UNITED STATES DEPARTMENT OF THE INTERIOR

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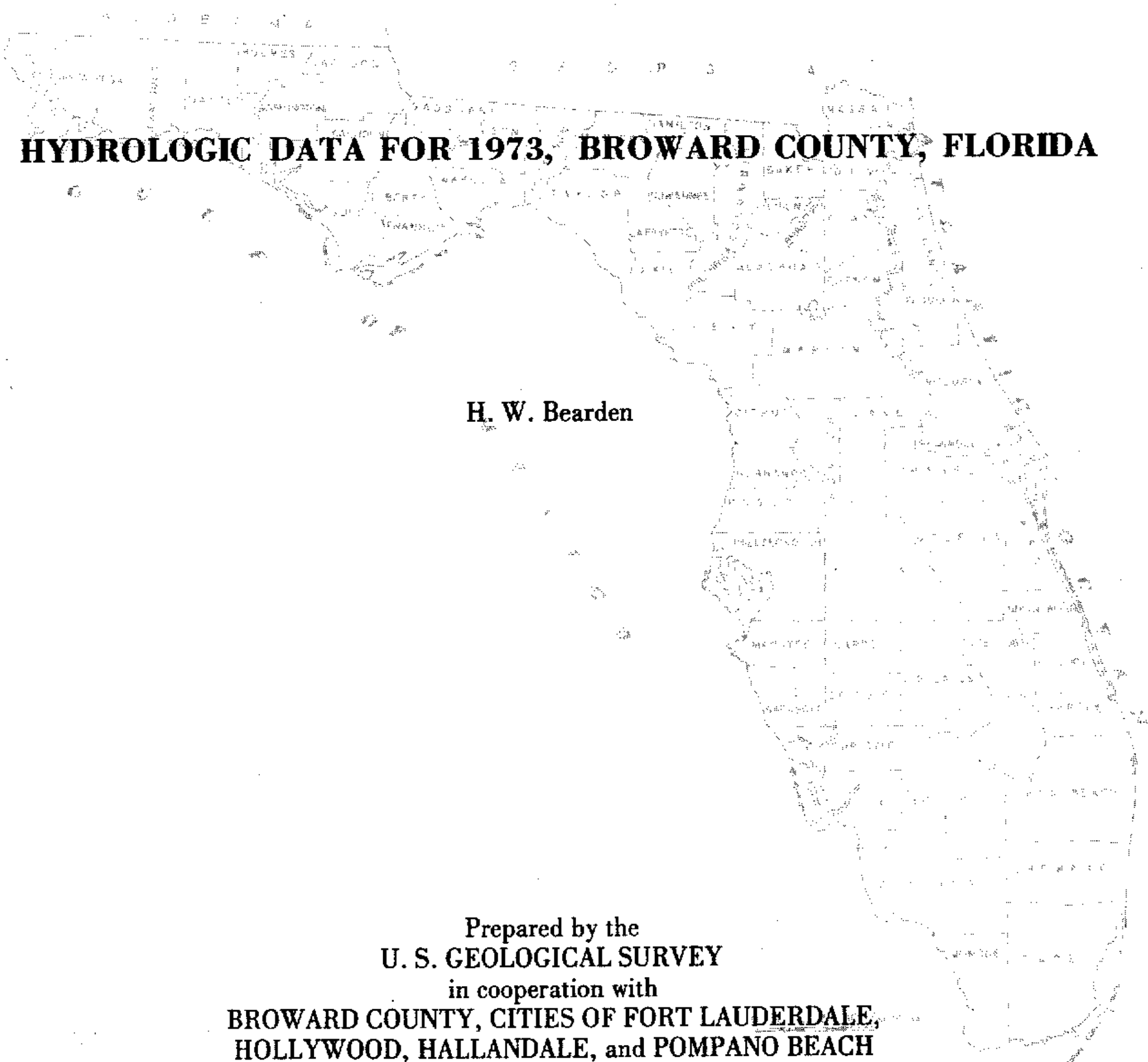

HYDROLOGIC DATA FOR 1973, BROWARD COUNTY, FLORIDA

H. W. Bearden

Prepared by the
U. S. GEOLOGICAL SURVEY
in cooperation with
BROWARD COUNTY, CITIES OF FORT LAUDERDALE,
HOLLYWOOD, HALLANDALE, and POMPANO BEACH
BUREAU OF GEOLOGY, FLORIDA DEPARTMENT OF NATURAL RESOURCES,
and
CENTRAL AND SOUTHERN FLORIDA FLOOD CONTROL DISTRICT

Tallahassee, Florida

1974

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
TALLAHASSEE, FLORIDA
32303

From... Clyde S. Conover
Water Resources Division
325 John Knox Road
Suite F-240

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ILLUSTRATIONS (Cont'd)

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TABLES

HYDROLOGIC DATA FOR 1973, BROWARD COUNTY, FLORIDA

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INTRODUCTION

This report, the third of an annual series presenting hydrologic data in Broward County, Florida (fig. 1), includes hydrologic data for the 1973 water year. In it these data are compared with long-term records from rainfall, ground-water, surface-water, and water-quality stations.

In Geological Survey reports dealing with hydrologic data, records are presented for a water year -- October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months of that year. Thus, the year ended September 30, 1973, is called the "1973 water year." Where practicable, all data in this report are presented in water-year form.

The purpose of this report is to summarize hydrologic data on an annual basis for short-term water-management planning. For example, the year after a year of persistently low water levels (little rainfall) requires different water-management planning than the year after one of average or high water levels.

Major changes in hydrologic conditions in any year generally are a direct result of the amount and distribution of rainfall during that year. Major areal changes in conditions which may be permanent, result from construction of canals for drainage, establishment of controls on canals, withdrawals, and other such actions.

The cooperative program of water resources studies between the U.S. Geological Survey and the Broward County Board of Commissioners is conducted through the Water Resources Department and the Air and Water Pollution Control Board of Broward County.

WATER MANAGEMENT

There are two types of canals in Broward County, primary canals and secondary canals (fig. 2). Primary canals are regulated daily by the FCD (Central and Southern Florida Flood Control District) to maintain ground water levels and scheduled storage for each season and to provide flood protection. Secondary canals are maintained by the Broward County Water Resources Department and are used for drainage. Both agencies work cooperatively to operate the overall canal system as effectively as possible. During the wet season, when rainfall is high, water is discharged from the aquifer to the canal system and transported to the conservation areas or to the ocean. During the dry season, when rainfall is low, water is transported through the canal system from the

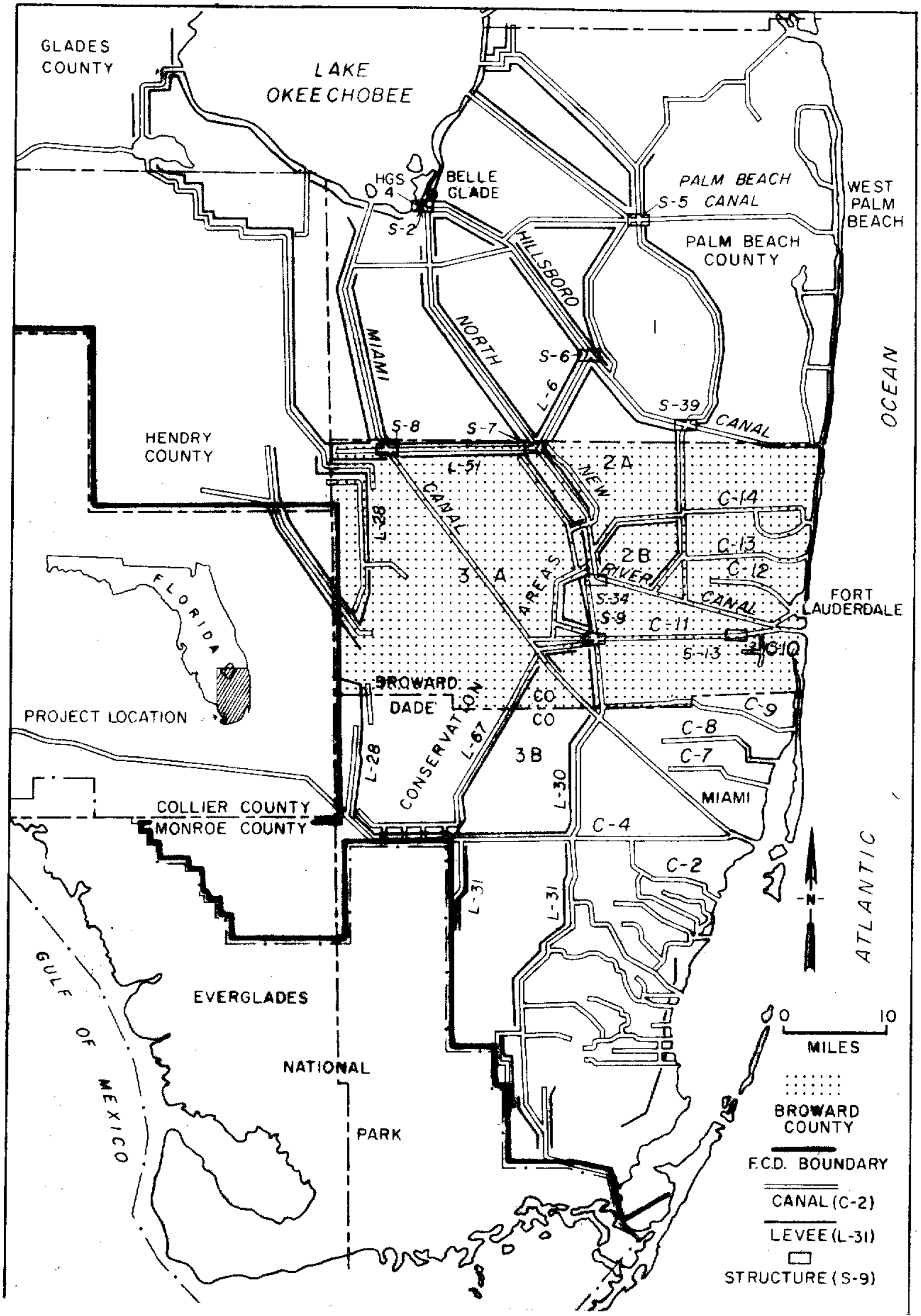


Figure 1.--Location of Broward County and the southeastern part of the FCD (Central and Southern Florida Flood Control District).

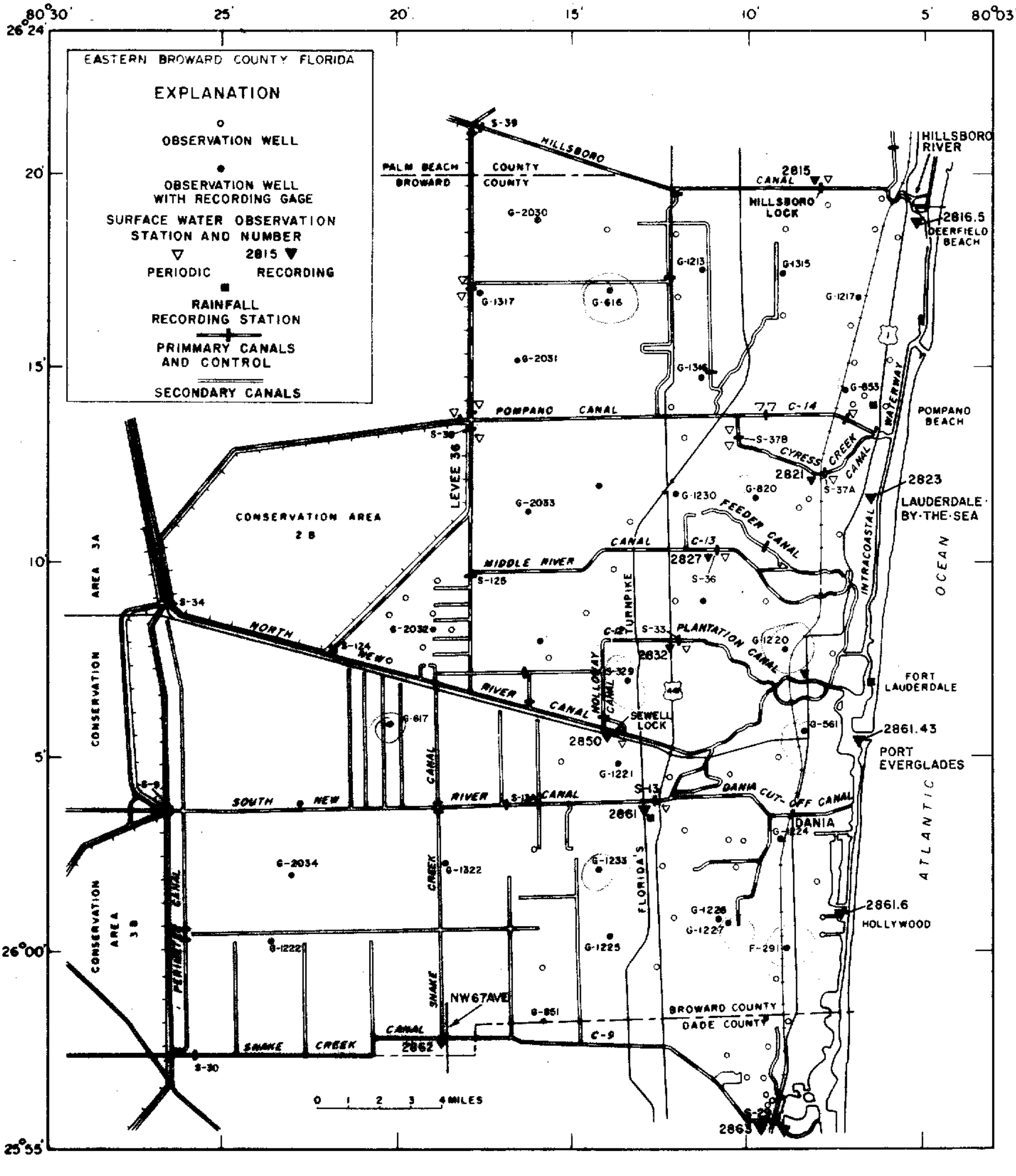


Figure 2.--Surface-water observation stations, rainfall stations, and observation wells in the east half of Broward County.

conservation areas for aquifer recharge in areas where ground-water use is large.

DATA COLLECTION

County-wide water-level fluctuations in the aquifer are monitored in 85 wells, 30 of which are equipped with recording instruments (fig. 2). Data from these wells help determine the effectiveness of the canal network in the county and aid in water management. Additional wells are in or near the clusters of municipal wells to monitor the effects of pumping.

A continuous record of stage and discharge was obtained from each of seven gaging stations (fig. 2) in canals in Broward County during the 1973 water year. The record for one station in Dade County, Snake Creek Canal at S-29, is also discussed in the report. The stations, except Snake Creek Canal at Northwest 67th Avenue (station 2862), are located at the eastern control structures in the canals. Tidal fluctuations in the Intracoastal Waterway are recorded at 4 stations (fig. 2).

Rainfall records from four stations in Broward County, 3 coastal and 1 inland station, are used in this report. The 3 coastal stations, Pompano, Fort Lauderdale, and Dania, are shown in figure 2. The inland station is located at the S-7 pump station on North New River Canal (fig. 1).

Samples are collected semi-annually at 27 sites (fig. 3) in primary canals in Broward County for chemical analysis of principal cations and anions and pesticides. Samples for analysis of nitrogen and phosphorus species and bacteria are collected at these sites quarterly. The cations and anions are commonly reported in milligrams per liter. Pesticides are generally reported in micrograms per liter. Field determinations of DO (dissolved oxygen), pH, temperature, specific conductance, and alkalinity are made at 4-hour intervals during a 24-hour period each quarter at the 27 sites.

Samples for chloride analysis are collected monthly at the salinity control structures and at selected sites in the tidal canals (fig. 3) and specific conductivity recorders are maintained in three canals near the centers of ground-water withdrawals.

Water samples for chloride analysis are collected semi-annually from the wells shown in figure 3 to determine the position of the salt front in the aquifer and to monitor its movement.

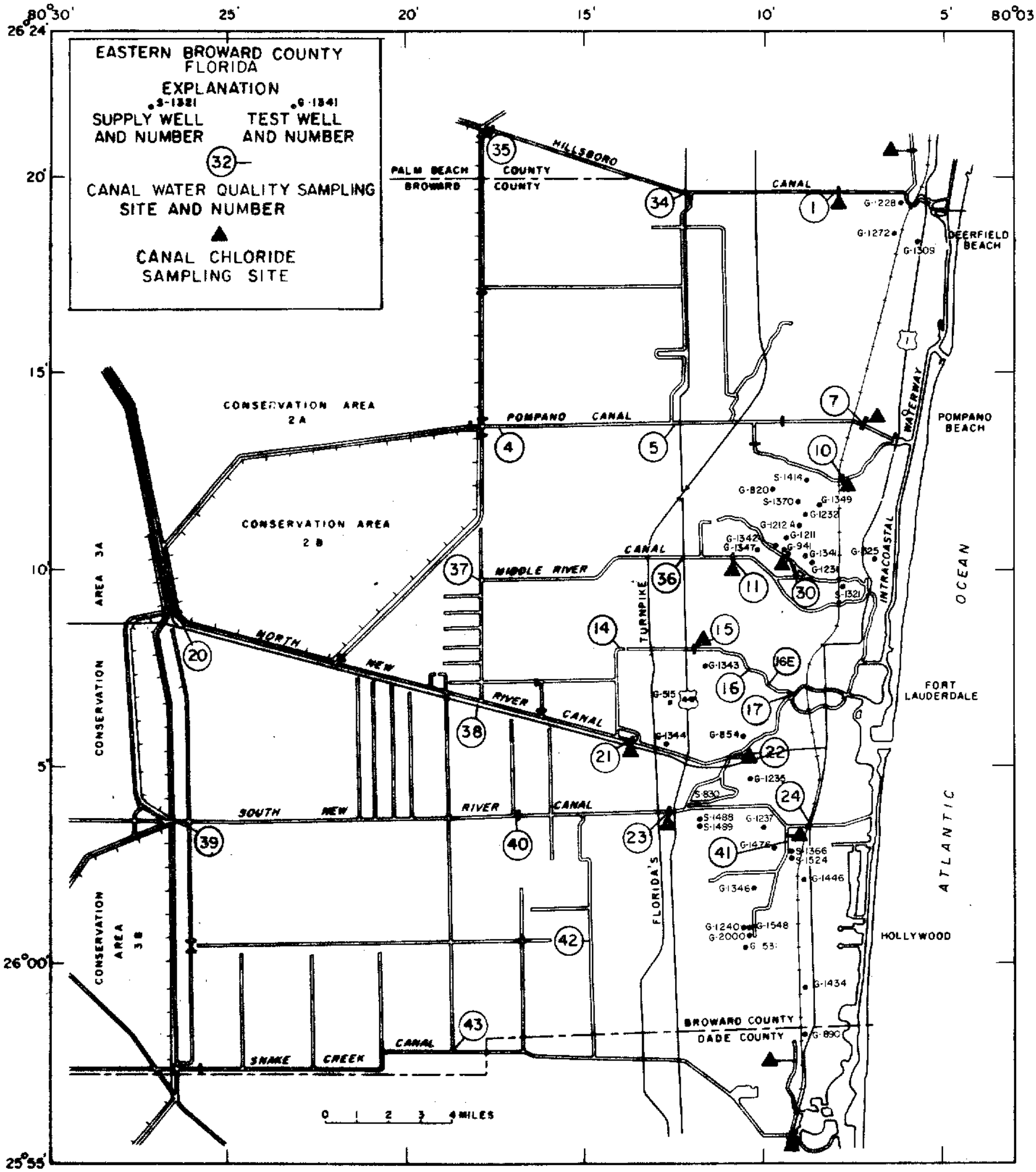


Figure 3.--Location of wells and canal sites sampled for chloride analysis, and canal water-quality sampling sites.

RAINFALL

The average water-year rainfall in Broward County, on the basis of 30 years of record (1943-1972), is 58.60 inches (table 1). Rainfall averaged 49.08 inches during the 1973 water year; 9.52 inches (16 percent) below the 30-year average. The average water-year rainfall for 1943-72 at the four stations varies from 62.71 inches at Fort Lauderdale in the coastal sector to 52.31 inches at North New River Canal in the inland sector. Rainfall also varies within a year. Usually the 5 months, June-October, account for more than 60 percent of the yearly total.

Rainfall was 7.19 inches below the 30-year average in the coastal areas (table 1) during the 1973 water year. Most of the deficiency occurred in October when rainfall was 7.59 inches below its monthly average and in April when rainfall was 1.76 inches below average (fig. 4). Rainfall exceeded the average in November by 2.78 inches and in August by 4.39 inches. Rainfall was 20 percent or less below average for the other months during the year.

Rainfall at the inland station, North New River at S-7, was 16.5 inches below the 30-year average during the 1973 water year and was below the average during each month except November and August.

GROUND WATER

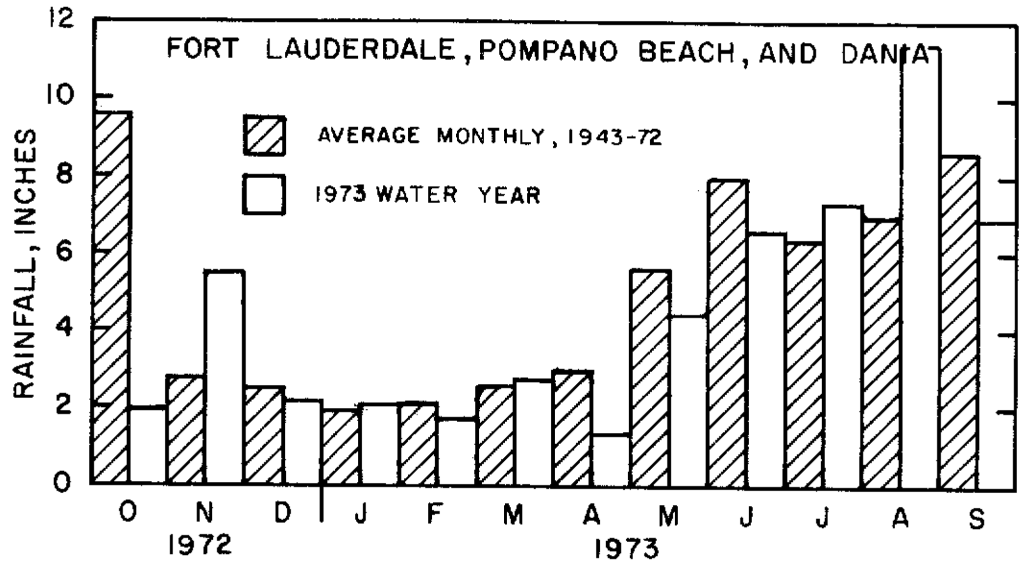
Ground water is the water in the zone of saturation--the zone in which the interstices, joints, crevices, fissures, solution holes, and all other voids are filled with water. A formation, group of formations, or part of a formation that contains sufficient saturated material to yield significant quantities of water to wells, are called aquifers (Lohman and others, 1972). The Biscayne aquifer is the source of all fresh ground water in Broward County.

The Biscayne aquifer in Broward County is composed chiefly of permeable limestone, sandstone, and sand that range in age from late Miocene through Pleistocene (Sherwood and others, 1973). The aquifer extends from land surface to more than 200 feet in depth along the coastal areas of Broward County and decreases in thickness westward until it pinches out at the surface near the Collier-Broward County line. The aquifer is underlain by massive beds of marine sediments and marl of low permeability.

The amount of fresh ground water in storage in the aquifer is determined by the recharge to and discharge from the aquifer. Infiltration of rainfall through surface materials and seepage from controlled canals and the conservation areas constitute the recharge. Discharge from the aquifer occurs by evapotranspiration, by ground-water flow to canals and the ocean, and by pumping from wells.

Table 1.--Summary of rainfall data by stations.

Location	1973 Water Year	Water Year Average (1943-72)
Eastern sector (coastal):		
Dania	45.59	57.01
Fort Lauderdale	60.31	62.36
Pompano	54.59	62.71
Average	53.50	60.69
Western sector:		
North New River Canal at S-7	35.81	52.31
Average of above stations	49.08	58.60



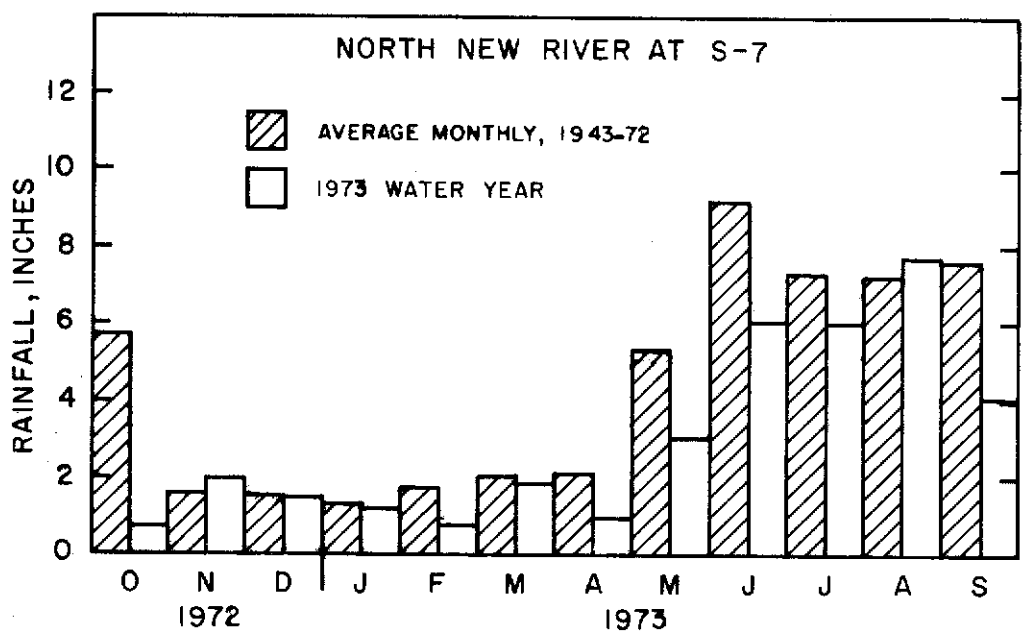


Figure 4.--Monthly rainfall for the 1973 water year and the average monthly rainfall, 1943-72, at Fort Lauderdale, Pompano Beach, Dania, and North New River canal at S-7.

