water column and bottom sediments, as well as pesticide determinations on 21 compounds in the bottom material, were completed by the USGS at the Mowry Canal mouth (USGS 02290725) on an irregular basis from 1975-1980 . The results of these samplings are presented in Table 5 (heavy metals in water), Table 6 (heavy metals in bottom material), and Table 7 (pesticides in bottom material).

Because of the limited amount of data available for both metals and pesticides, a definitive analysis is not attempted. However, the presence of several metals in the water column and bottom materials is noted. In addition, DDT and its breakdown products, polychlorinated biphenyls (PCBs), chlordane, and dieldrin, were all detected at the Mowry Canal mouth during the period of this study.

An important point to note is that agriculture is the predominant land use in the Mowry Canal basin. While many pesticides or herbicides are used for agriculture, mosquito control, and aquatic plant control throughout the basin, little is known about the amounts or the environmental fates of the metals and pesticides applied for these purposes. Table 8 lists some of the pesticides commonly used on crops in Dade County. No local studies or monitoring activities currently exist that quantify the runoff of these materials within the basin or their possible impact upon entry into Biscayne Bay.

SUMMARY AND CONCLUSIONS

Analysis of available discharge data indicates that from water-year 1975 to water-year 1980 the Mowry Canal discharged an average of 162,234 acre-feet annually, probably more than any other canal discharging into southern Biscayne Bay.

A significant relationship was found to exist between mean monthly rainfall at Homestead Experimental Station and mean monthly discharge from the Mowry Canal over the period of this study. A stronger relationship was found if mean monthly discharge was lagged one month behind mean monthly rainfall, possibly due to water management practices within the Dade County canal system.

Water quality data available from the Dade County Department of Environmental Resources Management and the United States Geological Survey indicate that the water quality of the Mowry Canal appears to be relatively good. Among the four DERM stations in the Mowry Canal system, water temperatures did not display significant areal variability, and temperatures were within tolerances of native fish species. Dissolved oxygen concentrations at DERM station 41 were significantly lower than at the other stations, generally less than the 4.0 mg l^{-1} Dade County surface water standard, possibly due to the inflow of poorly oxygenated groundwater near L-31N. Dissolved oxygen concentrations at station 39 were significantly higher than at the other stations for an unknown reason. Specific conductance at station 38, near Biscayne Bay, was significantly higher than more inland sites due to the occasional backflow of brackish water. Secchi disc transparencies were similar at all DERM stations with the exception of station 41, where clarity was significantly reduced for an unknown reason. Alkalinity

Table 5. Heavy metal concentrations (water column) in Mowry Canal at S-20F (USGS 02290725).

	As	Cu	Cd	Fe		Pb		Mn		Ni	Sr	Zn	Al	Hg
	Total 01002 $ug\ l^{-1}$	DIS 01040 $ug\ l^{-1}$	TR 01027 $ug\ l^{-1}$	DIS 01046 $ug\ l^{-1}$	TR 01045 $ug\ l^{-1}$	DIS 01049 $ug\ l^{-1}$	TR 01051 $ug\ l^{-1}$	DIS 01056 $ug\ l^{-1}$	TR 01055 $ug\ l^{-1}$	TR 01067 $ug\ l^{-1}$	DIS 01080 $ug\ l^{-1}$	DIS 01090 $ug\ l^{-1}$	TR 01105 $ug\ l^{-1}$	TR 71900 $ug\ l^{-1}$
31 Oct 75	1	ND	2	10	20	3	7	10	10	-	1200	4	-	.5
23 Jan 76	1	2	2	10	160	34	9	10	10	ND	970	ND	100	.5
26 Apr 76	1	2	ND	10	50	18	38	10	10	4	1300	20	30	.6
30 Nov 76	1	2	-	10	-	12	-	4	-	-	910	2	-	.6
14 Apr 77	1	-	ND	-	80	-	80	-	10	4	1100	-	-	.5
19 Oct 77	3	-	9	-	10	-	170	-	10	9	830	-	-	.5
04 Apr 78	2	-	ND	-	30	-	7	-	10	-	900	-	-	1.1
05 Mar 79	1	-	ND	-	50	-	7	-	10	-	950	-	-	.5
20 Jun 79	4	-	2	-	110	-	7	-	10	-	-	-	-	.5
06 Mar 80	1	-	0	-	50	-	1	-	10	-	1100	-	-	.5
22 Jul 80	4	-	3	-	150	-	5	-	10	-	-	-	-	.1
n	11	4	10	4	4	4	10	4	10	4	9	4	2	11
$\bar{x}$	1.8	1.5	1.8	10	10	16.8	33.1	8.5	10	4.2	1029	6.5	65	0.53

ND = Not detected
DIS = Dissolved
TR = Total recoverable
Total = Total

Data provided by USGS via WATSTORE data retrieval

Table 6. Total heavy metal concentrations in bottom material in Mowry Canal at S-20F (USGS 02290725).