Rainfall is the major source of recharge, thus, area-wide water levels in the aquifer fluctuate chiefly in response to variations in rainfall (figs. 5 and 6). During the wet season, water levels in the aquifer are high; during the dry season, water levels are low. Rainfall in Broward County during the 1973 water year was 16 percent below average; consequently, water levels in the aquifer during most of the year were slightly below average (figs. 5-8). The October 1972 water levels in wells G 616 and G 1220 were lower than the extreme low-water levels for 1962-72. This lower water level in G 616 persisted into November. Water levels were low until the heavy rains started in July 1973. In August 1973 water levels approached the extreme high levels for the period of record.

To prepare water-level contour maps, water-level measurements are made in the observation wells in Broward County (fig. 2) during the wet and dry seasons each year to obtain the extreme aquifer conditions for the year. The configuration of the water table, the hydraulic gradients, and the general direction of ground-water movement can be determined from the contours. Record high levels on November 1, 1965 (fig. 9) were the result of several days of heavy rainfall during a hurricane. Record low levels on May 5 1971 (fig. 10) were the result of several months of deficient rainfall and heavy withdrawals from wells during these months.

Ground-water levels in Broward County during the 1973 low-water period (fig. 11) were almost as low as during the 1971 record low-water period (fig. 10), although January-April rainfall was 7.58 inches in 1973 and 1.94 inches in 1971. Water levels in the areas adjacent to Middle River Canal were about 1-foot higher in 1973 and in the vicinity of well G-1222 were about 1-foot lower in 1973. Water levels in the vicinity of U.S. Highway 441 and Hillsboro Canal are maintained relatively high year-round by a local drainage district which pumps water from Hillsboro Canal into the secondary canals in the area. The low-water levels in 1973 (fig. 11) reflects the increased ground-water withdrawals.

Broward County's two major water suppliers are Fort Lauderdale and Pompano Beach. Fort Lauderdale operates two well fields, Prospect and Dixie (fig. 11). On May 9, 1973, during the height of the dry season, water levels in all three pumping centers were extremely low (figs. 12-17). In Pompano Beach well field and in Fort Lauderdale's Dixie well field water levels were about the same as in 1971 (fig. 10) and in adjacent areas slightly higher than in 1971. Water levels in the Prospect well field were about 1 foot higher in 1973 than in 1971, although pumpage was greater in 1973. For the 7-day period ending May 5, 1971 total pumpage from the Prospect well field was 186.5 mg (million gallons); for the 7-day period ending May 9, 1973 total pumpage was 261.5 mg - an increase of 75 mg (40 percent). Total pumpage for the same period increased 9.1 mg (7 percent) in the Pompano Beach well field in 1973 and decreased 4 mg (0.57 percent) in the Dixie well field in 1973.

A canal was dredged to increase recharge to the Biscayne aquifer

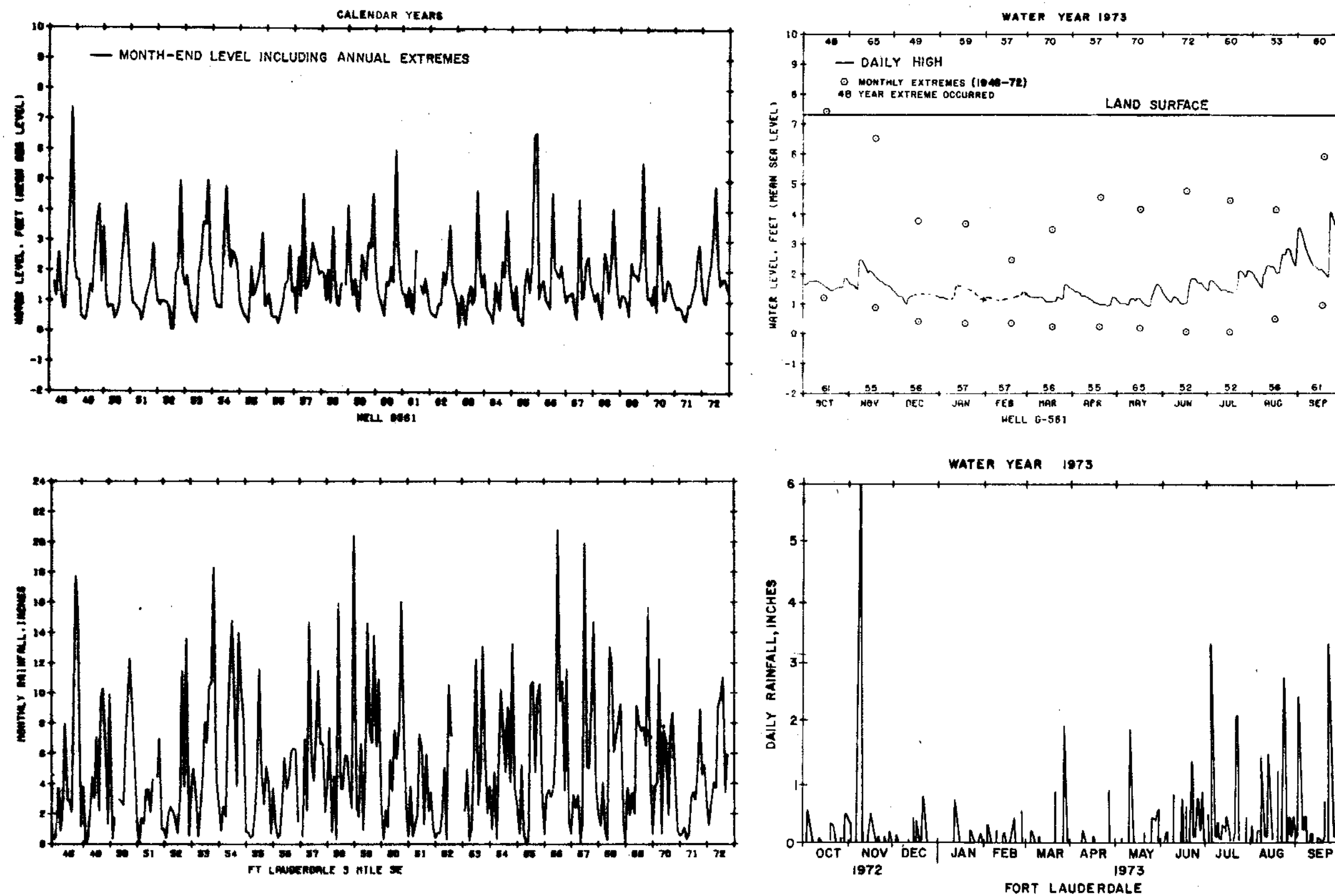


Figure 5.--Hydrographs of well G 561 and rainfall at Fort Lauderdale for the 1973 water year and 1948-72 calendar years.

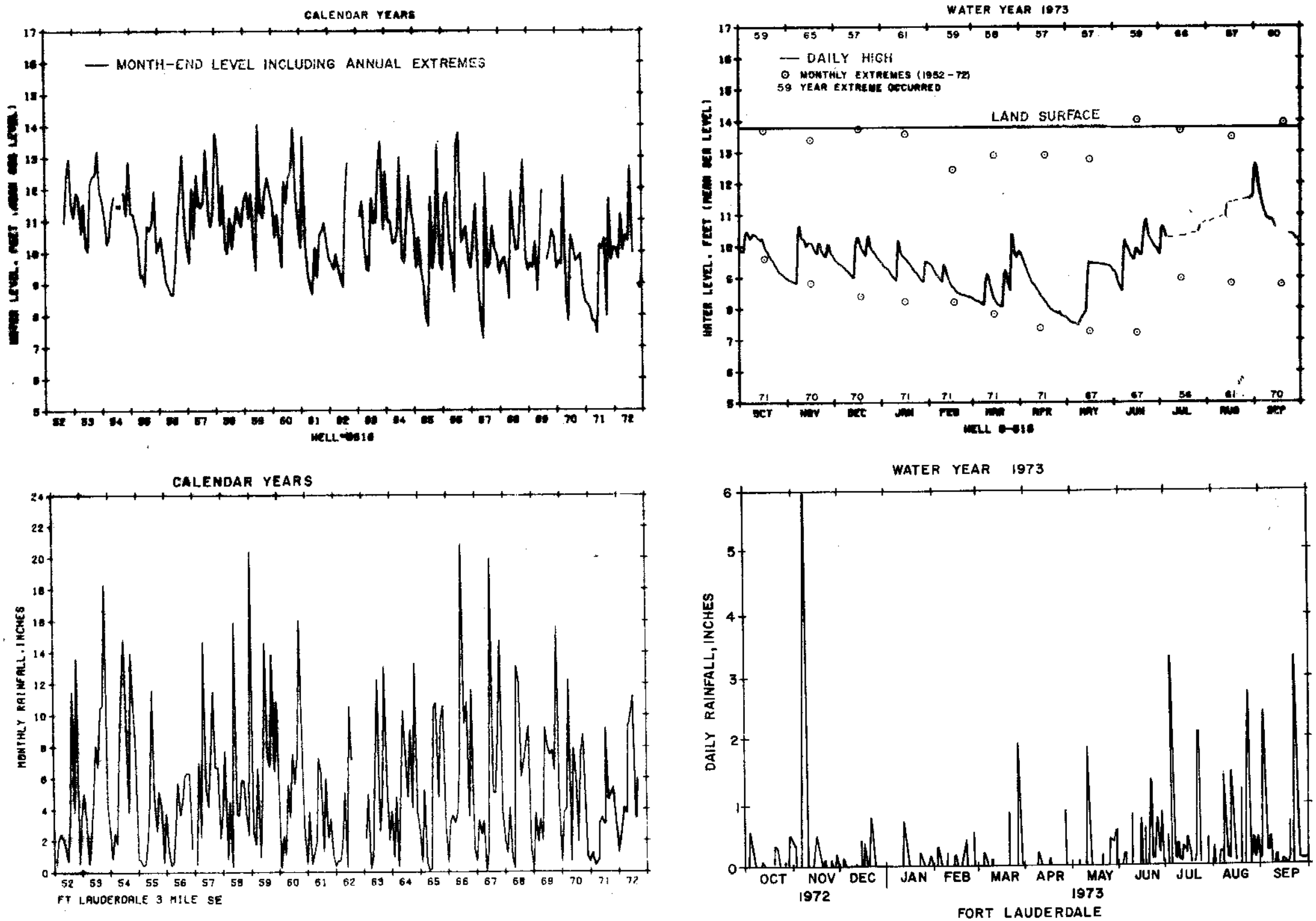


Figure 6.--Hydrographs of well G 616 and rainfall at Fort Lauderdale for the 1973 water year and 1952-72 calendar years.

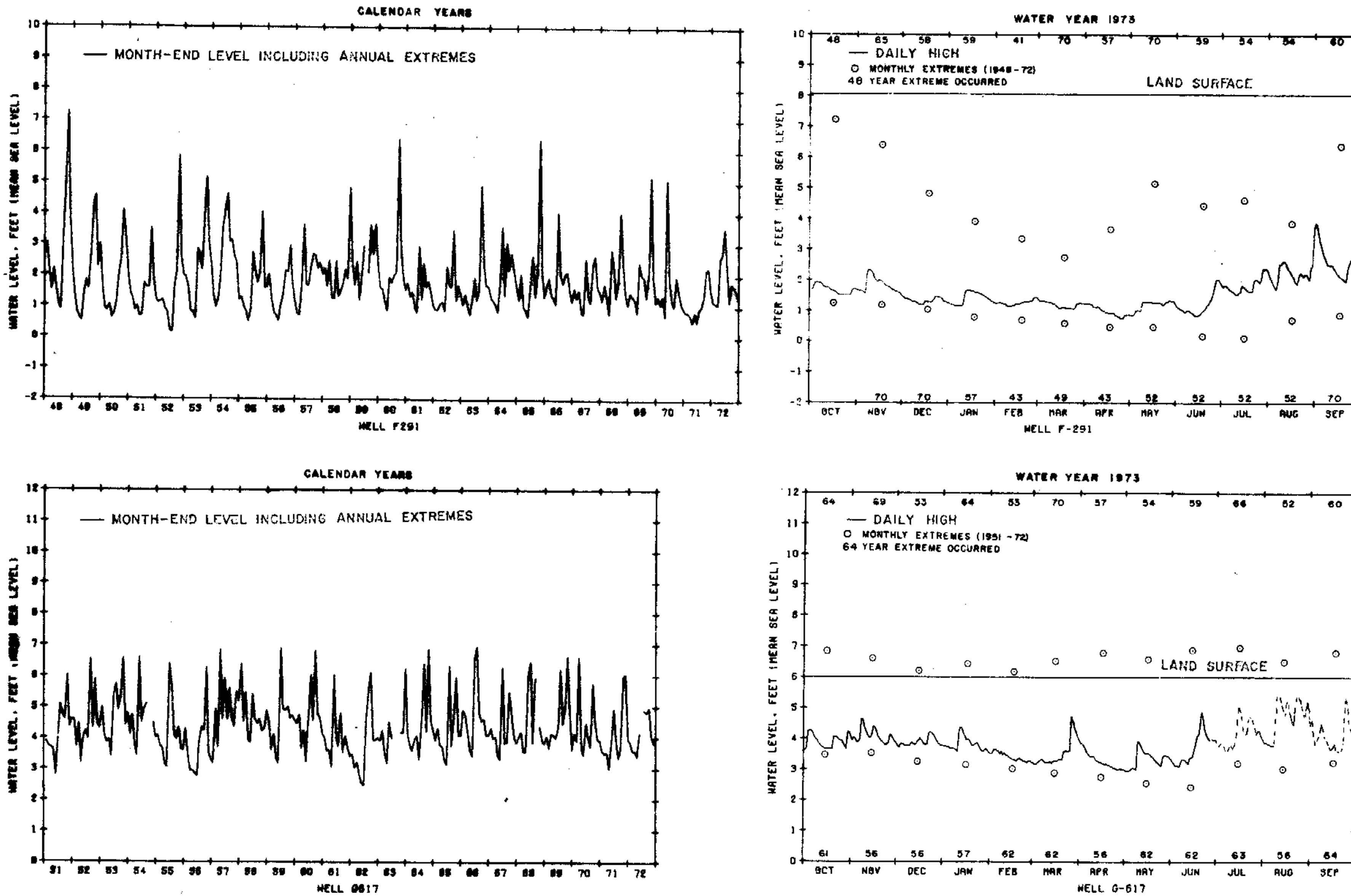


Figure 7.--Hydrographs of wells F-291 and G-617 for the 1973 water year and 1948-72 and 1951-72 calendar years, respectively.

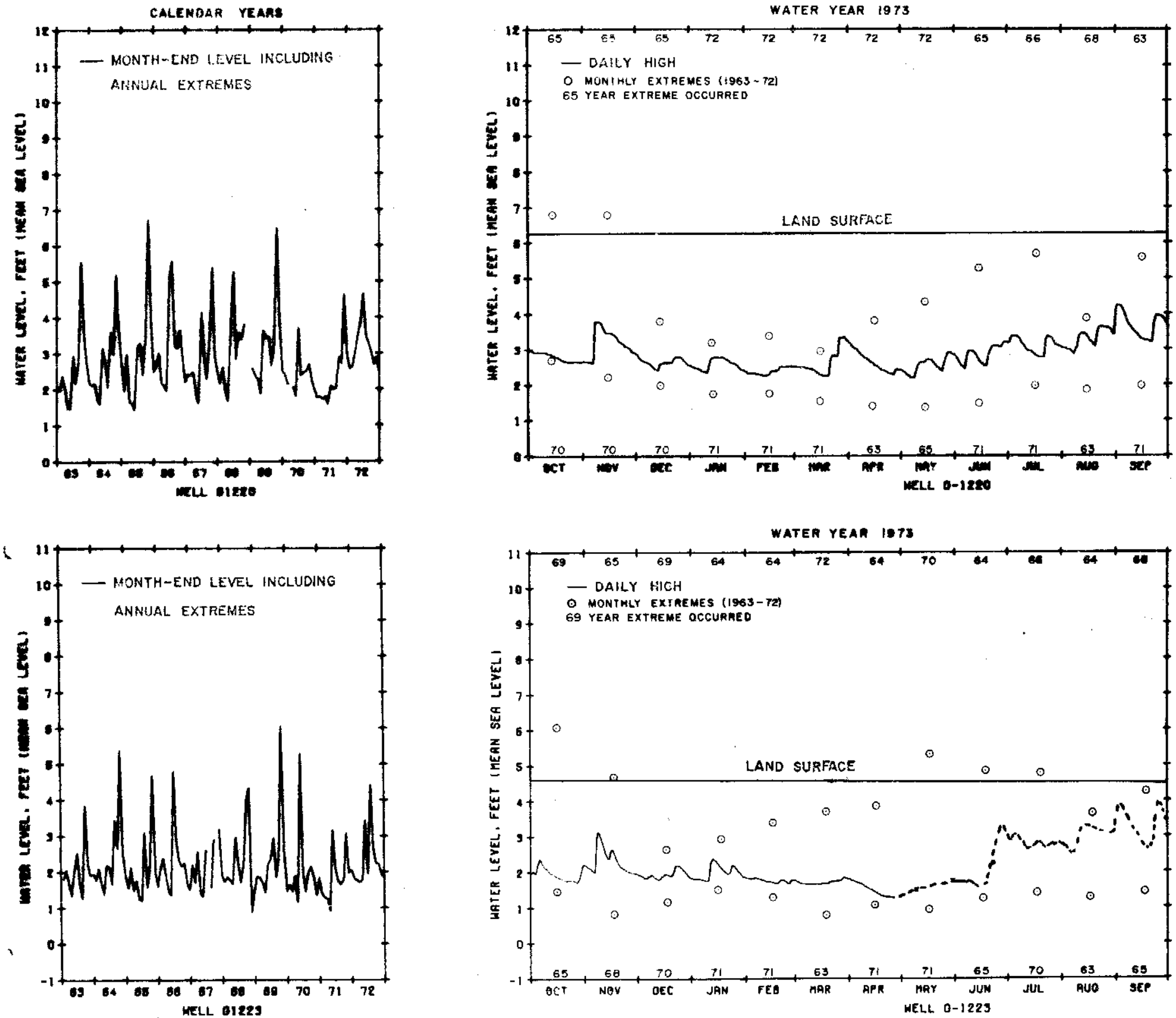


Figure 8.--Hydrographs of wells G 1220 and G 1223 for the 1973 water year and 1963-72 calendar years.

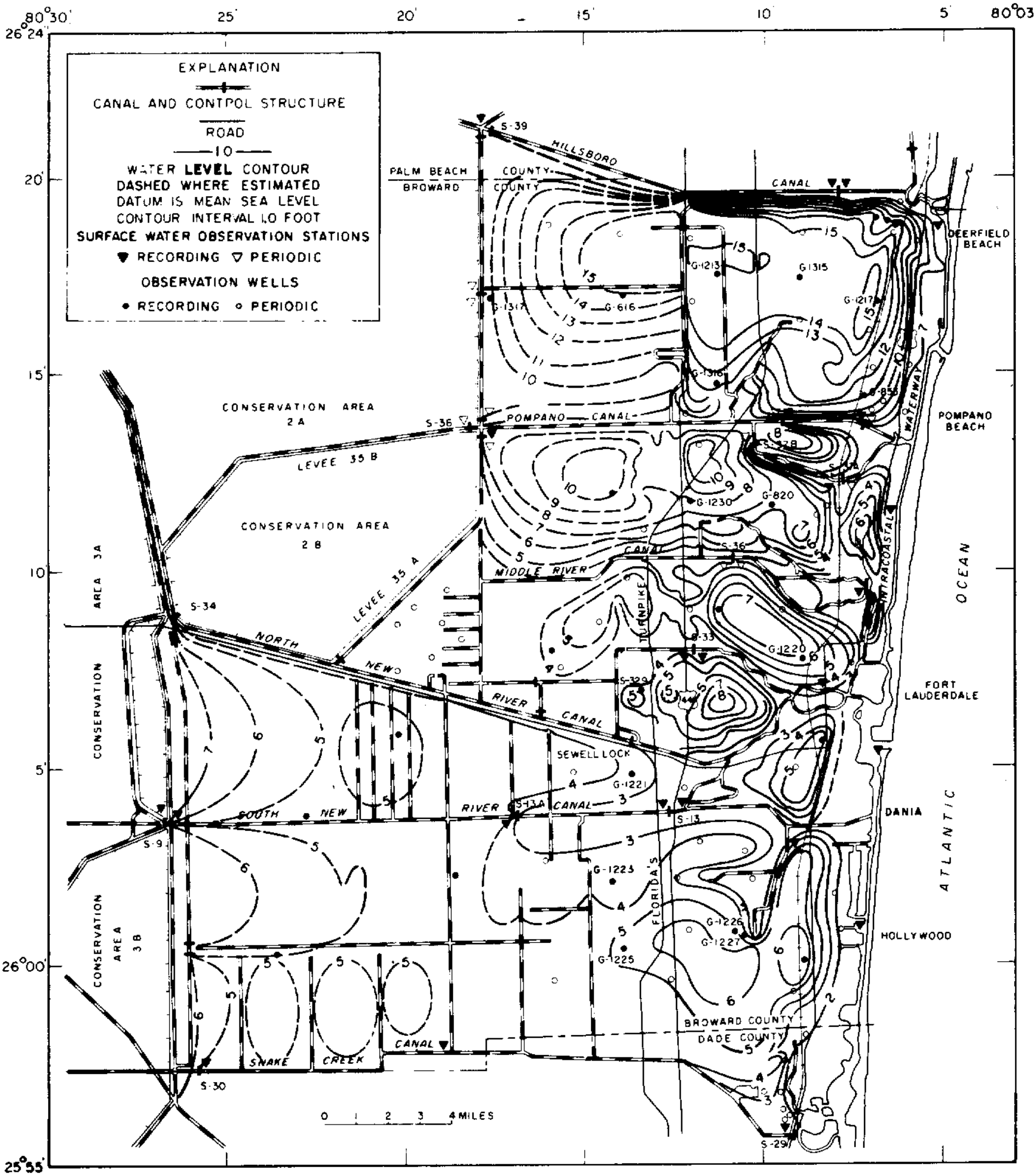


Figure 9.--Water-level contour map of eastern Broward County during record high water levels, November 1, 1965.

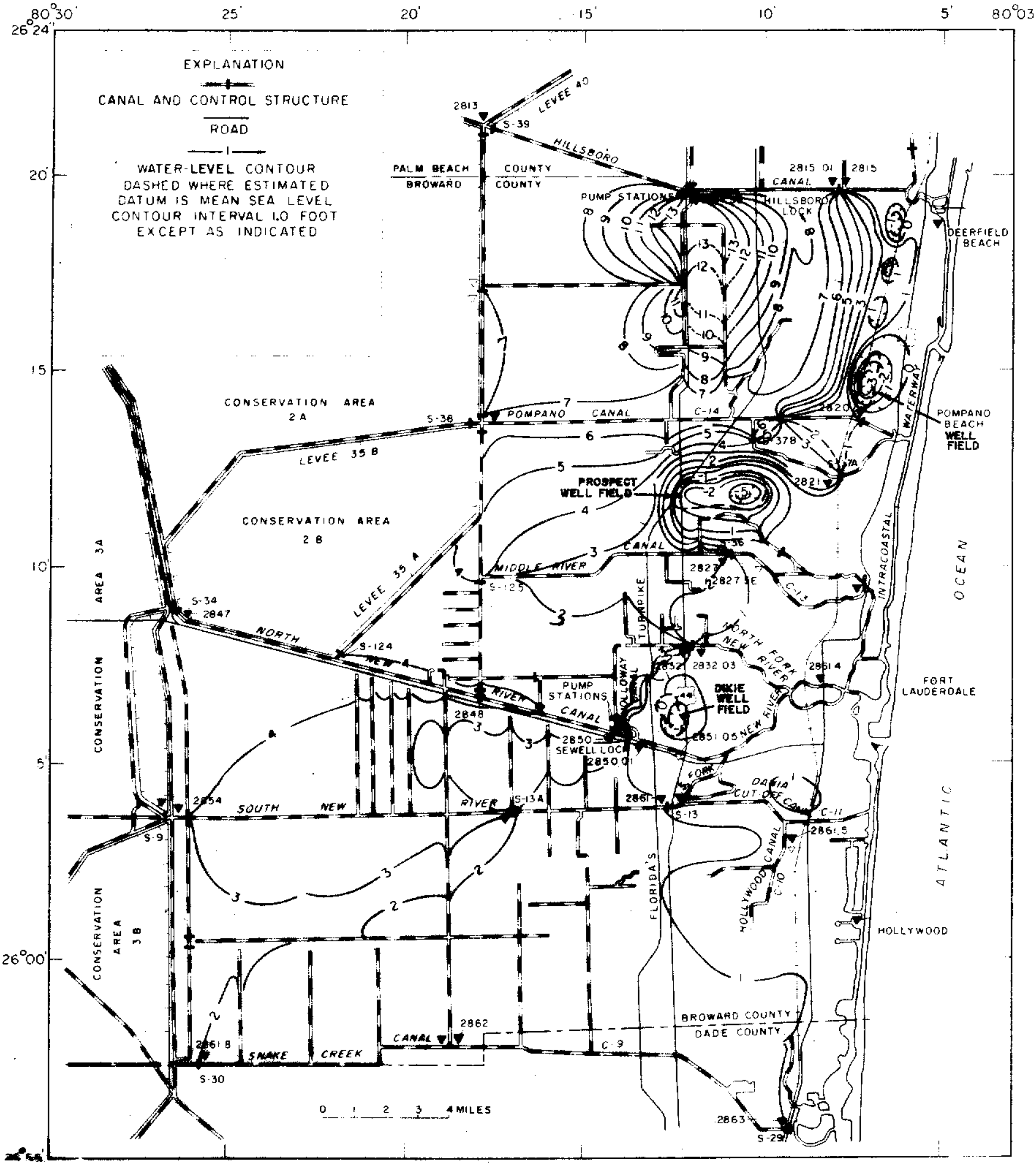


Figure 10.--Water-level contour map of eastern Broward County during record low-water levels, May 5, 1971.

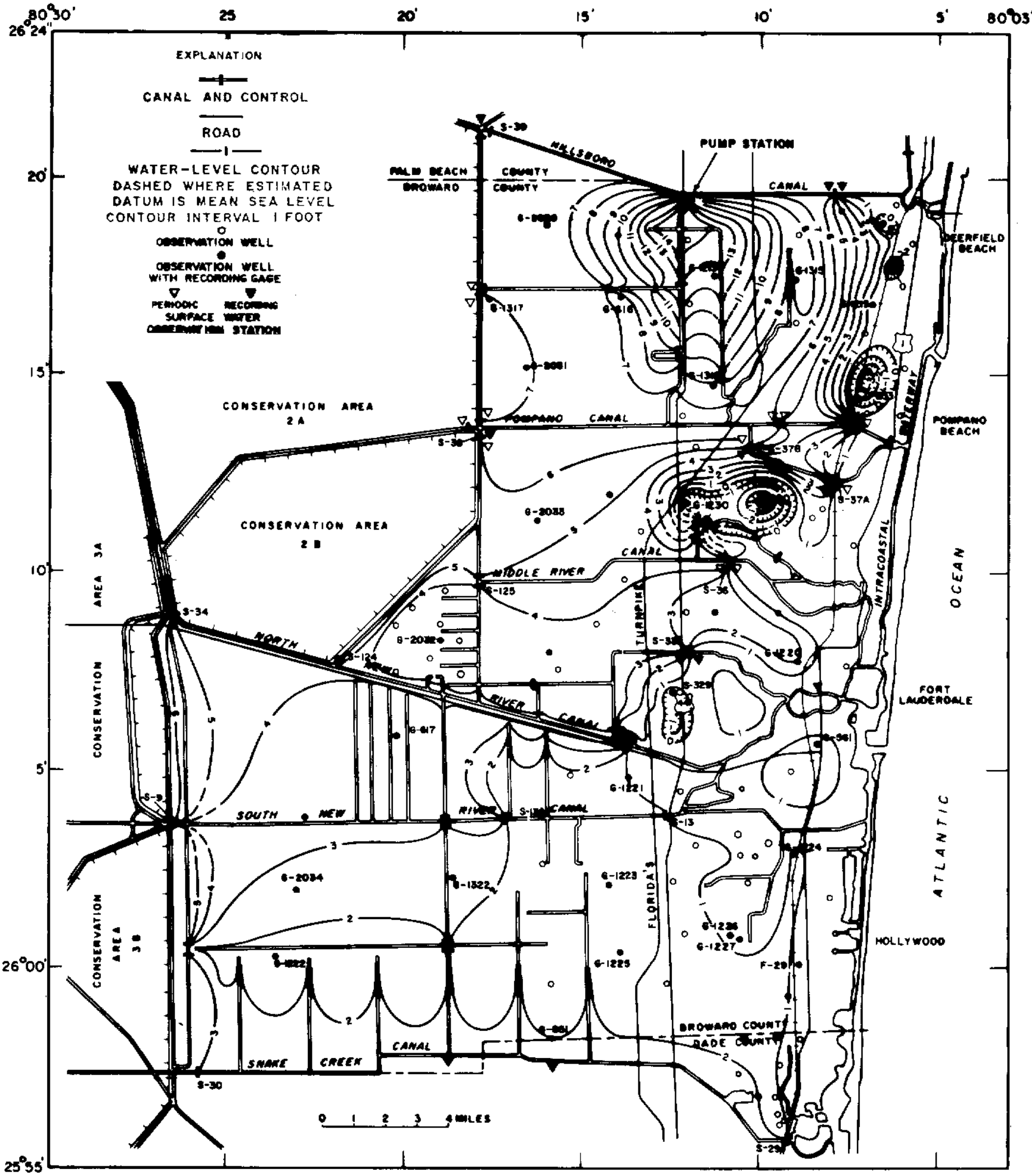


Figure 11.--Water-level contour map of eastern Broward County during low-water levels, May 9, 1973.

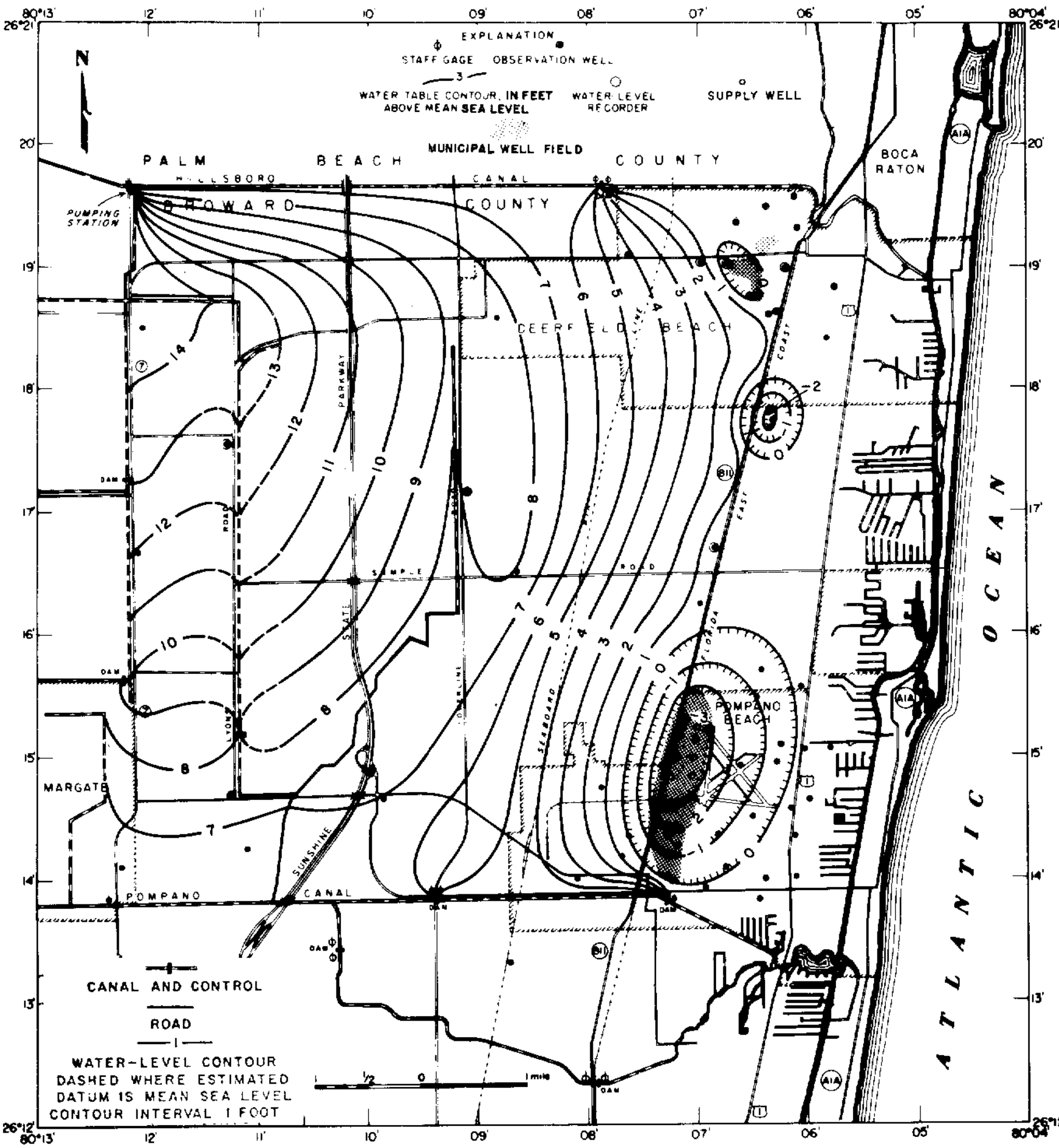


Figure 12.--Water-level contour map of the Pompano Beach well field and surrounding area during low-water levels, May 9, 1973.

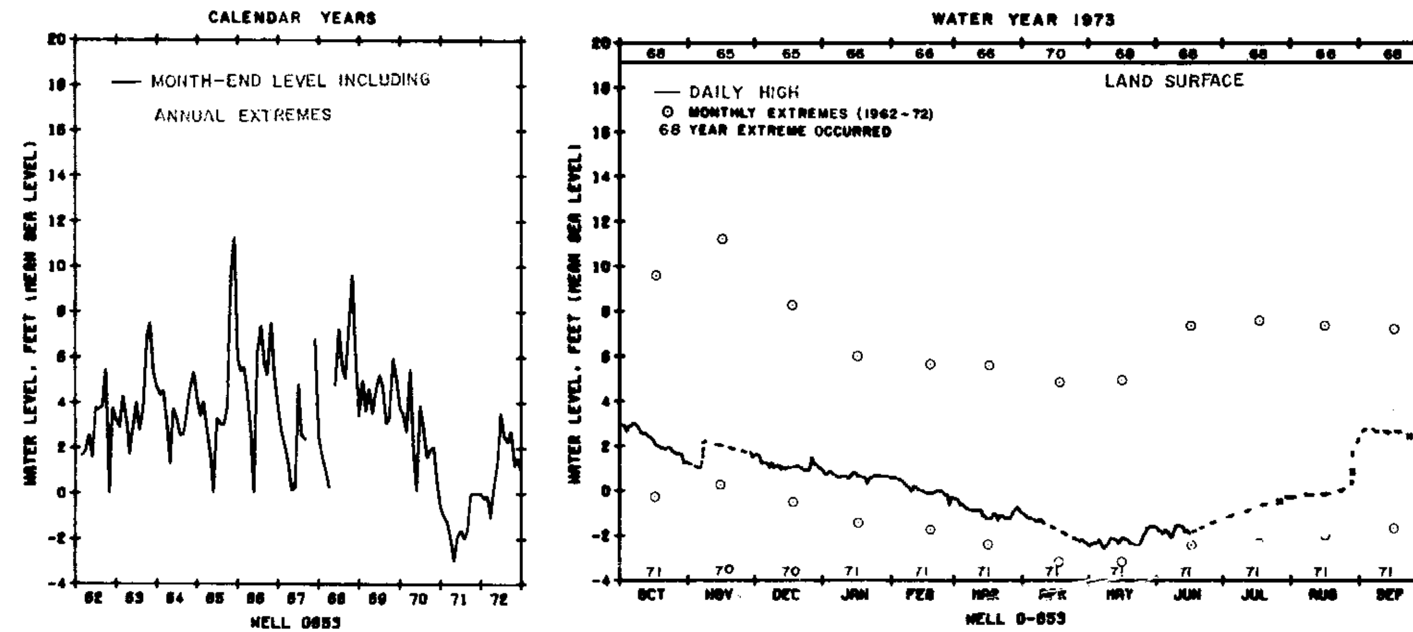
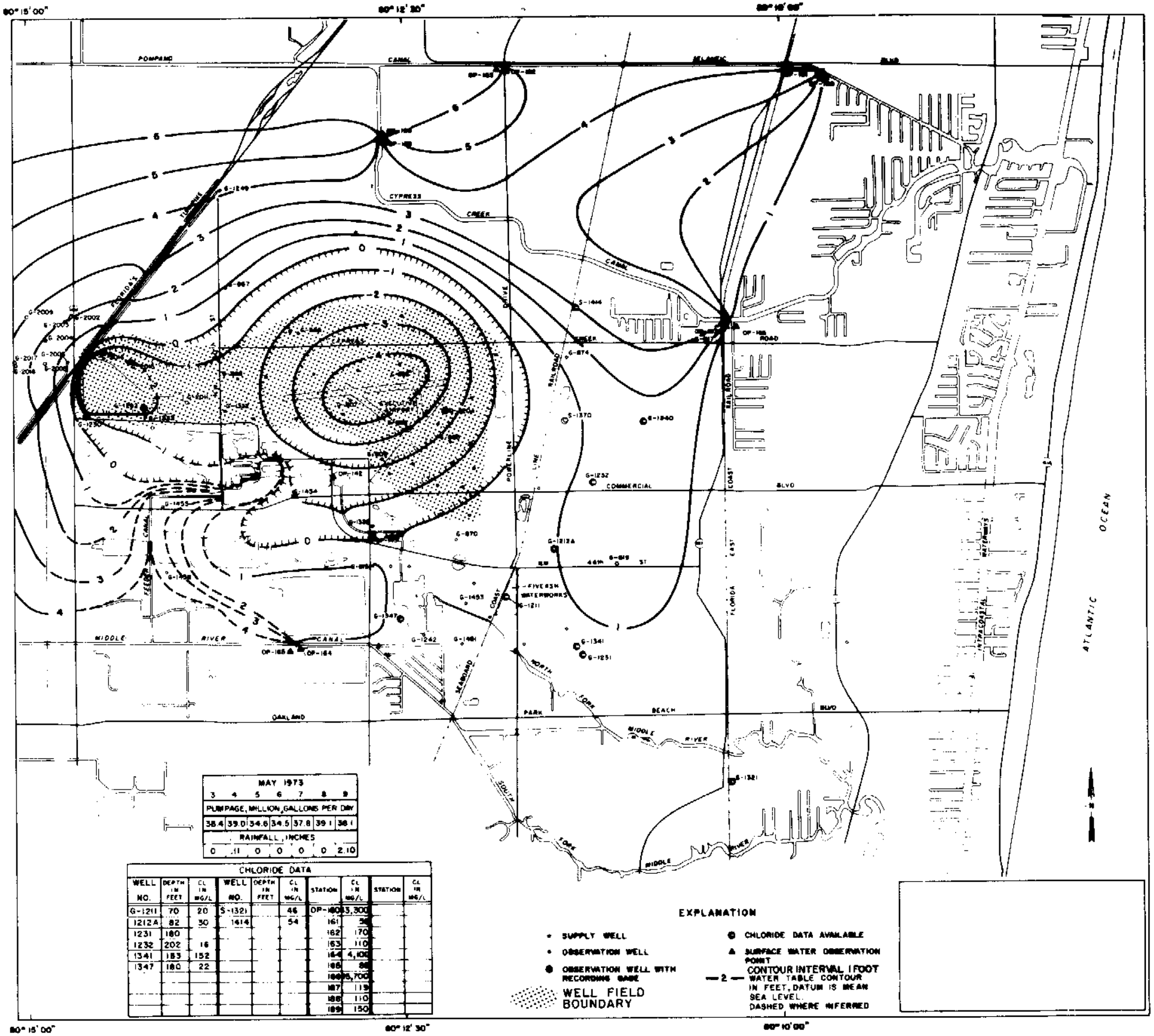


Figure 13.--Hydrographs of Pompano Beach well G 853, for the 1973 water year and 1962-72 calendar years.



MAY 1973						
3	4	5	6	7	8	9
PUMPAGE, MILLION GALLONS PER DAY						
38.4	39.0	34.6	34.5	37.8	39.1	38.1
RAINFALL, INCHES						
0	.11	0	0	0	0	2.10

CHLORIDE DATA

WELL NO.	DEPTH IN FEET	CL IN MG/L	WELL NO.	DEPTH IN FEET	CL IN MG/L	STATION	CL IN MG/L	STATION	CL IN MG/L
G-1211	70	20	S-1321		46	OP-160	3,300		
1212A	82	30	1414		54	161	56		
1231	180					162	170		
1232	202	16				163	110		
1341	183	152				164	4,100		
1347	180	22				166	86		
						166	5,700		
						167	115		
						168	110		
						169	150		

Figure 14.--Water-level contour map of the Fort Lauderdale Prospect well field and surrounding area during low water levels, May 9, 1973.

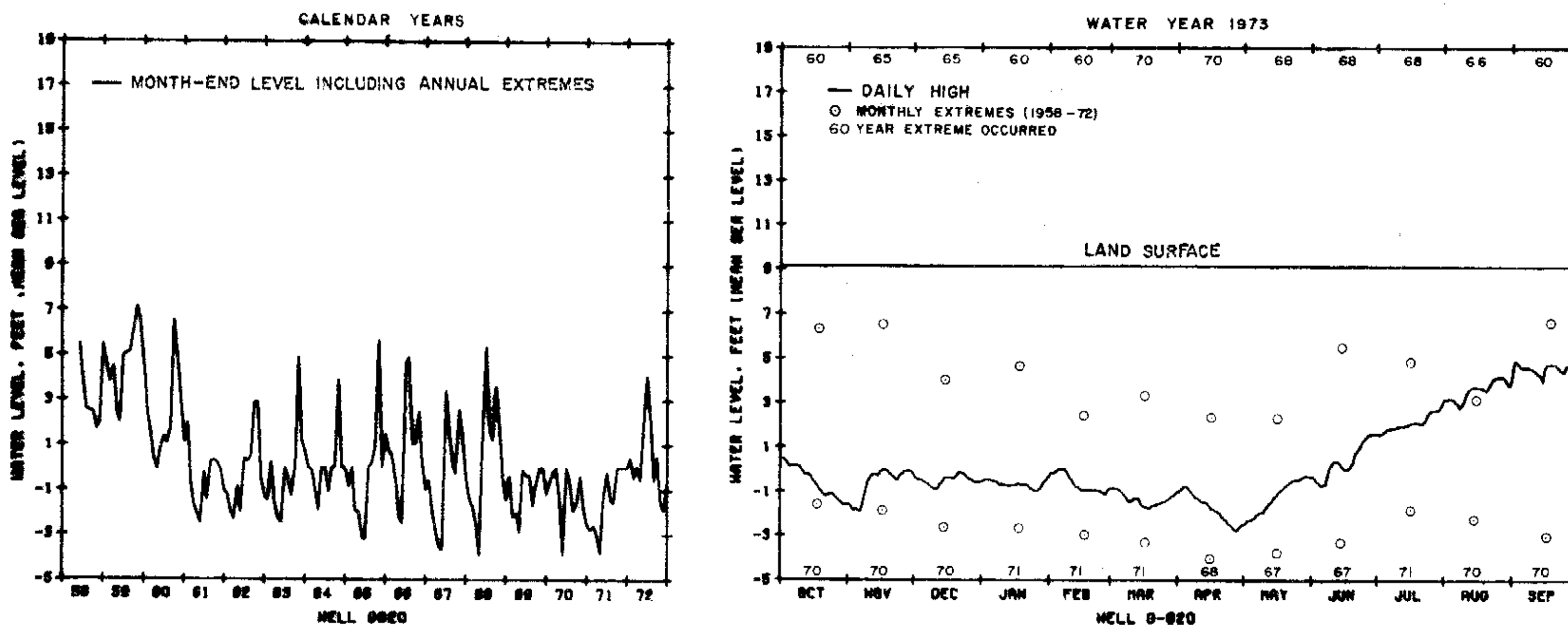
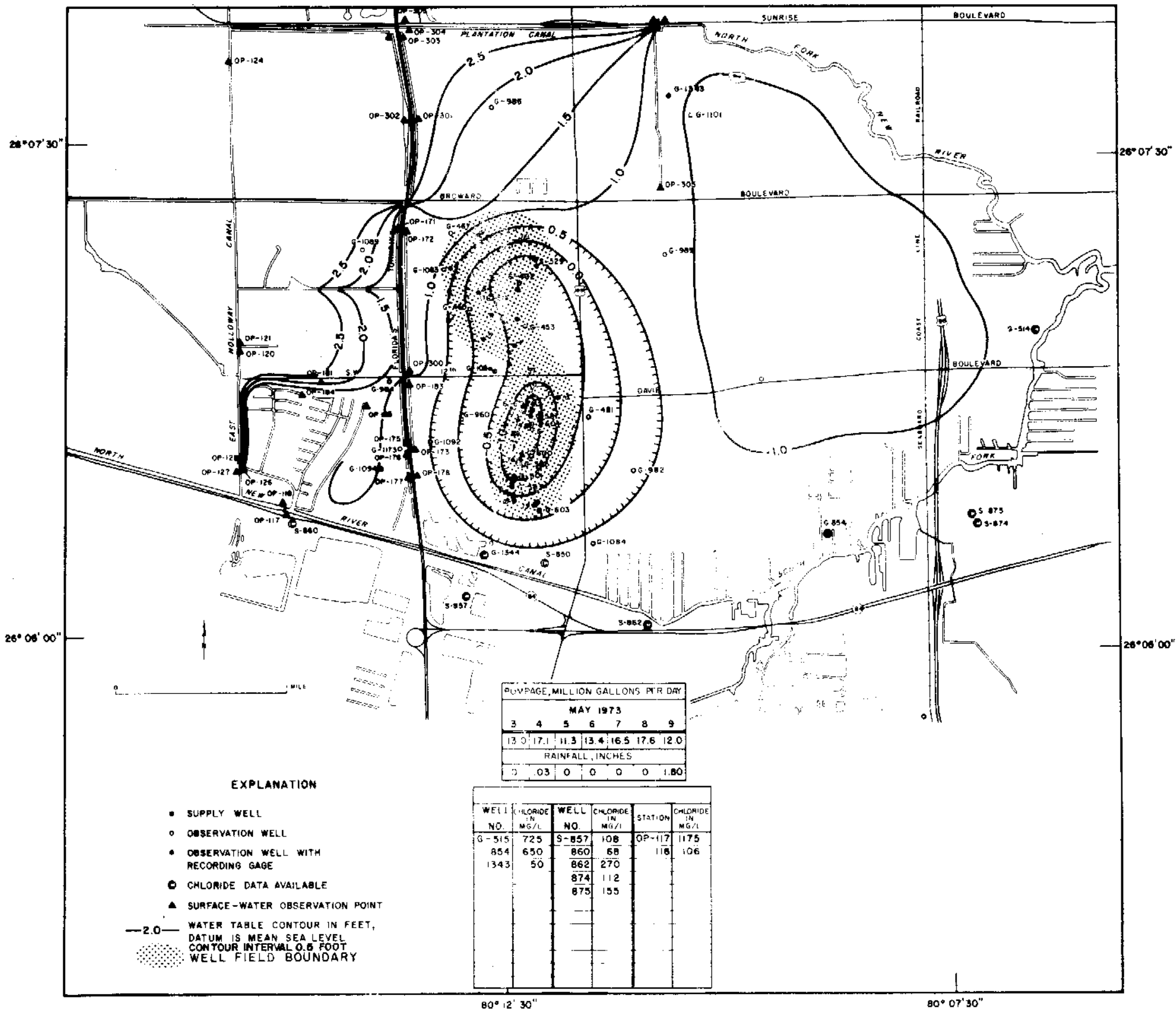


Figure 15.--Hydrographs of Fort Lauderdale Prospect well G 820, for the 1973 water year and 1958-72 calendar years.



PUMPAGE, MILLION GALLONS PER DAY						
MAY 1973						
3	4	5	6	7	8	9
13.0	17.1	11.3	13.4	16.5	17.6	12.0
RAINFALL, INCHES						
0	.03	0	0	0	0	1.80

WELL NO.	CHLORIDE IN MG/L	WELL NO.	CHLORIDE IN MG/L	STATION	CHLORIDE IN MG/L
G-515	725	S-857	108	OP-117	1175
854	650	860	68	118	106
1343	50	862	270		
		874	112		
		875	155		

Figure 16.--Water-level contour map of the Fort Lauderdale Dixie well field and surrounding area during low-water levels, May 9, 1973.