	As $ug\ g^{-1}$	Cu $ug\ g^{-1}$	Cd $ug\ g^{-1}$	Fe $ug\ g^{-1}$	Pb $ug\ g^{-1}$	Mn $ug\ g^{-1}$	Zn $ug\ g^{-1}$
23 Jan 76	5	10	10	1100	10	50	10
14 Apr 77	4	10	10	500	20	10	10

Data provided by USGS via WATSTORE data retrieval

Table 7. Pesticides in bottom material at USGS station 02290725. All concentrations are reported as ug kg^{-1}

	Aldrin 39333	Lindane 39343	Chlordane 39351	DDD 39363	DDE 39368	DDT 39373	Dieldrin 39383	Endrin 39393	Ethion 39399	Toxaphene 39403	Heptachlor 39413
23 Jan 76	.0	.0	.0	.0	33	3.7	.0	.0	-	.0	.0
14 Apr 77	.0	.0	.0	13	35	.0	.0	.0	.0	.0	.0
05 Mar 79	.0	.0	11	.0	3.0	.0	.0	.0	-	.0	.0
06 Mar 80	.0	.0	.0	1.2	1.6	.0	.4	.0	.0	.0	.0
n	4	4	4	4	4	4	4	4	2	4	4
$\bar{x}$	0.0	0.0	2.75	3.55	18.15	0.92	0.1	0.0	0.0	0.0	0.0

	PCB 39519	Malathion 39531	Parathion 39541	Diazinon 39571	Methyl Parathion 39601	2,4D 39731	2,4,5-T 39741	Silvex 39761	Trithion 39787	Methyl Trithion 39791
23 Jan 76	10	-	-	-	-	-	-	-	-	-
14 Apr 77	0	.0	.0	.0	.0	0	0	0	.0	.0
05 Mar 79	110	-	-	0	-	0	0	0	-	-
06 Mar 80	470	.0	.0	.0	.0	-	-	-	.0	.0
n	4	2	2	2	2	2	2	2	2	2
$\bar{x}$	147.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Data provided by USGS via WATSTORE data retrieval.

Table 8. Common agricultural pesticides utilized in Dade County, Florida (1980-1981).

Crop	Dade County Acreage (1978-79)	Commonly used pesticides		
Tomatoes	10,750	Maneb Mancozeb Copper	Methomyl Methyl Bromide Methamidophos	Permethrin Chloropicrin Chlorothalonil
Beans	7,650	Sulfur Maneb Mancozeb	Methomyl Trifluralin Dimethoate	
Potatoes	6,000	Mancozeb Phorate Ethylene Dibromide	Methimidophos Carbaryl	
Squash	3,400	Sulfur Methomyl Acephate	Maneb Mancozeb	
Sweet Corn	3,500	Parathion Mancozeb Methomyl		
Avocados	7,700	Dicofol Malathion Mancozeb	Copper Benomyl Ethion	
Field Corn	-	Atrazine Methomyl	Maneb Chlorpyrifos	
Variable	-	Paraquat Zineb Glyphosate	Aldicarb Simazine Carbophenothion	Fonofos Diazinon Fenaminosulf

Note: The above list has been assembled from several sources including the Florida Department of Environmental Regulation, Dade County Cooperative Extension Service, Institute of Food and Agricultural Sciences (University of Florida), and various growers and supply houses in Dade County.

concentrations and pH value mesurements at the USGS station fell within a relatively narrow range, and were typical of the generally well buffered fresh-waters of the region.

Nutrient data indicates that a high nitrogen loading exists in the area of C-103N, as the highest nitrite plus nitrate nitrogen concentrations occurring in the Dade County canal system are reported here. Total phosphorus concentrations at the USGS station were found to be very low throughout the period of record.

Bacteriological counts at the four DERM stations indicate that in general bacteriological contamination in the Mowry Canal system is not a problem, and counts were typically the lowest reported in Dade County canals.

A number of heavy metals and pesticides have been detected in the sediments at the USGS station. However, a paucity of data prevents a definitive understanding of the situation at this time.

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The authors would like to express their appreciation to the following individuals and organizations for their assistance and cooperation in completing this report. Bob Brown of the South Florida Water Management District provided basin delineations for southeastern Dade County. Jim Labowski of the Dade County Department of Environmental Resources Management provided information and data from the DERM Canal Monitoring Program. Bob Usherson of the Dade County Planning Department was instrumental in providing the 1980 aerial land use photographs from which land use within the Mowry Canal basin was determined. Dr. David Parkhurst of Indiana University provided helpful insight into the statistical analysis. Finally, we would like to express our appreciation to Dr. John S. Zogorski of South Dakota School of Mines, Dr. Robert Hirsch and Dr. David Rickert both of the USGS (Water Resources Division, Reston, Virginia), and the Resources Management staff of Biscayne National Park who reviewed this manuscript, and Dee Childs and Jessie Brundige who typed the manuscript.

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