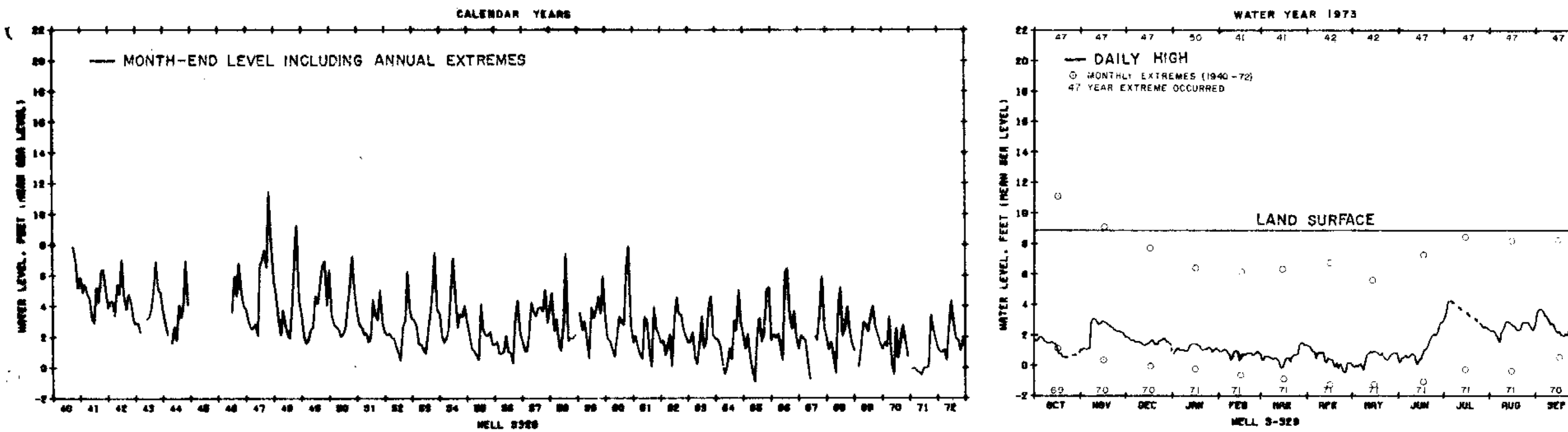


Figure 17.--Hydrographs of Fort Lauderdale Dixie well S-329, for the 1973 water year and 1941-72 calendar years.

in the vicinity of the Prospect well field (McCoy, 1973). Fresh water is conveyed into the Feeder Canal by way of Middle River Canal (C-13). McCoy determined that the canal probably contributed about 3 million gallons of water a day to the Biscayne aquifer during the drought of 1971. With improvements to the Feeder Canal since 1971, the water-level data indicate that the canal was contributing in excess of 10 million gallons a day at the end of the 1973 dry season.

SURFACE WATER

Discharge throughout the surface flow system in Broward County was dependent on the intensity and duration of rainfall until the establishment of the water-management system in the County. Major modifications to the regional canal system in Broward County began about 1953 and were virtually complete by 1962. The extreme flows have been greatly modified and the duration of moderate or optimum flows greatly lengthened.

The water conservation areas (fig. 1) constructed in the Everglades in the western part of Broward County impound water for use in the coastal areas and the Everglades National Park during the dry periods, and help maintain high fresh water heads along the coast to prevent saltwater intrusion. In addition to rain that falls on the conservation areas and water conveyed into the areas from Lake Okeechobee and the upgradient part of the management system, excess water from the coastal areas may be backpumped into storage at pump station S-9 on South New River Canal (fig. 2). During droughts Broward County's fresh-water supply is chiefly dependent on the regional water-management system and the canal network.

Discharge

Stage-discharge relations are used to obtain a continuous record of flow at all stations except South New River Canal at S-13 and Snake Creek Canal at Northwest 67th Avenue where deflection meters are the most effective means of obtaining flow records. Determining flows in the highly controlled canal system has been greatly aided by the cooperation of the FCD and Broward Water Resources Department in furnishing logs of control changes.

Discharge measurements are made periodically in the canals at the stream-gaging stations to determine whether the stage-discharge or the stage and deflection-discharge relation is remaining constant or is changing. Measurements were made at all gaging stations in Broward County during the 1973 water year.

Because major modifications to the regional water-management system were not complete until 1962, discharge data for 1962-72 were used to compile mean discharges for each month to compare with the 1973 monthly mean discharges. Discharge data for 1962-70 were used to compile duration curves to compare with the 1971, 1972, and 1973 duration curves.

Hydrographs of canal discharge and stage show trends and extremes for the period of record. Monthly discharge was plotted on the long-term hydrographs and daily discharge on the hydrographs for the 1973 water year. Maximum and minimum daily mean stage for each month are plotted on the long-term hydrographs and daily mean stages are plotted on the hydrographs for the 1973 water year.

Hillsboro Canal

Hillsboro Canal is one of the major canals in the FCD network (fig. 1). The canal is 52 miles long, extending from Lake Okeechobee through Conservation Area 1 and the urban area to the ocean. At the eastern boundary of Area 1, flow through the Hillsboro Canal is regulated by structure S-39. Flow released at S-39 enters Broward County 10 miles west of Deerfield Beach and travels east to the Deerfield Lock and Dam, where it is regulated through the lock chamber and five spillways that constitute the dam.

The yearly mean discharge of 177 cfs (cubic feet per second) at the Deerfield Lock and Dam for the 1973 water year (fig. 18) was 25 percent below the average discharge of 233 cfs for 1962-72. Monthly mean discharges from October through June of the 1973 water year with the exception of November were far below the mean monthly discharges for 1962-72, but from July through September 1973 greatly exceeded the mean monthly discharges for 1962-72. Daily discharge exceeded 400 cfs 20 percent of the time during 1962-70 and exceeded 300 cfs 20 percent of the time during 1973. The 1973 and 1972 flow-duration curves are similar.

The stage at the lock and dam was held above 7 feet msl (mean sea level) during most of the 1973 water year (fig. 19) to replenish the aquifer thereby preventing salt-water encroachment and providing irrigation water for the farms to the west. Canal discharge was slightly below average during 1973, probably because of the below average rainfall and increased diversions for irrigation needs of the farms adjacent to the western part of the canal.

Pompano Canal (C-14) and Cypress Creek Canal

Pompano Canal (fig. 2) is a primary canal extending 12 miles east from Levee 36 Canal at structure S-38 to Pompano Beach where it flows southeast 2 miles to the Intracoastal Waterway. Flow is generally eastward and is dependent upon releases from Conservation Area 2A at S-38 and inflow from lateral canals from the north along the canal. Three miles west of Pompano Beach, Pompano Canal is joined by Cypress Creek Canal where flow is either diverted to Cypress Creek Canal (fig. 2) or continues eastward in Pompano Canal. Flow in Cypress Creek Canal is regulated by controls S-37B and S-37A (fig. 2).

The yearly mean discharge of 93 cfs in Cypress Creek Canal

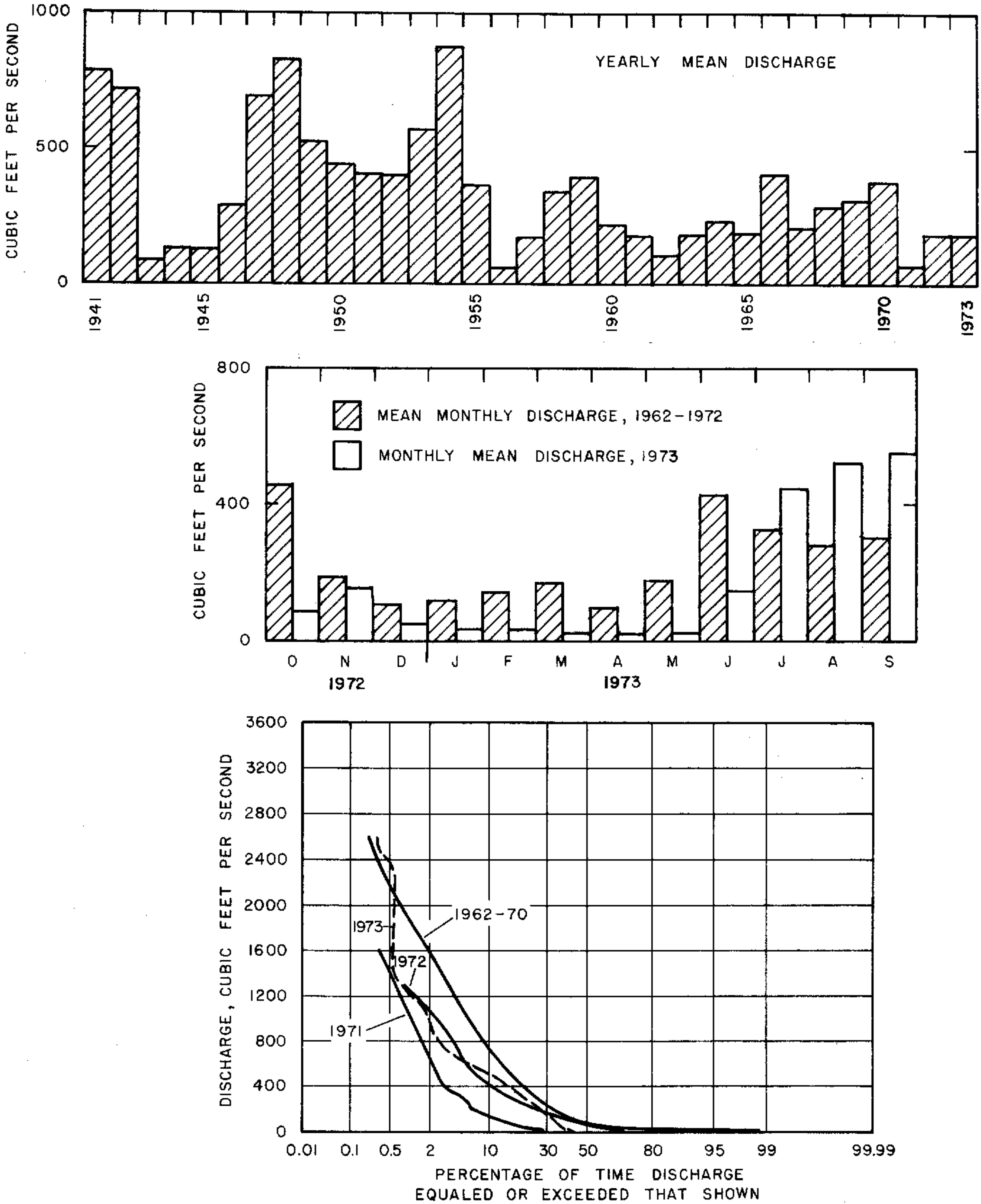


Figure 18.--Discharge data and flow-duration curves for Hillsboro Canal near Deerfield Beach.

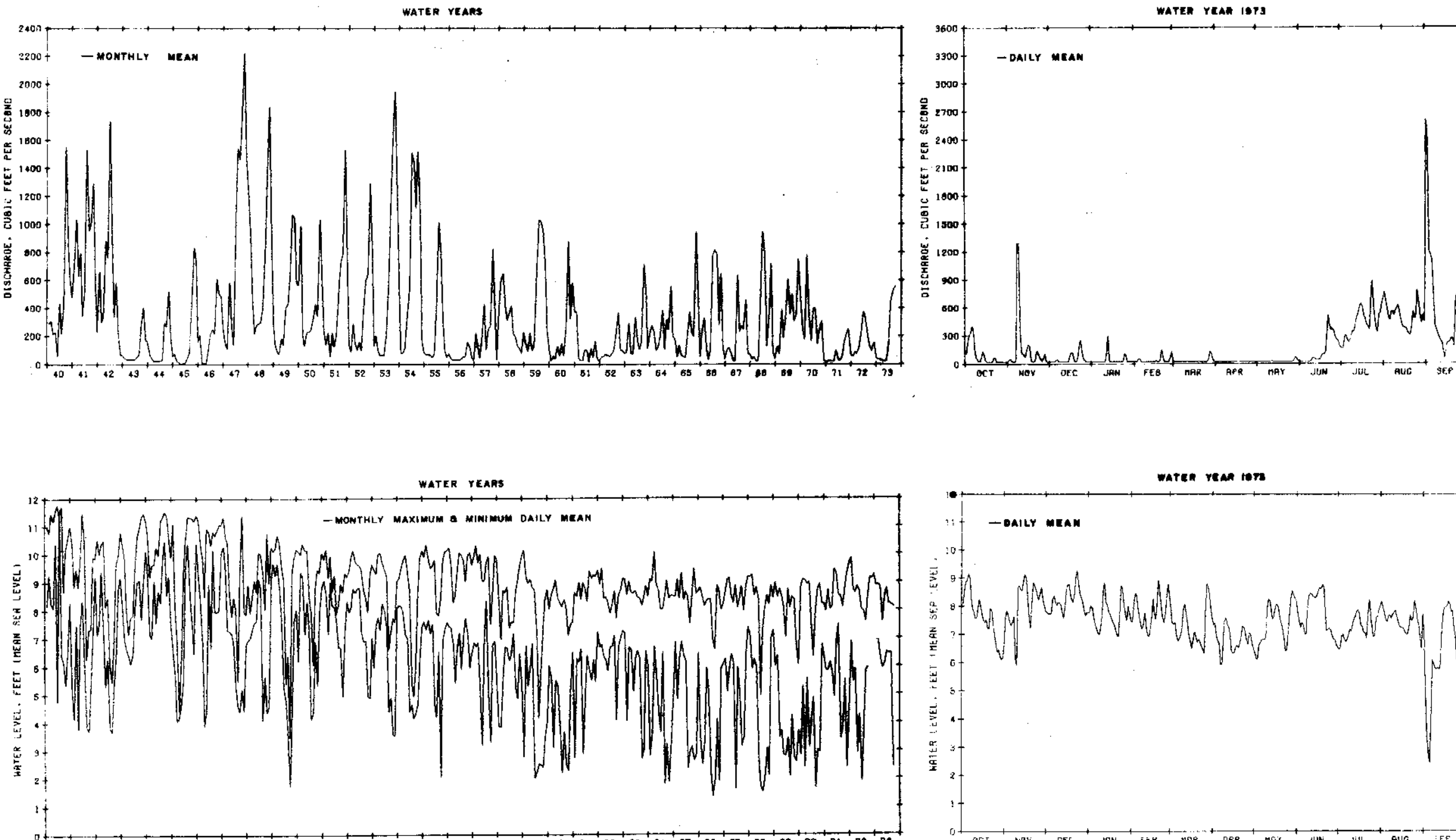


Figure 19.--Discharge and stage hydrographs for Hillsboro Canal near Deerfield Beach for the 1973 water year and 1940-73 water years.

(fig. 20) for the 1973 water year was 48 cfs (34 percent) less than the average discharge for 1963-72. The 1972 and 1973 flow-duration curves were similar. The stage at S-37A was held at about 3.5 feet above msl most of the time during the 1973 water year (fig. 21) to replenish the aquifer in the area of the Fort Lauderdale Prospect well field.

Middle River Canal (C-13)

Middle River Canal is a primary canal that extends from C-42 Canal near Conservation Area 2B, to the Intracoastal Waterway (fig. 2). Flow in the canal is regulated by controls in C-42 Canal and by control structure S-36, 1.5 miles east of U.S. Highway 441. Flow downstream of the control is affected by tidal fluctuations. A by-pass feeder canal is connected to the north side of the Middle River Canal 1 mile west of S-36. The feeder canal flows northward for 1 mile thence eastward for about 1.5 miles by means of connected borrow pits. The canal was constructed to replenish the aquifer in the Prospect well-field.

The yearly mean discharge in Middle River Canal for the 1973 water year was 19 cfs (fig. 22), 21 percent below the 1962-72 average of 24 cfs. Since 1962, the yearly mean discharge was greatest, 45 cfs, in 1966 and 1968. Most of the flow in Middle River Canal is being diverted through the Feeder Canal to recharge the Biscayne aquifer in the area of the Fort Lauderdale Prospect well field. The stage at S-36 was held above 4.0 feet msl during most of the 1973 water year (fig. 23) to facilitate replenishment of the aquifer in the area and to prevent salt-water encroachment into the area.

Plantation Canal (C-12)

Plantation Canal is a primary canal that extends east from Holloway Canal (fig. 2) to the North Fork New River. Flow in the canal is regulated by S-33, 0.5 mile east of U.S. 441. Seaward flow in the canal is generally low because the area drained by the canal is small and there is no interconnecting canal to provide flow from another source. During long dry periods this lack of flow has caused effluent wastes to concentrate and stagnant conditions to develop.

The yearly mean discharge for 1973 at S-33 was 24 cfs (fig. 24), the same as the average discharge for 1962-72. Except for flows greater than 70 cfs which occurred 3 percent of the year, the duration curve for 1973 generally conforms to the shape of the 1963-70 duration curve. The stage at S-33 was held between 3.0 and 4.0 feet msl during most of the 1973 water year (fig. 25) to prevent salt-water encroachment.

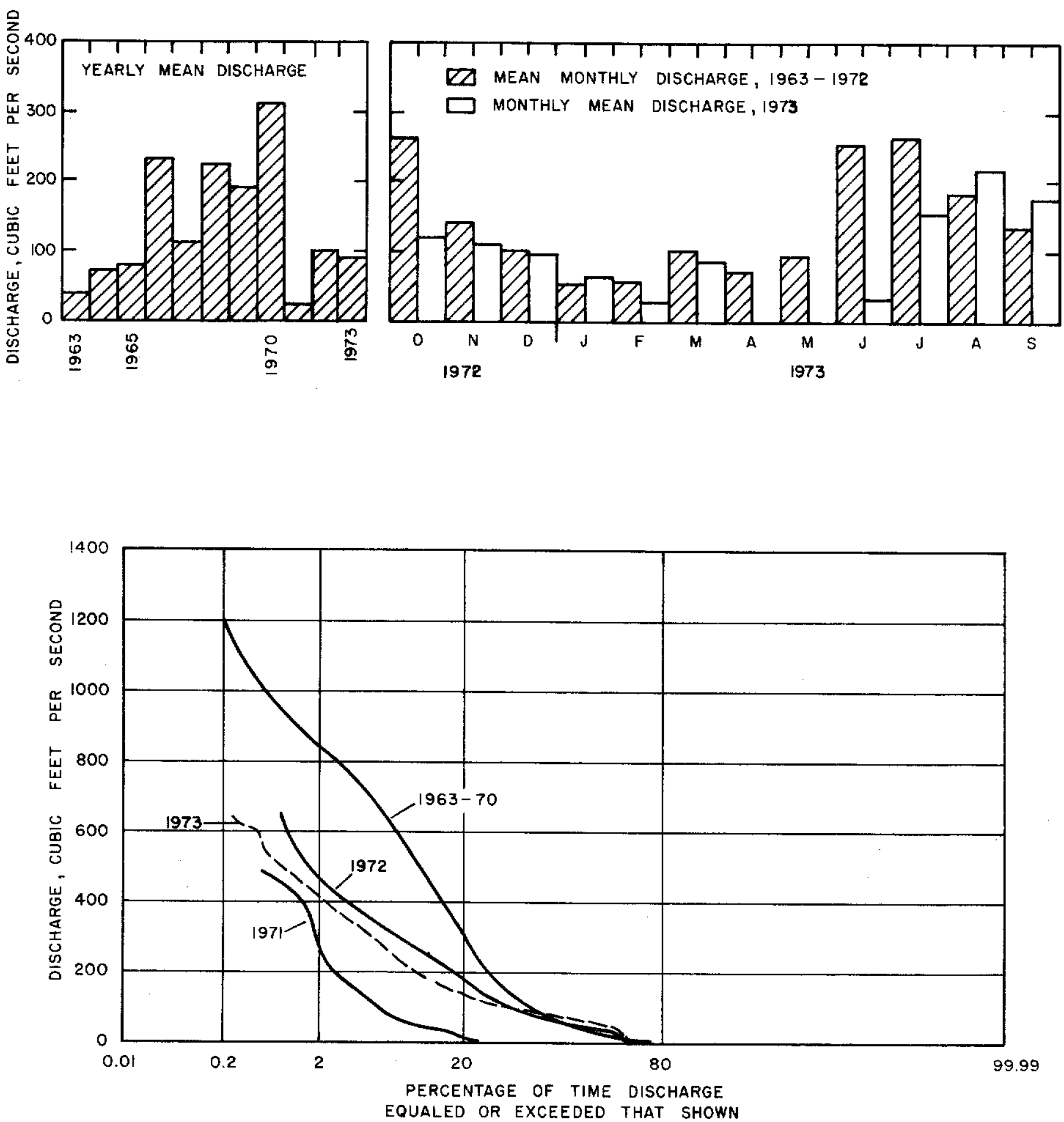


Figure 20 .--Discharge data and flow-duration curves for Cypress Creek Canal at S-37A, near Pompano Beach.

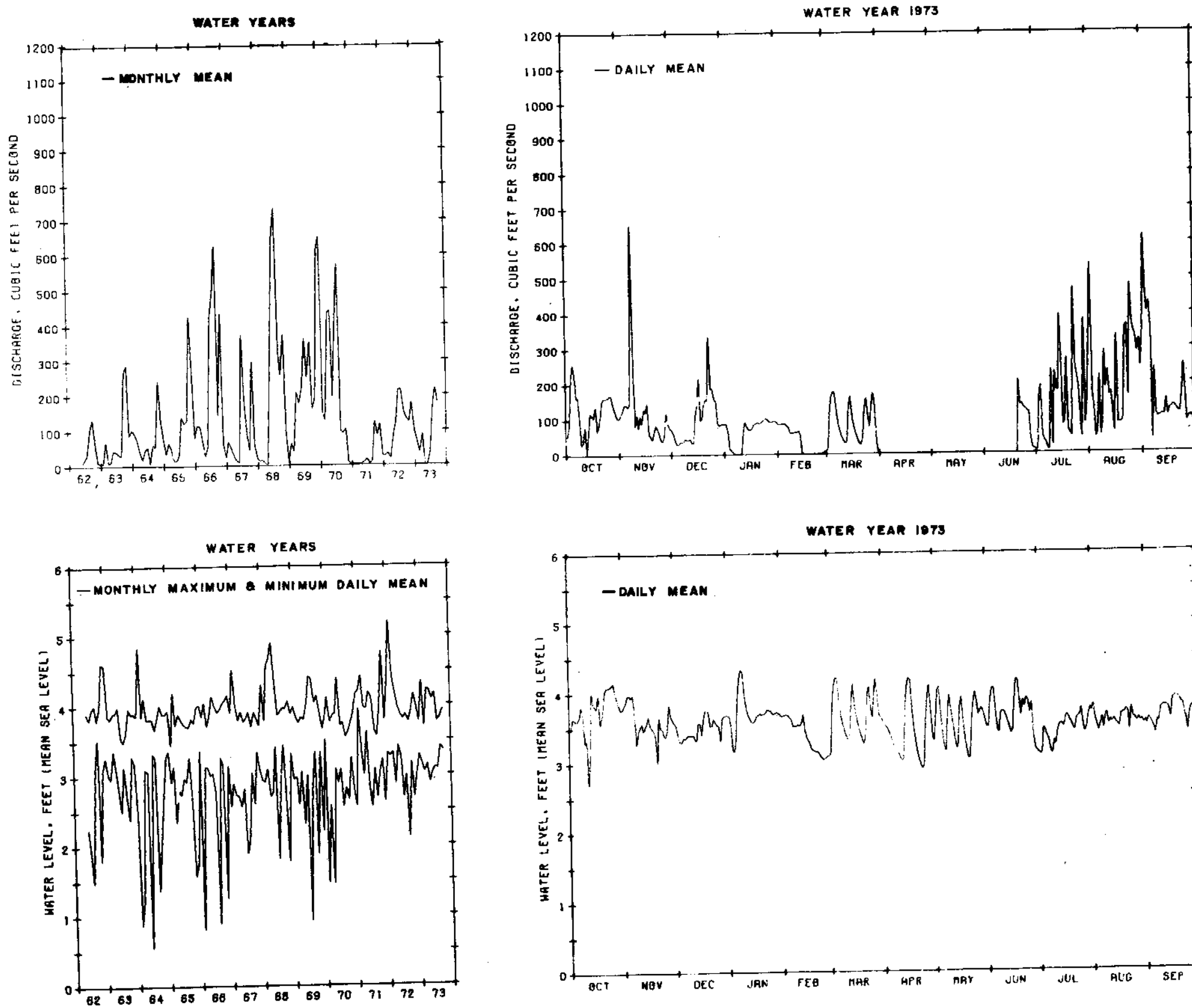
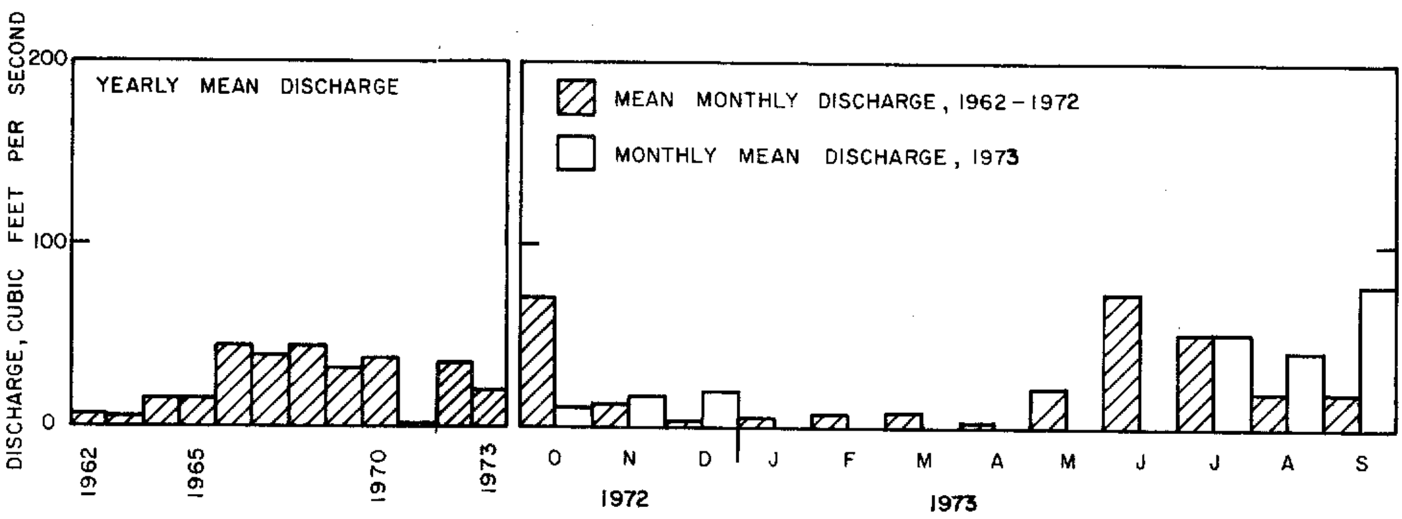


Figure 21.--Discharge and stage hydrographs for Cypress Creek Canal at S-37A, near Pompano Beach for the 1973 water year and 1963-73 water years.



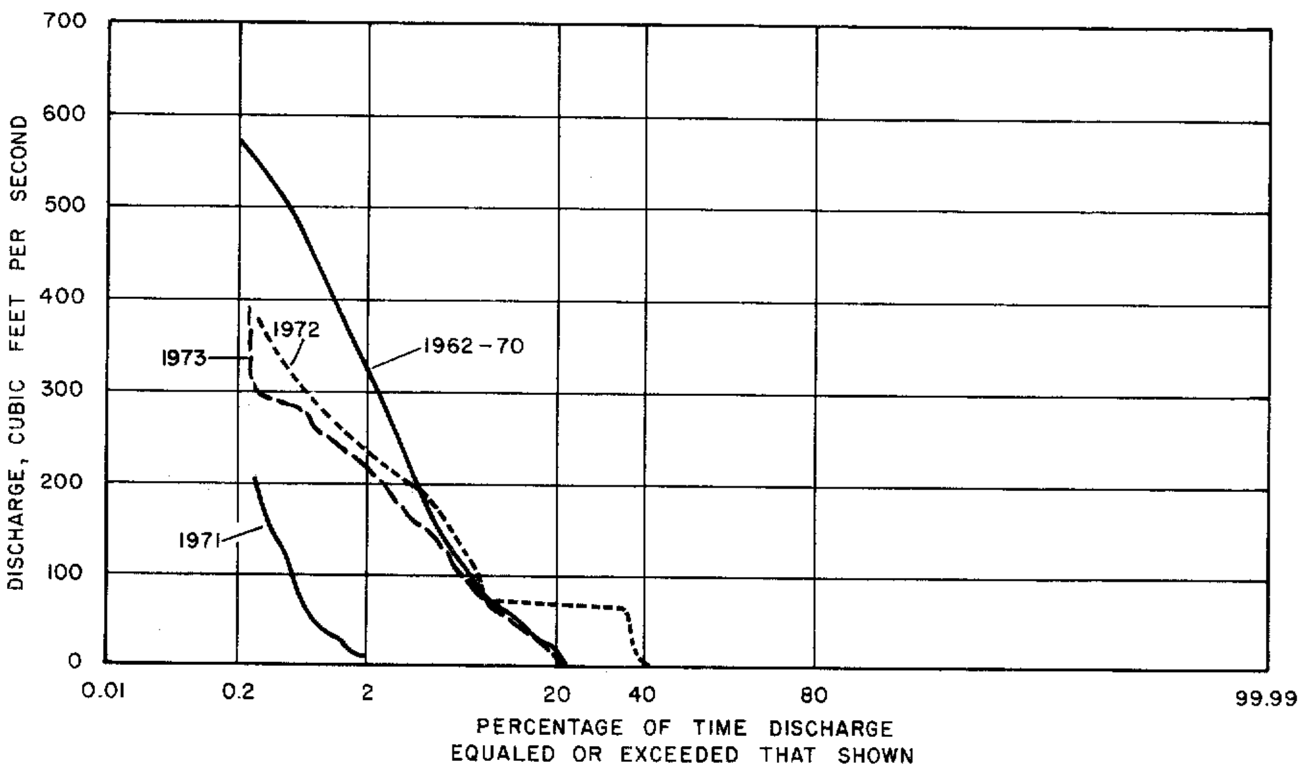


Figure 22 --Discharge data and flow-duration curves for Middle River Canal at S-36, near Fort Lauderdale.

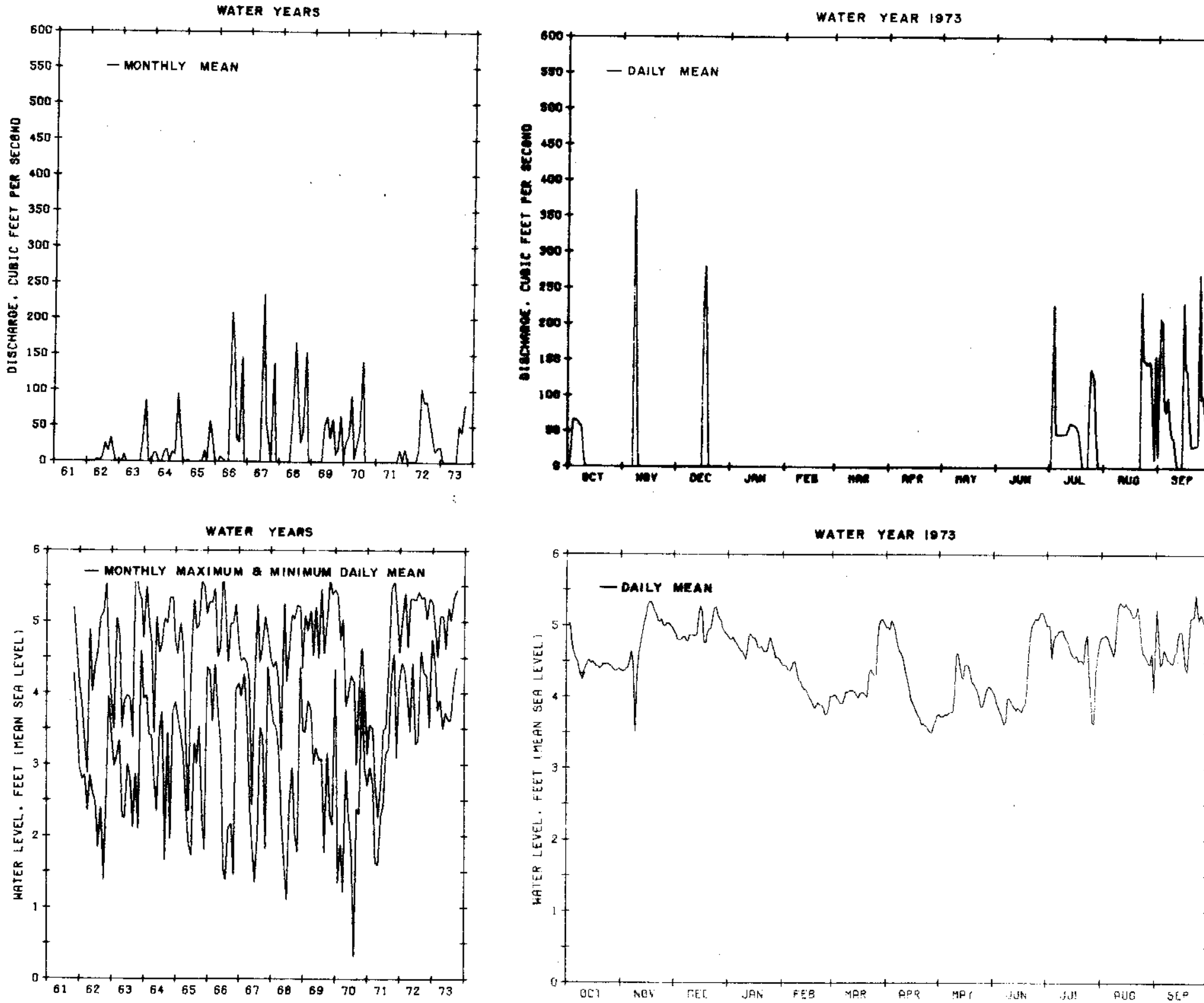


Figure 23.--Discharge and stage hydrographs for Middle River Canal at S-36, near Fort Lauderdale for the 1973 water year and 1962-73 water years.

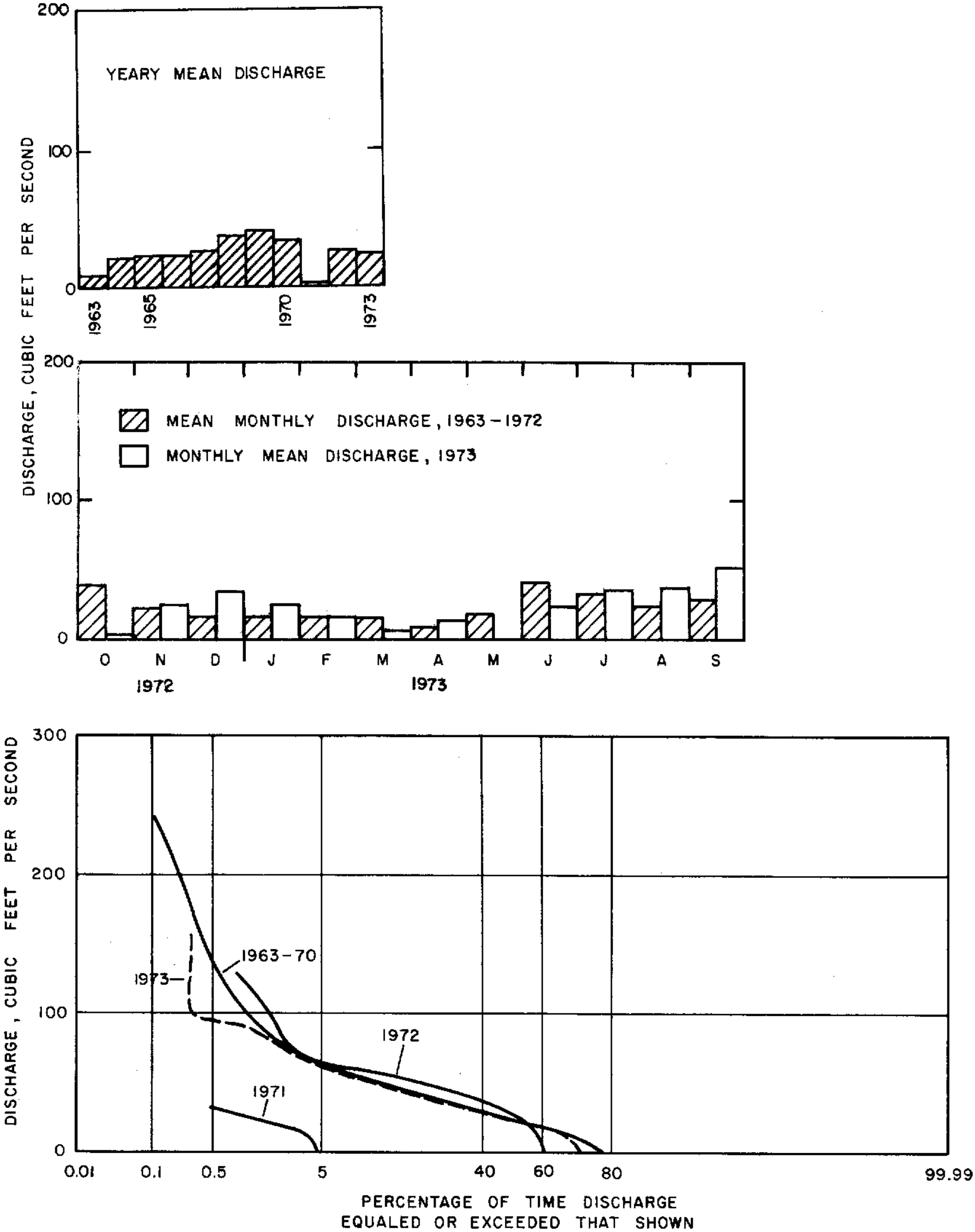


Figure 24 --Discharge data and flow-duration curves for Plantation Road Canal at S-33, near Fort Lauderdale.

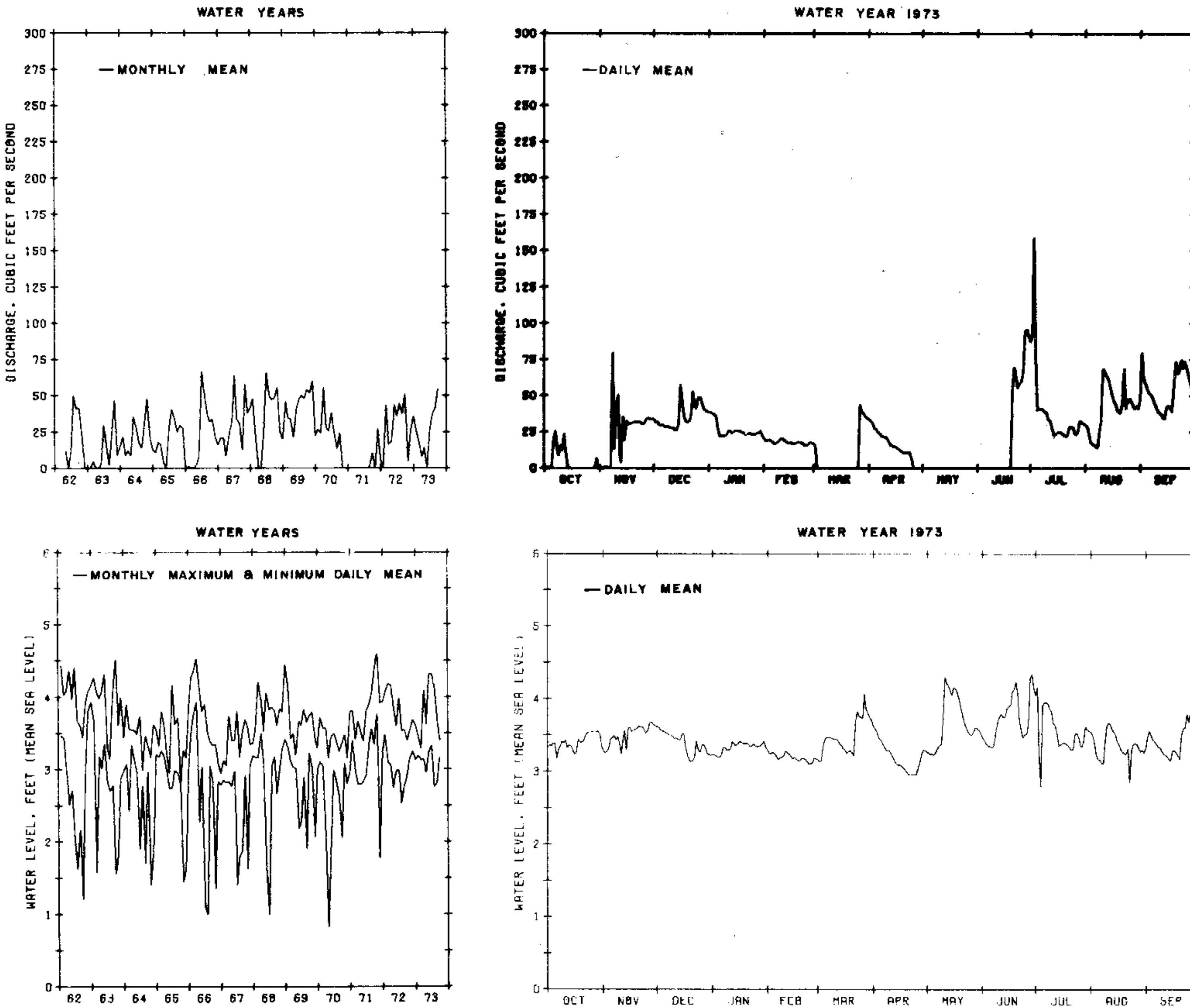


Figure 25.--Discharge and stage hydrographs for Plantation Road Canal at S-33, near Fort Lauderdale for the 1973 water year and 1962-73 water years.

North New River Canal

North New River Canal (fig. 1) is a primary canal and one of the major canals in the FCD network. The canal is 60 miles long, extending from the southeastern tip of Lake Okeechobee, south 30 miles to pump station S-7. From pump station S-7, the canal extends south through the western boundary of Conservation Area 2A to control S-34 where flow is controlled by manually operated head gates. Inside Area 2A the canal is divided into two segments, the upper of which is cut off from the lower by levees. South of S-34 the canal turns east and extends 14 miles to the Sewell Lock and Dam and then to the ocean.

The yearly mean discharge at the Sewell Lock and Dam was 84 cfs for the 1973 water year (fig. 26), the third lowest yearly mean discharge for the 30-year period, 1941-72 (fig. 26) and 149 cfs below the average discharge for 1962-72. The flow-duration curves in figure 26 indicate that 40 percent of the time, discharge equalled or exceeded 20 cfs in 1971, 170 cfs in 1972, 40 cfs in 1973, and 230 cfs during 1962-70. The 1971 and 1973 flow-duration curves conformed closely. The stage at the lock and dam was held above 3.5 feet msl during most of the 1973 water year (fig. 27) about 0.5 foot lower than 1972.

South New River Canal (C-11)

South New River Canal, a primary canal, begins at the Miami Canal (fig. 1) in Conservation Area 3A in western Broward County and extends east about 5 miles to the eastern boundary of Area 3A at pump station S-9 (fig. 1). The canal extends east from S-9 18 miles until it divides into the Dania Cut-off Canal and the South Fork New River. Pump station S-9 removes flood water from the South New River Canal east of S-9 and discharges it into Conservation Area 3A. Control station S-13A, 4.4 miles west of U.S. Highway 441, and S-13, a pump station with a sluice gate control at U.S. Highway 441, regulate flow in the east part of the canal.

The yearly mean discharge at S-13 for 1973 was 78 cfs (fig. 28), far below the average discharge of 169 cfs for 1962-72. Flow was below the mean monthly discharge for 1962-72 during each month of the 1973 water year. Rainfall was 11.42 inches below average during the 1973 water year at the Dania station (table 1), which is located on South New River Canal at S-13.

The stage at S-13 on the easternmost reach of the canal averaged about 1.7 feet above msl (fig. 29) during the 1973 water year. The mean daily stages varied little from December 1972 - June, 1973. Water levels at S-13 are generally maintained lower than those at other salinity control structures in the county because the canal drains a very low, flood prone area. Water levels are held slightly below 2.0 feet above msl most of the time.

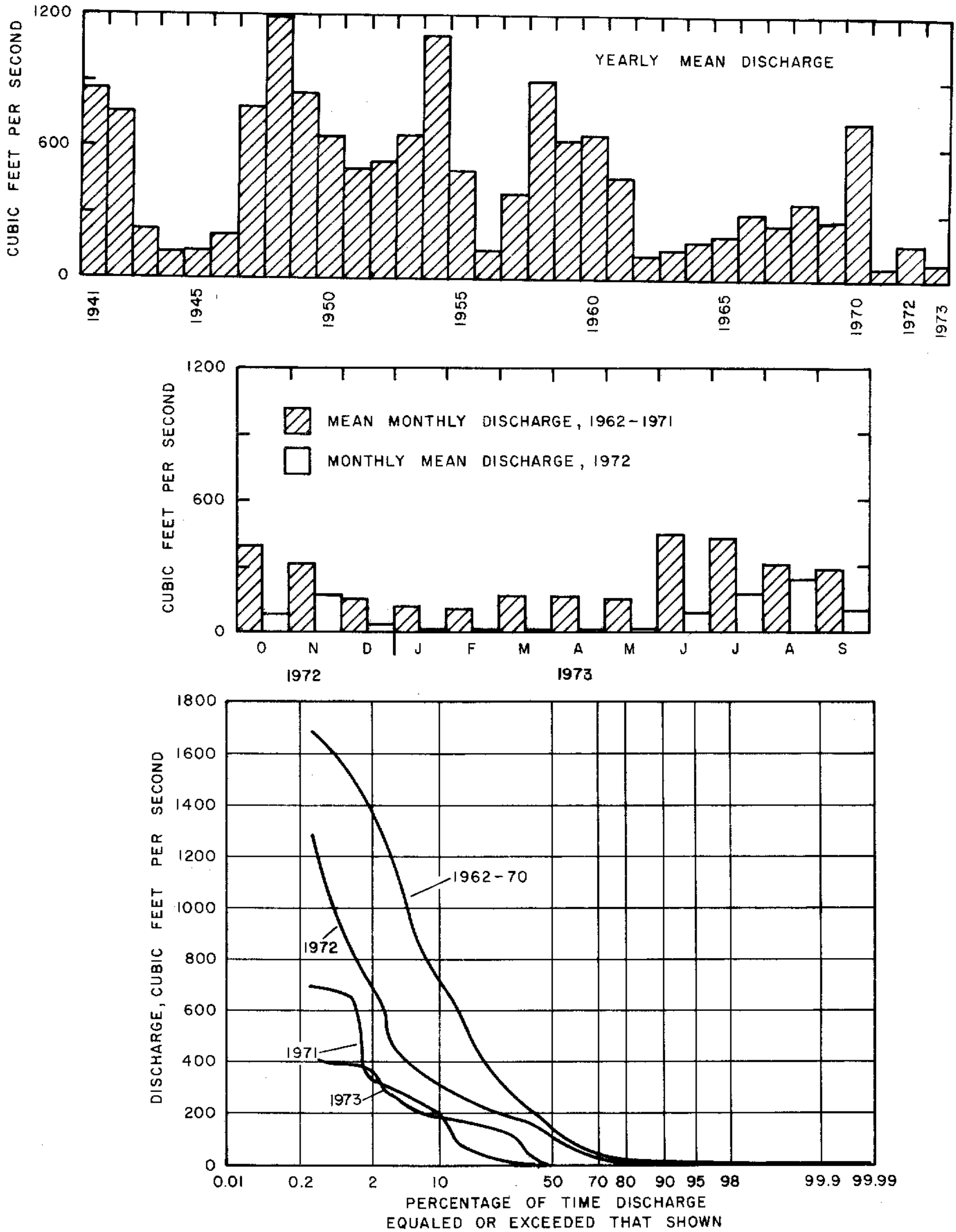


Figure 26 --Discharge data and flow-duration curves for North New River Canal near Fort Lauderdale (lock and dam).

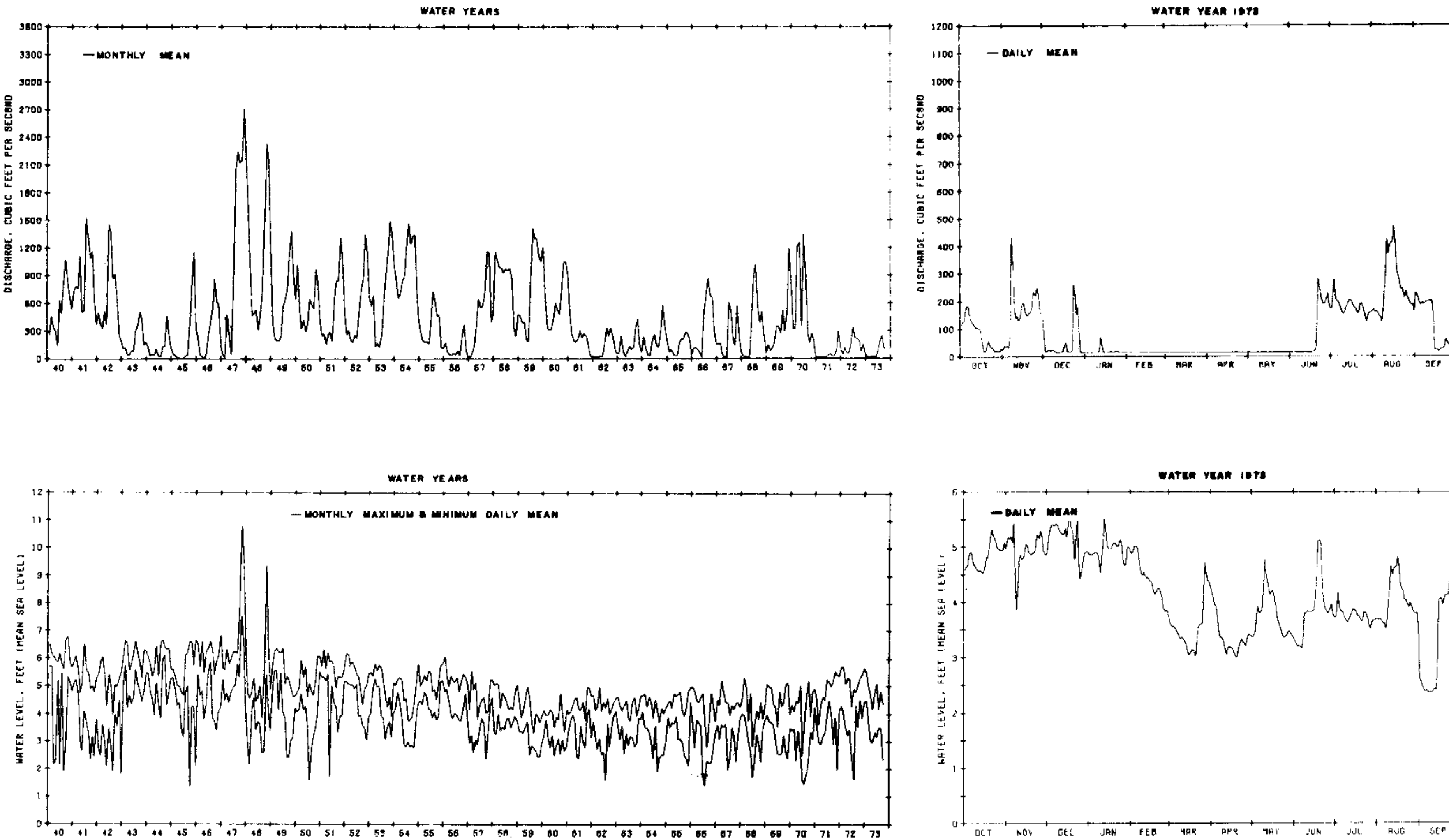


Figure 27.--Discharge and stage hydrographs for North New River Canal near Fort Lauderdale (lock and dam) for the 1973 water year and 1940-73 water years.

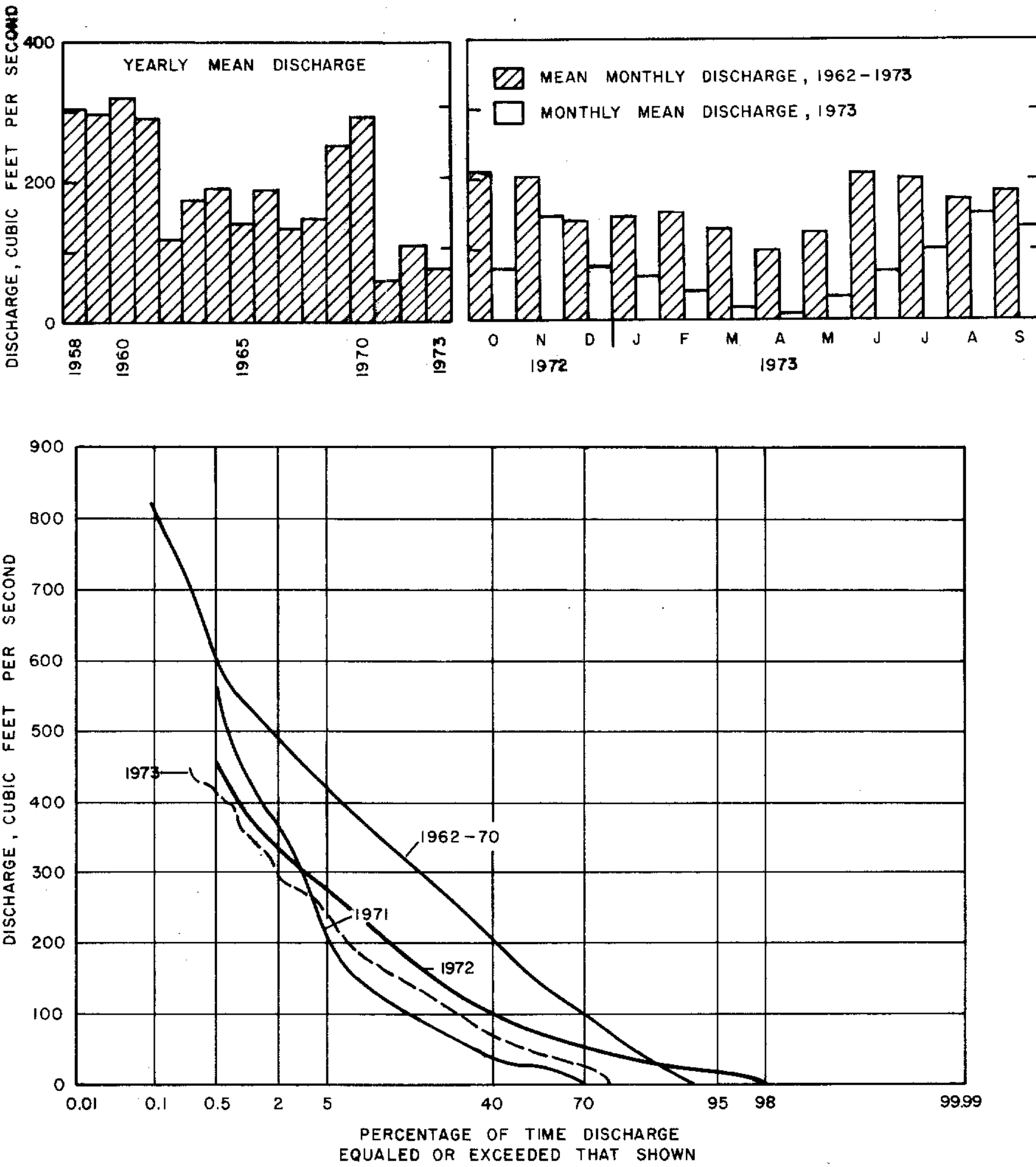


Figure 28.--Discharge data and flow-duration curves for South New River Canal at S-13, near Davie.

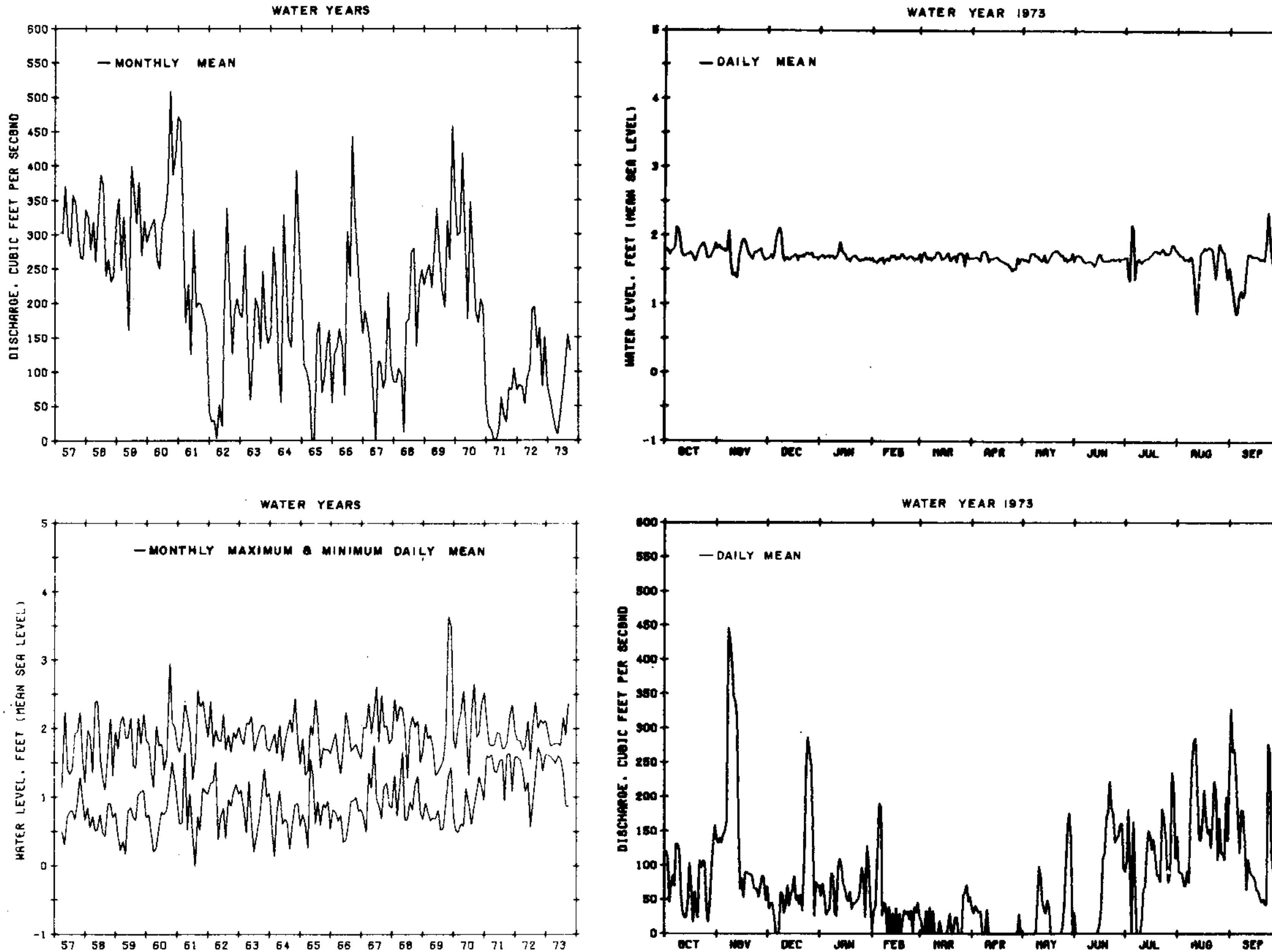


Figure 29.--Discharge and stage hydrographs for South New River Canal at S-13, near Davie for the 1973 water year and 1957-73 water years.

Snake Creek Canal (C-9)

Snake Creek Canal is the primary drainage channel for the coastal area along the Dade County - Broward County boundary (fig. 2). The canal extends eastward from the perimeter canal on the east side of Conservation Area 3B to the coast. Although most of the lower reach of the canal is in Dade County it forms the southern drainage boundary for Broward County. Flow in the canal is regulated by gated culverts at S-30, 0.75 mile east of the Area 3B boundary, and submerged sluice gates at S-29, just east of U.S. Highway 1. Flow in the canal is maintained chiefly by ground-water inflow, but water can be diverted from the conservation areas by manipulation of controls. Snake Creek Canal also has a north-fork about 8 miles east of S-30 that extends to North New River Canal (fig. 2). Discharge at S-29 is regulated to maintain optimum stages in flood-prone areas along the upstream reaches of the canal during the wet season and to replenish the aquifer and prevent salt-water encroachment in the coastal area during the dry season.

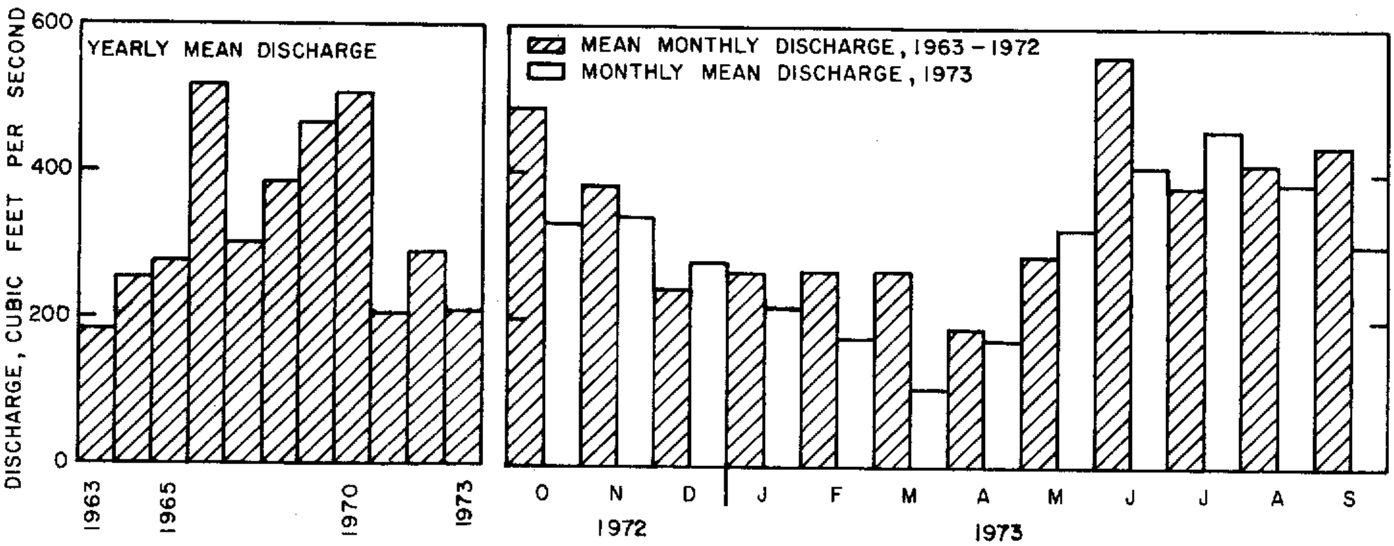
The yearly mean discharge of 209 cfs (fig. 30) for 1973 at Northwest 67th Avenue was much lower than the average discharge of 340 cfs for 1963-72 and only 3 cfs higher than for the extreme dry year of 1971. Monthly mean discharges during 1973 were below the 1963-72 mean monthly averages except in August and September. At discharges less than 240 cfs, which occurred 60 percent of the time, the duration curve for 1973 was below the 1971 duration curve. The stage was held between 2.0 and 2.5 feet above msl during most of the 1973 water year and there was little variation in the mean daily stages (fig. 31).

The yearly mean discharge for 1973 at S-29 was 300 cfs (fig. 32), 28 percent lower than the average discharge of 414 cfs for 1962-72. At discharges less than 360 cfs, which occurred 70 percent of the time, the 1973 duration curve conformed very closely to the 1971 curve. Daily mean discharge at S-29 is generally 50-100 cfs higher than at Northwest 67th Avenue and was 93 cfs higher in 1973. During extremely dry years, the flows at both stations are about the same because S-29 remains closed through the dry months to maintain high levels in the canal. The stage at S-29 was held above 1.5 feet msl during most of the 1973 water year (fig. 33).

Intracoastal Waterway

The Intracoastal Waterway parallels the coast in Broward County (fig. 2) and is separated from the ocean by a narrow offshore bar. Seaward flow from all of the canals in Broward County discharges into the waterway, then to the ocean through one of the several narrow inlets in Palm Beach, Broward, and Dade Counties.

Water levels in the Intracoastal Waterway are affected by flow



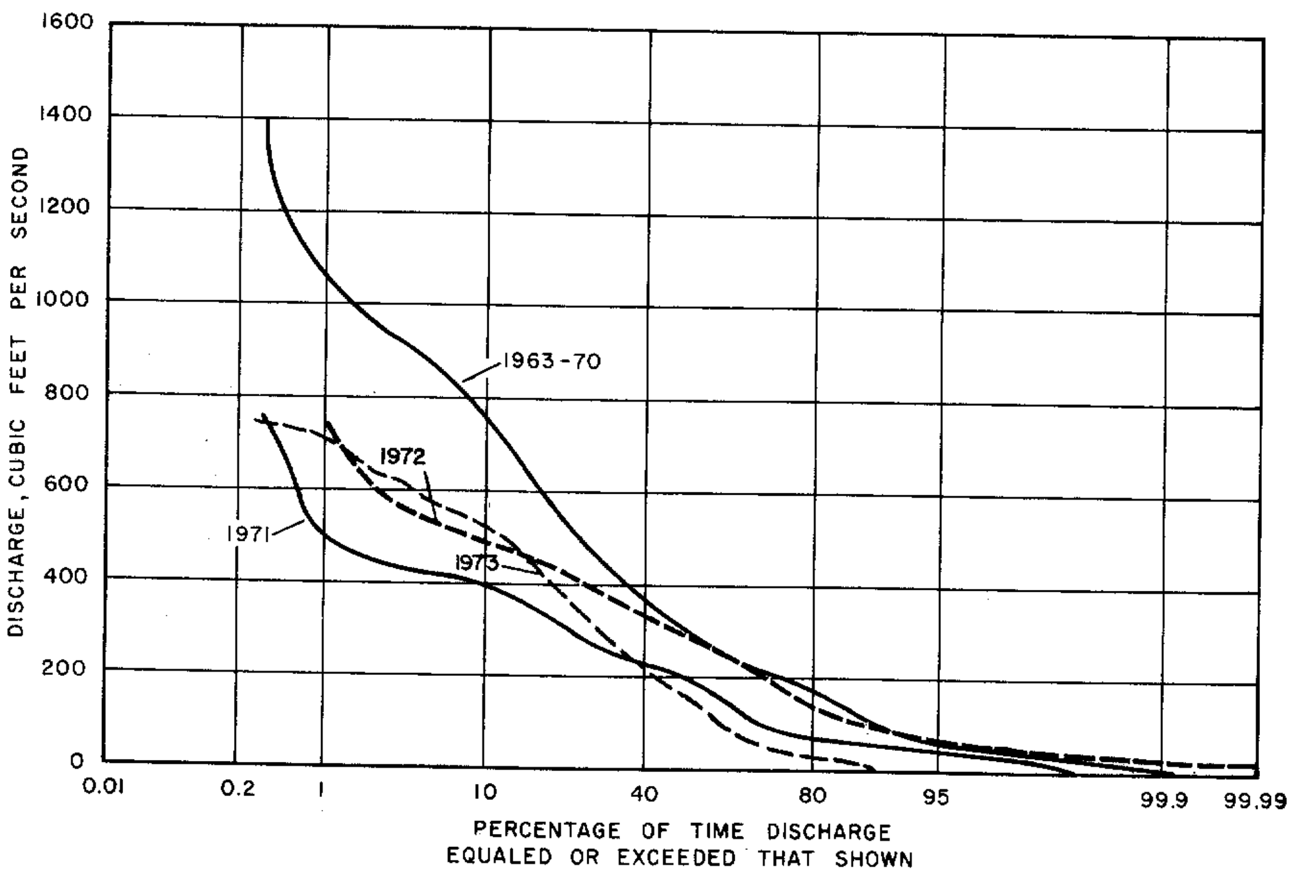


Figure 30 --Discharge data and flow-duration curves for Snake Creek Canal at Northwest 67th Avenue near Hialeah .

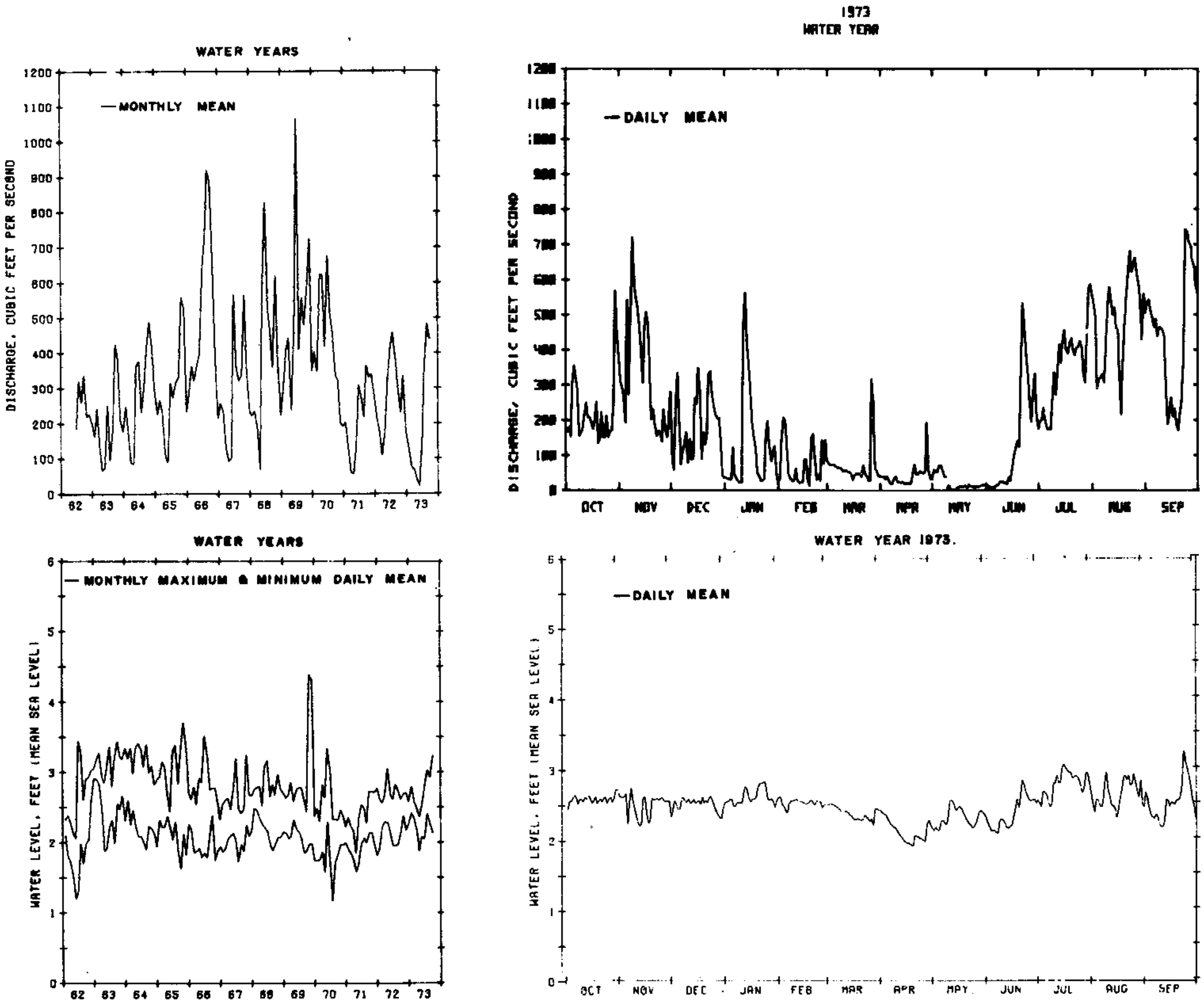


Figure 31.--Discharge and stage hydrographs for Snake Creek Canal at Northwest 67th Avenue, near Hialeah for the 1973 water year and 1962-73 water years.

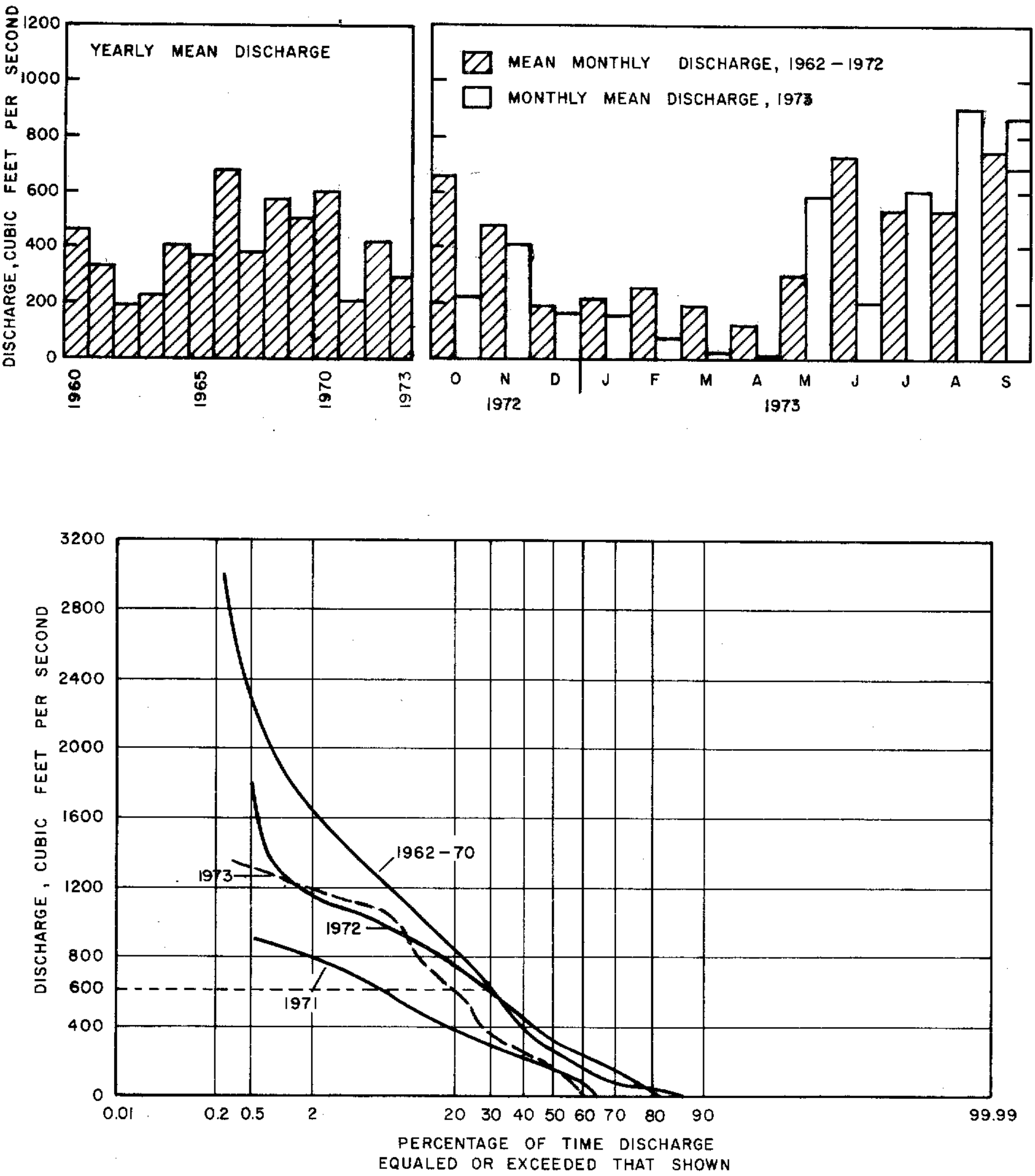


Figure 32 --Discharge data and flow-duration curves for Snake Creek Canal at S-29, at North Miami Beach.

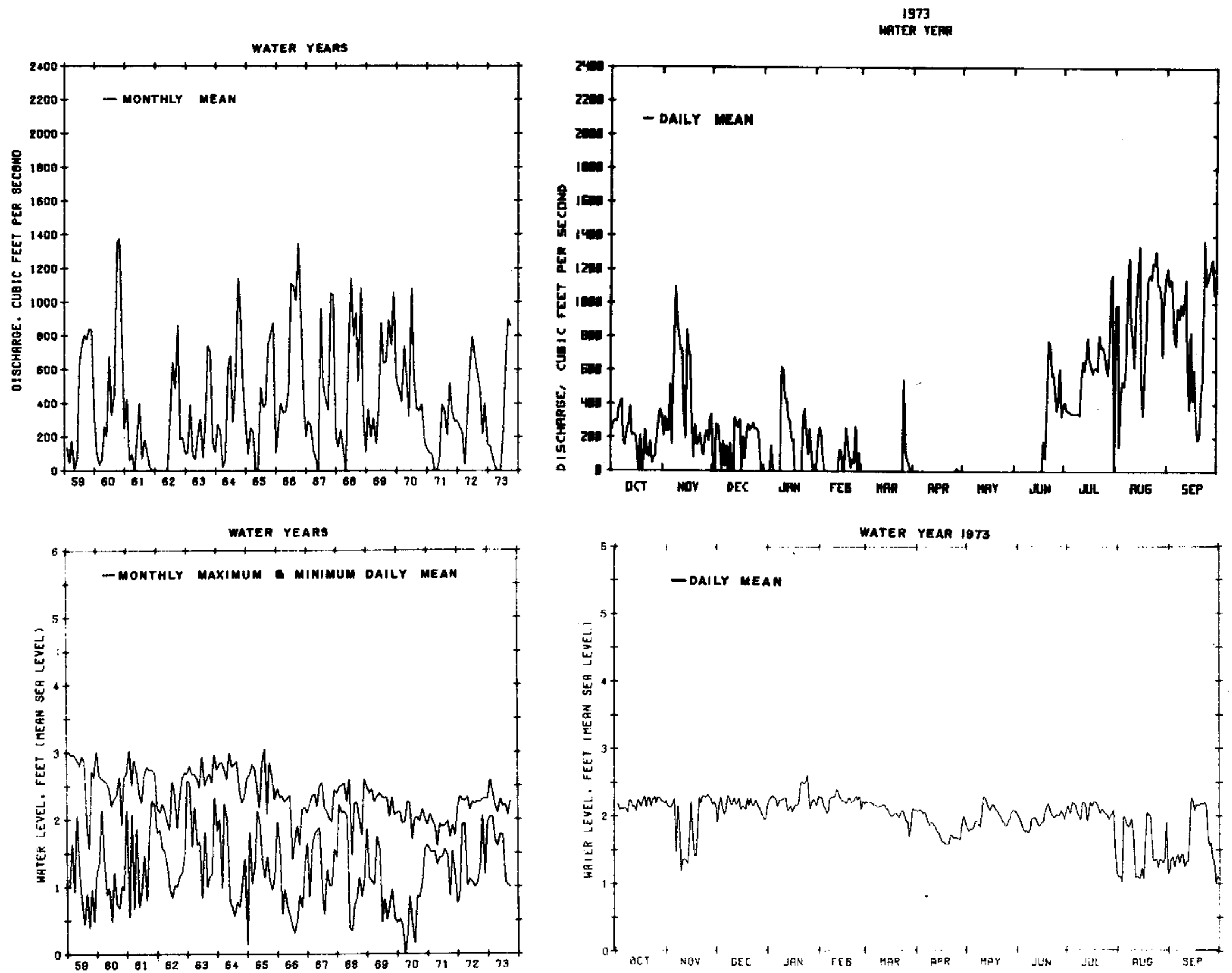


Figure 33.--Discharge and stage hydrographs for Snake Creek Canal at S-29, at North Miami Beach for the 1973 water year and 1959-73 water years.

from the management system chiefly when discharge is high. The daily high and low water levels in the waterway during the 1973 water year (figs. 34 and 35) were about the same as the monthly high and low water levels during the 1968-72 water years. There was little change in the low-and high-water levels from the 1972 water year except for a slight decline in high water levels (0.2-foot average) at Port Everglades.

WATER QUALITY

Ground water in Broward County can be used for most purposes without treatment and can be easily treated to meet standards recommended by the U.S. Public Health Service (1962) for public supply. The water is hard because of limestone dissolved from the Biscayne aquifer and it contains large quantities of iron in some areas.

The quality of untreated or raw surface waters in Broward County meets criteria for most uses, but the quality is highly variable. In general, the concentrations of the principle cations and anions in surface waters (table 2) in Broward County are below the limits established by Florida State Water Standards (Grantham and Sherwood, 1968) and the criteria set by the FDPC (Florida Department of Pollution Control) for pollution of surface waters (table 3). The iron concentration at the eight sites in table 2, exceeded the 0.3 mg/l limit set by the FDPC at 3 of the sites. Water with iron concentration higher than 0.3 mg/l will also cause staining (McKee and Wolf, 1963). Although, not considered to be a major factor, the surface waters in Broward County are generally very hard. Water whose calcium carbonate is in excess of 120 mg/l is considered hard (Rainwater, 1960, p. 173). Calcium carbonate greatly exceeds 120 mg/l at every site (table 2).

Typical indicators of man-made contaminants are major nitrogen and phosphorus sepecies, bacteria, detergents, and pesticides. Bacteriological parameters include B.O.D. and total and fecal coliforms. Pesticides include all the insecticides and herbicides.

Nitrogen and Phosphorus

High levels of nitrogen (nitrite, nitrate, ammonia, and organic nitrogen) and phosphorus are usually attributed to urban and agricultural waste, fertilizers and urban runoff. In the densely populated coastal areas, the major source of nitrogen and phosphorus compounds are the waste waters from sewage treatment plants.

Phosphorus and nitrogen compounds occur in water in several forms. The most common ionized form of phosphorus in water is orthophosphate. It is the only form derived from natural sources and the type most readily assimilated by plants.

Ammonia nitrogen in water generally originates from decomposition

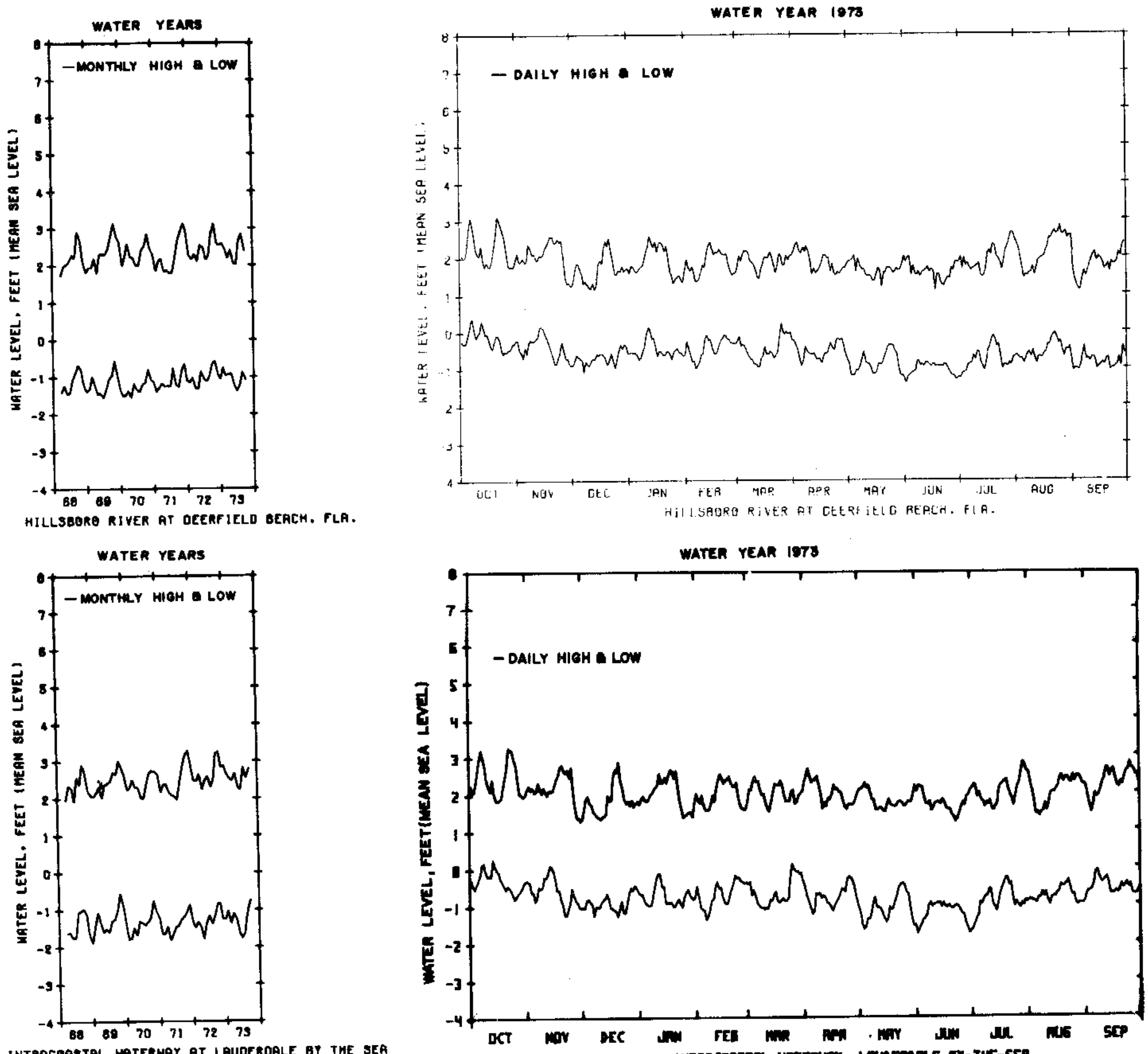


Figure 34.--Hydrographs of tidal fluctuations in Hillsboro River at Deerfield Beach and in the Intracoastal Waterway at Lauderdale-by-the-Sea, for the 1973 water year and 1968-73 water years.

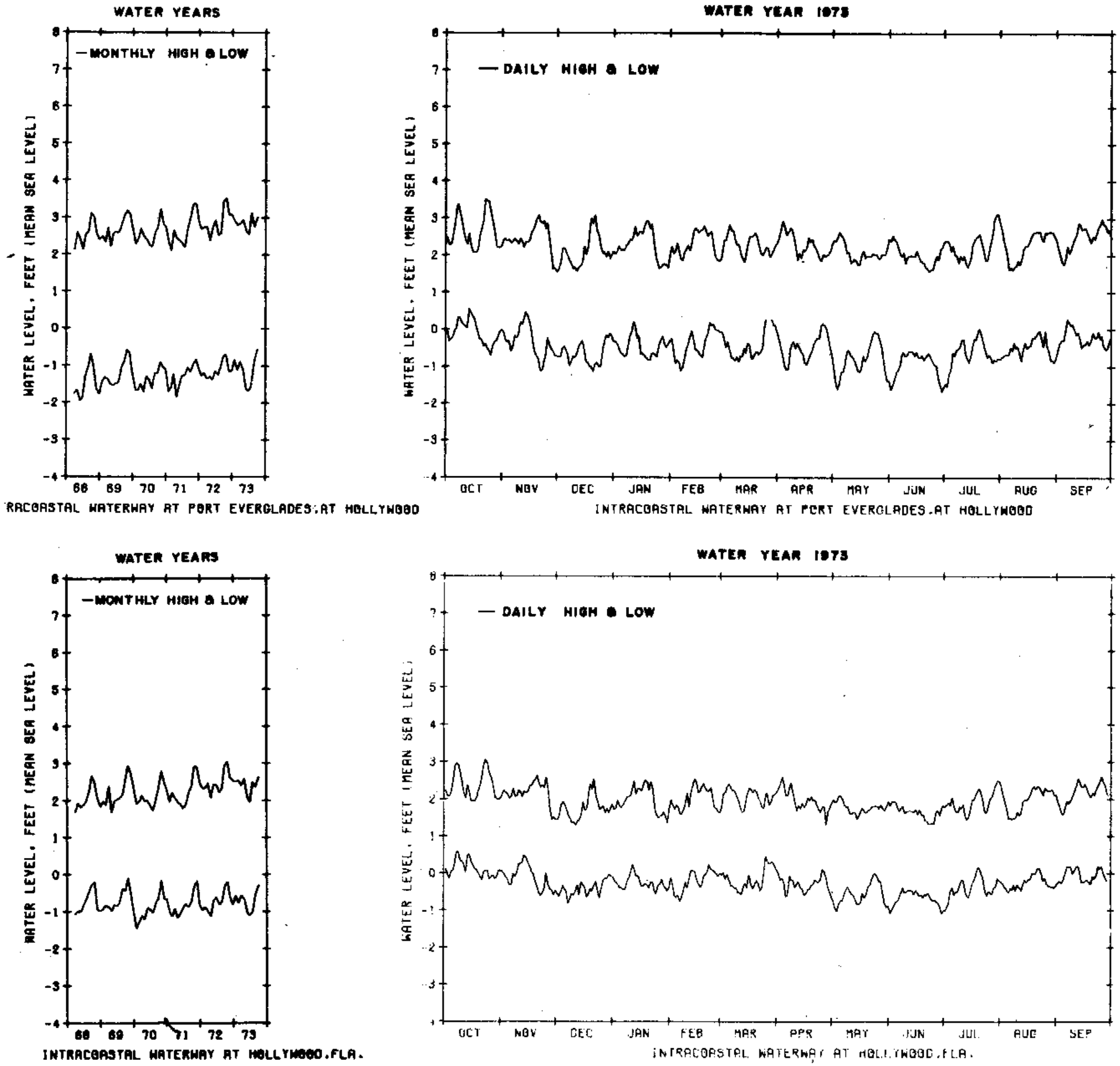


Figure 35.--Hydrographs of tidal fluctuations in the Intracoastal Waterway at Port Everglades, at Hollywood and at Hollywood, for the 1973 water year and the 1968-73 water years.

Table 2.--Ranges of water-quality parameters at selected sites in Broward County Canals, 1973 water year.
(milligrams per liter except where noted; for location of sites see figure 3).

	Site 1	Site 7	Site 10	Site 11
Temperature (°C)1/	23-28	22-29	24-29	22-30
Turbidity2/	2-7	3-10	3-10	2-10
Specific Conductance 3/	660-808	530-630	650-760	560-670
Color	45-100	40-60	40-55	45-55
Arsenic (As)	0.00-0.01	0.00-0.01	0.01	0.00-0.01
Chloride (Cl)	48-96	38-51	65-76	54-78
Chromium (Cr^{+6})	0.00	0.00	0.00	0.00
Copper (Cu)	0.00-0.01	0.00	0.00	0.00-0.01
Fluoride (F)	0.4-0.6	0.3-0.4	0.5	0.4-0.5
Iron (Fe)	0.11-0.21	0.11-0.30	0.01-0.07	0.12-0.30
Lead (Pb)	0.004-0.008	0.011-0.035	0.000-0.003	0.002-0.012
Oils and Grease	9.8-12	10-12	10-12	13-19
Dissolved Solids @ 180°C	415-520	320-491	424-455	358-393
Bicarbonate (HCO_3)	262-288	216-276	228-296	183-284
Zinc (Zn)	0.00-0.02	0.00-0.02	0.00-0.01	0.00-0.03
Non Carbonate	25-55	23-30	40-42	29-60
Hardness as $CaCO_3$ (Ca,Mg)	250-280	200-230	250-270	210-230
pH (units)	7.2-7.8	7.2-8.2	7.5-8.3	7.1-8.0
Phosphorus				
Total phosphate (PO_4) as P	0.04-0.49	0.02-0.24	0.16-0.25	0.37-0.88
Ortho as P	0.04-0.44	0.02-0.16	0.16-0.24	0.34-0.88
Nitrogen				
Nitrate (NO_3) as N	0.01-0.40	0.0-0.3	0.0-0.4	0.0-1.2
Nitrite (NO_2) as N	0.01-0.20	0.00-0.05	0.02-0.36	0.01-0.25
Ammonia (NH_4) as N	0.04-0.30	0.01-0.27	0.12-0.40	0.25-2.1
Organic as N	0.87-1.4	0.84-2.2	1.0-1.7	0.96-2.2
Detergents (one sample only)	0.0	0.0	0.05	0.04
B.O.D.	0.8-2.7	2.1-2.8	1.4-2.7	4.2-7.9
Coliform5/				
Total	730-26,200	3,600-20,000	710-35,000	1,400-12,300
Fecal	20-150	70-470	0-210	2-160
DDT Family6/				
Water	0.00	0.00	0.00	0.00
Sediment	1.3-10.1	28.0-84.3	52.2-252	8.4-19.1
Silvex6/				
Water	0.00-0.02	0.00-0.69	0.00-0.38	0.00-0.02
Sediment	0.00		0.00	

1 degrees Celsius
2 Jackson turbidity units
3 micromhos at 25C°
4 platinum - cobalt scale
5 colonies per 100 milliters
6 micrograms per liter (water) or kilogram (sediment)

Table 2.--(Cont.) Ranges of water-quality parameters at selected sites in Broward County Canals, 1973 water year.
(milligrams per liter except where noted; for location of sites see figure 3)

	Site 15	Site 21	Site 23	Site 43
Temperature 1/	24-28	18-29	18-28	22-26
Turbidity 2/	7-15	3-10	1-16	3-10
Specific Conductance 3/	445-600	660-800	580-660	640-650
Color 4/	40-100	50-80	80	45-60
Arsenic (As)	0.01	0.01	0.00-0.01	0.00-0.01
Chloride (Cl)	41-72	60-110	42-52	52-64
Chromium (Cr^{+6})	0.00-0.02	0.00	0.00	0.00
Copper (Cu)	0.00-0.02	0.00	0.00-0.01	0.00-0.01
Fluorides (F)	0.4	0.6-1.1	0.4-0.5	0.3-0.5
Iron (Fe)	0.18-0.48	0.08-0.20	0.22-0.42	0.41-0.63
Lead (Pb)	0.006-0.035	0.002-0.022	0.002-0.016	0.001-0.003
Oils and Grease	9.2-10	7.5-14	8.0-12	7.9-15
Dissolved Solids @ 180°C	244-349	410-467	362-410	385-394
Bicarbonate (HCO_3)	76-239	264-300	256-300	282-296
Zinc (Zn)	0.00-0.08	0.00-0.03	0.00-0.02	0.00-0.02
Non Carbonate Hardness	0-24	14-33	24-40	14-27
Hardness as $CaCO_3$ (Ca,Mg)	52-210	250-260	240-280	250-270
pH (units)	7.2-8.5	7.6-8.2	7.7-8.2	7.7-8.3
Phosphorus				
Total Phosphate (PO_4) as P	1.1-5.0	0.00-0.02	0.05-0.17	0.00-0.03
Ortho as P	1.1-4.8	0.00-0.01	0.04-0.20	0.00-0.03
Nitrogen				
Nitrate (NO_3) as N	0.0-0.1	0.0-0.4	0.2-0.7	0.0-0.2
Nitrite (NO_2) as N	0.02-0.27	0.00-0.04	0.04-0.06	0.01-0.02
Ammonia (NH_4) as N	2.4-17.0	0.05-0.45	0.22-0.50	0.14-0.25
Organic as N	0.96-2.8	1.0-2.4	1.4-2.1	0.89-1.7
Detergents (one sample only)		0.21		0.01
B.O.D.	4.3-7.7	0.4-4.8	1.9-6.3	0.3-1.8
Coliform 5/				
Total	400-7.0x10+6 7/	30-24,000	1,600-13,000	100-8,000
Fecal	10-2,900	10-60	80-900	10-70
DDT Family 6/				
Water	0.00	0.00	0.00	0.00
Sediment	14.1-125.3	0.4-57.5	2.7-26.0	0.6-1.2
Silvex 6/				
Water	0.02-0.87	0.02-0.77	0.00-0.53	0.00
Sediment	0.00-14.0	0.00-0.03	0.00-15.0	

1 degrees celsius
2 Jackson turbidity units
3 micromhos at 25C°
4 platinum - cobalt scale
5 colonies per 100 milliters
6 micrograms per liter (water) or kilogram (sediment)
7 estimate

Table 3.--Florida Department of Pollution Control criteria for surface waters. (milligrams per liter except where noted)

The Florida Department of Pollution Control has established 5 classes for Florida's surface waters. The waters are classified according to their usage as follows:

Class I -- Public water supplies
Class II - Shellfish harvesting
Class III - Recreation - Propagation and management of fish and wildlife.
Class IV - Agricultural and industrial water supply.
Class V - Navigation, utility and industrial use.

Criteria for the different classes varies, with the most stringent criteria for Class I, then Class II, etc. Because most of Florida's waters are used for recreation, fish, and wildlife, Class III was chosen for use in this report.

Criteria for All Classes:

Characteristic	Value Not to Be Exceeded
CHEMICAL	
Arsenic	0.05
Chloride (Fresh Water)	250
Chromium	0.05
Copper	0.5
Cyanide	0.00
Detergents	0.5
Flouride	10
Iron	0.30
Lead	0.05
Oils and Grease	15
Phenol	0.001
1/ Dissolved solids	500
Zinc	1

1/ Dissolved solids not to exceed 500 mg/l as a monthly average or 1000 mg/l at any time.

Table 3.--(Continued) Florida Department of Pollution Control criteria for surface waters. (milligrams per liter except where noted)

Additional Criteria for Class III:

Characteristic	Value Not To Be Exceeded
CHEMICAL	
pH (units)	6.0 - 8.5
PHYSICAL	
1/ Temperature (°F)	93
Turbidity (Jackson Turbidity Units)	50
Specific conductance (micromhos per centimeter)	500
Dissolved oxygen (DO)	2/
Biochemical oxygen demand (BOD)	2/
Toxic substances	3/
Deleterious	4/

1/ Temperature shall be less than 10 percent increase of prevailing background temperature after reasonable mixing with a 93°F (34°F) temperature maximum.

2/ DO and BOD criteria are discussed in the narrative section of this report.

3/ Toxic substances - free from substances attributable to municipal, industrial, agricultural or other discharges in concentrations or combinations which are toxic and harmful to humans, animal or aquatic life.

4/ Deleterious - free from materials attributable to municipal, industrial, agricultural, or other discharges producing color, odor, or other conditions in such a degree as to create nuisance.

of nitrogenous organic matter. It is usually the initial compound in the complex nitrogen chain and may eventually oxidize to nitrite and then to nitrate. Substantial concentrations of ammonia nitrogen in waters may indicate contamination by organic wastes.

Nitrite in water is generally formed by bacterial action on ammonia and organic nitrogen. Nitrite, an unstable compound, oxidizes rapidly to nitrate; thus it is not usually found in high concentrations in water. Like ammonia, nitrite is often an indicator of contamination by organic wastes.

Nitrate normally does not occur in high concentrations in natural surface waters because it is readily available for consumption by plants. It may be present in high concentrations in canals where sewage effluent is being discharged.

Federal and stage authorities have not (1974) established criteria for nitrogen and phosphorus species for surface water bodies except for nitrate and nitrite in surface waters to be used for public supply. The EPA (Environmental Protection Agency), lists 10 mg/l of nitrate plus nitrite (NO_2-N + NO_3-N) as permissible criteria.

Samples from 16 sites in the conservation areas of the west part of Broward County areas essentially free of man-made contaminants were collected during October 1971 and March 1972 and analyzed for major nitrogen and phosphorus species. The analyses of these samples except for phosphorus, were compared with the analyses of the quarterly samplings during the 1973 water year from the 25 sites in Broward County (fig. 3). The median values for ammonia, nitrite, and nitrate nitrogen for all the samples collected in the conservation areas were 0.05, 0.00, and 0.05 mg/l, respectively. The median values for ammonia, nitrite, and nitrate nitrogen for all the samples collected in Broward County during the 1973 water year were .30, .03 and .10 mg/l, respectively. Ranges of major nitrogen and phosphorus species from selected sites in the Broward County canals during the 1973 water year are shown in table 2.

Bacteria

The coliform group of bacteria includes organisms from many diverse origins including soil, vegetation and the feces of warm-blooded animals. Differentiation of the fecal coliform from the total coliform is necessary because fecal coliform bacteria indicate the presence of waste from warm-blooded animals, a likely source of water-borne pathogens capable of infecting man.

The concentrations of coliforms allowed by FDPC and EPA depend on the classification and use of the waters. The FDPC requires that in Class III waters (waters to be used for recreation and the propagation and management of fish and wildlife), total coliforms are not to exceed 1,000 per 100 ml on a monthly average; nor to exceed this number in more than 20 percent of the samples examined during the month. The FDPC requirements for surface waters to be used for public supply, Class I waters, are the same as for Class III waters. In surface waters to be used as sources for public supplies the EPA lists 10,000 total coliforms per 100 ml (milliliters) and 2,000 fecal coliforms per 100 ml as permissible limits and 100 total coliforms and less than 20 fecal coliforms per 100 ml as desirable limits. These criteria are of value in comparing one water with another.

Total coliforms exceeded the permissible limits for water for public supply and Class III waters at all sites except site 43 during the 1973 water year (table 2). Also, the range in total coliforms increased from the 1972 water year at all sites except sites 11 and 32. Fecal coliforms were over the permissible limit for water for public supply only at site 15, above control S-33 in Plantation Canal. The increase in total coliforms was probably due to the increase in the amount of sewage effluent being put into the canals.

The BOD (biochemical oxygen demand) is a measure of the amount of oxygen consumed by living organisms (mainly bacteria) while utilizing the organic matter present in the water, under conditions similar to those that occur in nature. The standard 5-day BOD test is actually a measure of the decomposable organic material stabilized during a 5-day incubation period at 20°C.

High BOD levels lower the DO concentration to levels that are detrimental to water quality and plant and animal life. Where re-aeration, dilution, and/or photosynthesis offset or minimize this depletion, BOD does not interfere with the reasonable uses of the water. The FDPC criterion says that BOD should not be altered to exceed values which would cause dissolved oxygen to be depressed below 4.0 mg/l or 70 percent saturation unless background data indicate lower values under unpolluted conditions. In a low velocity stream such as the canals in Broward County, a 5-day BOD of 5 mg/l might be sufficient to produce deoxygenation resulting in anaerobic conditions and damaging plant and animal life. The BOD level exceeded 5 mg/l at sites 11, 15 and 23 and were extremely high, near 5 mg/l, in some of the other canals.

Dissolved Oxygen

DO concentration is measured in milligrams of oxygen per liter of water. Weather conditions, sunlight intensity, surface runoff, ground-water inflow, photosynthesis, and the decomposition of organic materials are constantly affecting the production or utilization of oxygen. As a result of these physical, chemical or biological activities the DO content changes daily and seasonally.

The FDPC and EPA have established criteria for DO content in waters intended to be used for Class III waters. The FDPC criterion states that the DO content shall not be artificially depressed below 4 mg/l or 70 percent saturation unless background information indicates lower values under unpolluted conditions. The EPA criterion states that the DO content should remain above 5 mg/l daily; under extreme conditions the DO may range between 5 and 4 mg/l for short periods of time, provided that the water quality is favorable in all other respects.

The DO content in Broward County canals is generally lowest in September - December after the rainy season when water levels and flow in the canals are high (fig. 36). During high-flow periods storm runoff introduces water from the Everglades, conservation, agricultural and urban areas, that is high in oxygen - consuming materials. The DO content is generally highest in January - June, the dry season when canal flow is low. During the low-flow periods submersed plant communities have an opportunity to establish themselves and may increase the DO content.

Detergents

Detergents, MBAS (methylene blue active substance), are found at times in all the canals. These parameter reflects the household and industrial cleaners introduced into the canals by man. The EPA lists 0.5 mg/l as permissible criteria for surface waters to be used for public supply. The FDPC lists 0.5 mg/l (table 3) as the limit for pollution of surface waters. Detergent levels were extremely low in Broward canals during the 1973 water year (table 2).

Pesticides

Of the insecticides found in Broward County canals, the DDT family (DDT, DDD, and DDE) is generally present in the highest concentration; of the herbicides, silvex is generally present in the highest concentration. Concentrations are generally much higher in the sediments (table 2) than in the water although concentrations in both are generally within a safe range. Federal and state authorities have not set any limits (1973) for pesticides in surface waters except for surface waters to be used for public supply. The EPA lists 0.042 ug/l (micrograms per liter) of DDT as permissible and no limit for silvex.

SEA-WATER INTRUSION

With the construction of deep drainage canals in Broward County, sea water could flow inland during periods of low discharge. Drainage induced by the canals lowered the water table below the level required to prevent the movement of sea water into the aquifer. Drawdown caused by heavy pumping from well fields along the coast has also become a factor in sea-water intrusion in recent years. Ground-water levels are lowered as much as 5 feet below msl in some well fields during the dry season.

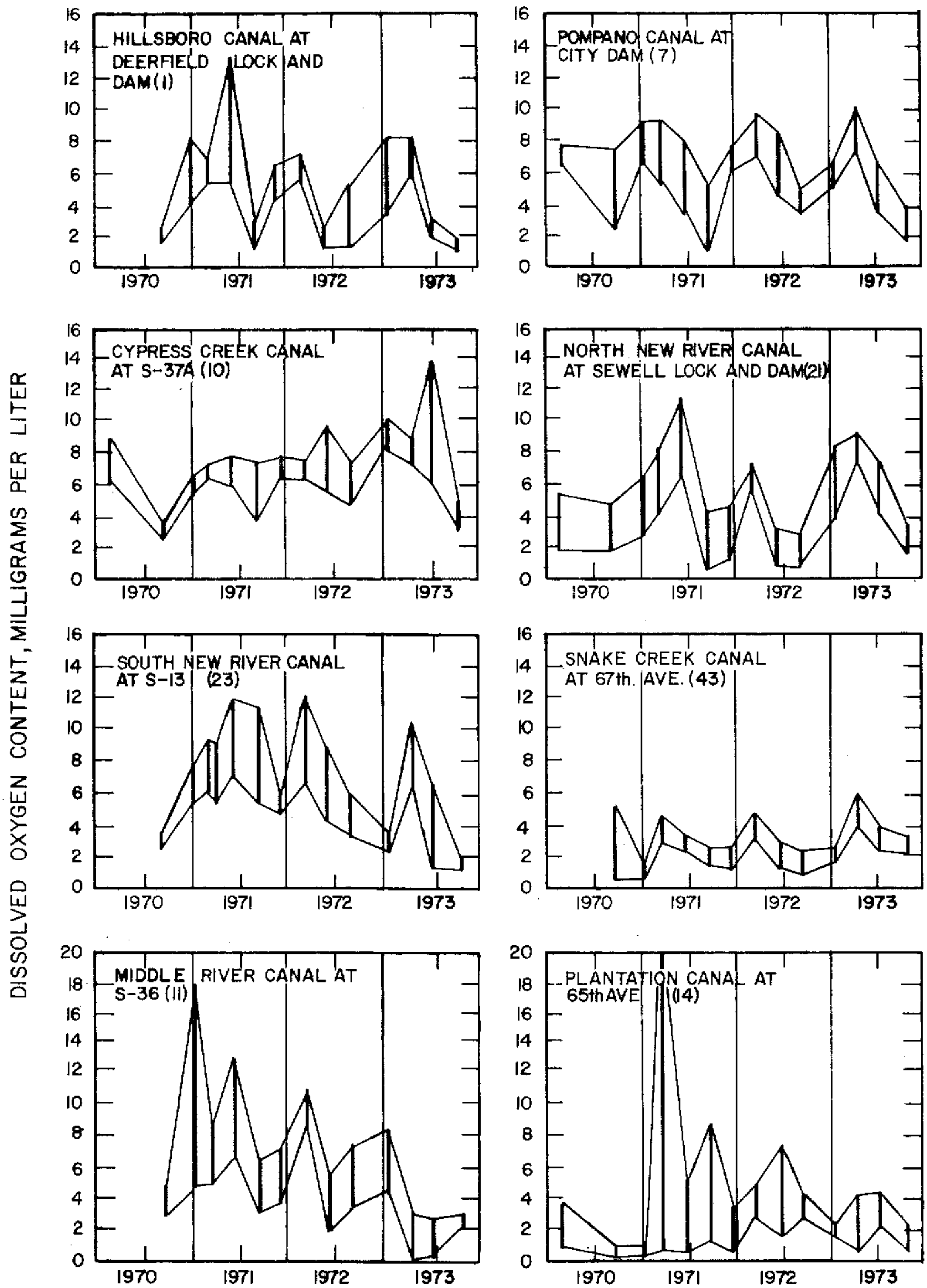


Figure 36.--Range of dissolved oxygen content for a 24-hour period at selected times and selected sites in Broward County Canals.

Controls have been built on all major canals near the coast to halt upstream movement of sea water and to maintain high fresh-water heads to prevent intrusion into the aquifer. However, the controls are 2 to 5 miles from the Intracoastal Waterway; thus sea water can move inland that far when water levels and discharge in the canals are low. The chloride concentration of water downstream from most of the controls in Broward County varies from 15 mg/l in some canals to 18,700 mg/l, depending on whether low-water or high-water conditions prevail (fig. 37).

When sea water moves into the uncontrolled reaches of the canal during low-water periods, it also infiltrates the aquifer. The approximate position of the saline front which varies slightly from low to high-water periods is shown on figure 38 for the coastal area of Broward County. The position of the salt-water front is determined by sampling test wells for chloride analysis (fig. 3) near the salt-water-fresh-water interface along the coastal areas. The chloride concentration of water from many of the wells varies greatly from low to high-water periods (table 4). Water from some of the wells increased in chloride and others decreased over the period of record (figs. 39 and 40). The wells with decreasing chloride concentration reflect the effects of better water management in that area. In the wells that yield water whose chloride concentration has been increasing, water levels have declined.

WATER USE

All public water supplies in Broward County are derived from wells. In the vicinity of many of the wells the aquifer is replenished in part by the infiltration of water from nearby canals. Most supplies in the urban area are provided by municipal systems, although some single and multi-unit domestic systems are supplied by individual wells. It is estimated that between 30,000 and 35,000 private wells produce a total of 3.65 billion gallons per year (Sherwood and others, 1972).

In Broward County, 32 municipal and privately owned utilities supply a permanent population of 828,000 and a peak tourist season population of about 1,000,000. During 1973 the seven largest suppliers (table 5) pumped 30.739 billion gallons or 84.2 million gallons daily for public supply. Pumpage in 1973 was 1.582 billion gallons more than in 1972 -- the third largest annual increase since 1961 (fig. 41). The greatest annual increase in pumpage since 1961 occurred in 1970. Long dry seasons prevailed during 1970 and 1971, especially in 1971 when rainfall was 39 percent deficient, and water consumed for lawn irrigation was extremely high. Rainfall in 1972 was above average especially during the dry period, therefore, pumpage in that year was slightly less than in 1971. Rainfall was 7.19 inches (12 percent) deficient in the coastal areas and 9.52 inches (16 percent) deficient overall (table 1), during the 1973 water year.

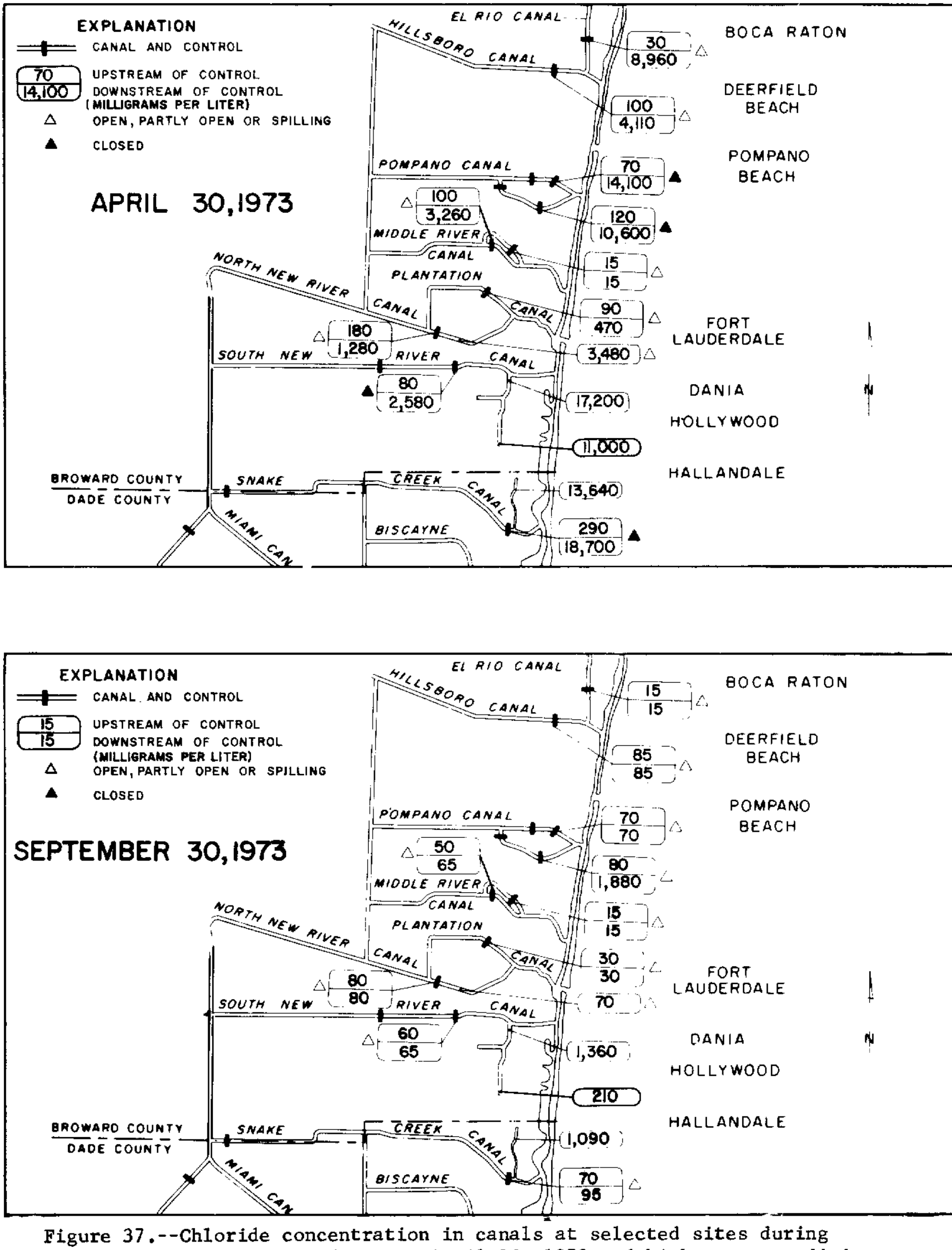


Figure 37.--Chloride concentration in canals at selected sites during low-water conditions, April 30, 1973 and high-water conditions, September 30, 1973.

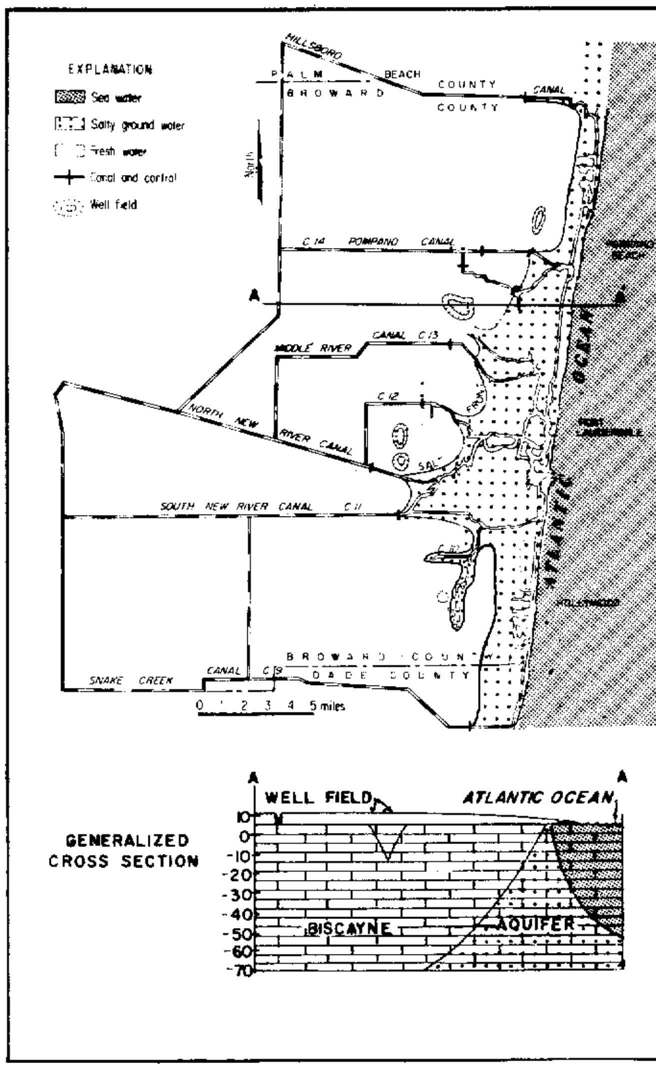


Figure 38.--Extent of sea-water intrusion, 1973.

Table 4.--**Chloride concentration of water from wells in Broward County.** **(Results in milligrams per liter)**

Well No. [1/]	Chloride Concentration Low-Water Conditions 5-14-73	Chloride Concentration High-Water Conditions 10-2-73	Date Record Began		Chloride Concentration Period of Record Maximum	Chloride Concentration Period of Record Minimum
S 830	1,625	1,650	Nov.	1946	2,800	1310
S 1321	46	108	Mar.	1963	120	21
S 1366	385	300	Oct.	1960	520	28
S 1414	54	60	Mar.	1959	143	20
S 1488	22	26	June	1965	54	15
S 1489	22	26	June	1965	42	13
S 1524	255	124	Nov.	1970	190	52
G 515	725	680	April	1960	840	600
G 820	16	- -	June	1956	41	14
G 854	650	600	Sept.	1959	860	155
G 1211	20	64	Aug.	1962	64	16
G 1212A	30	38	Aug.	1962	38	12
G 1232	16	14	Nov.	1967	26	11
G 1235	470	560	Nov.	1967	880	442
G 1237	- -	102	Oct.	1967	260	102
G 1240	236	225	Sept.	1967	250	82
G 1340	80	94	Feb.	1968	177	72
G 1343	50	42	Mar.	1968	130	14
G 1344	- -	295	Mar.	1968	404	290

1/ For location of wells see figure 3.

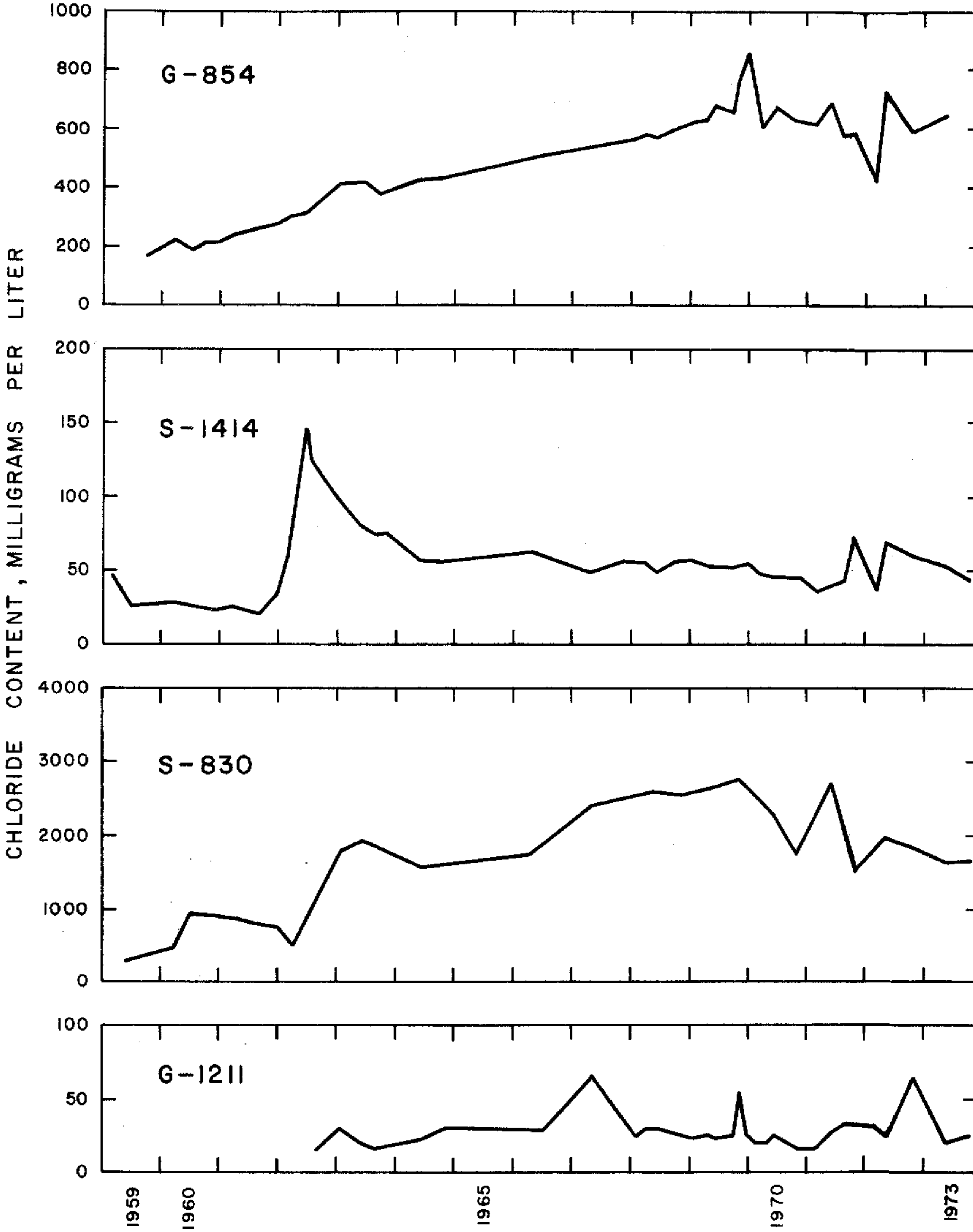


Figure 39.--Chloride concentration of water in wells G 854, S 1414, S 830, and G 1211 in Broward County.

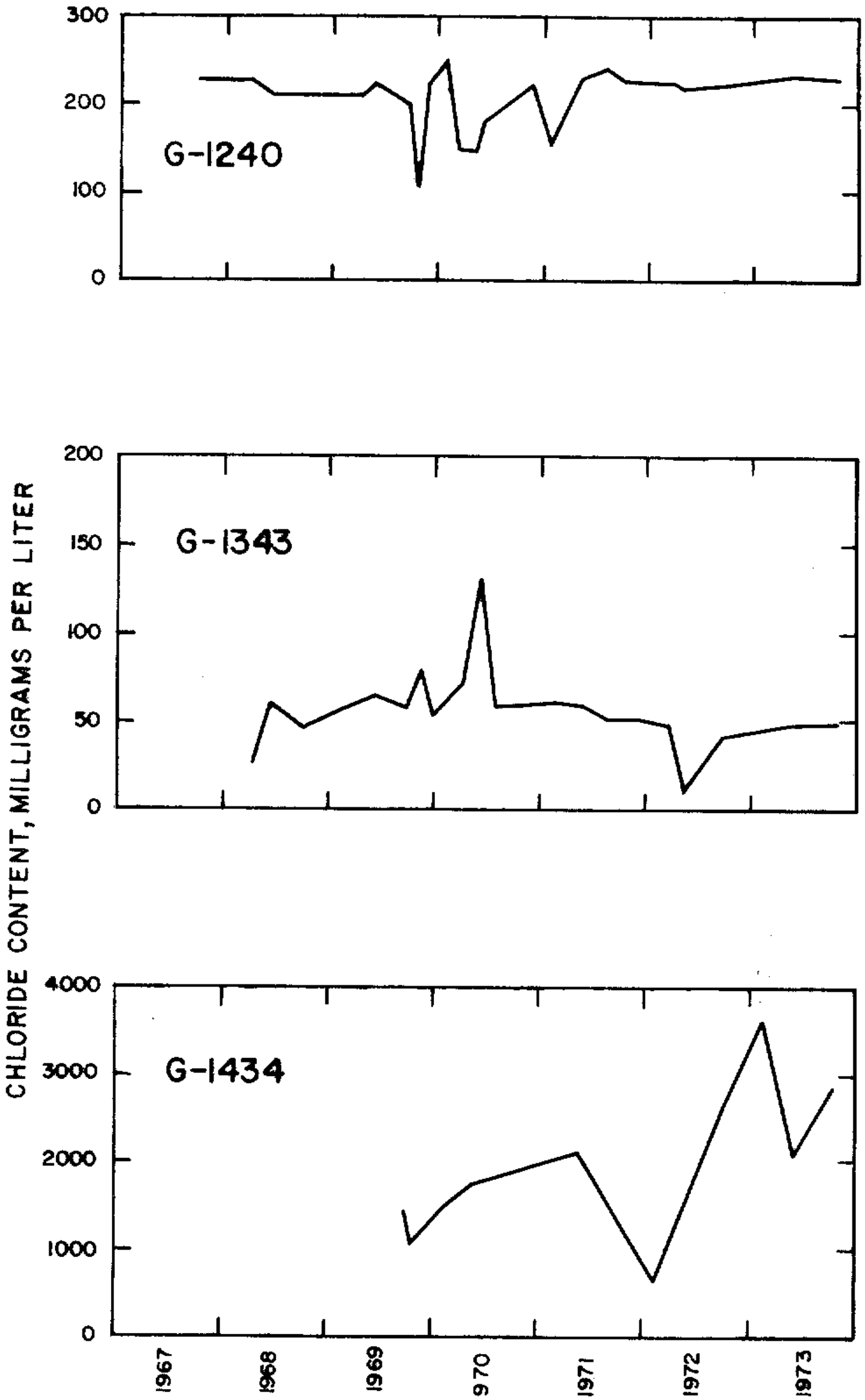


Figure 40.--Chloride concentration of water in wells G 1240, G 1343, and G 1434 in Broward County.

Table 5.-- Total water pumped by the major municipal suppliers in Broward County in 1973.

City	Total Pumpage (million gallons)
Fort Lauderdale	15,601
Pompano	5,466
Hollywood	4,802
Deerfield Beach	1,681
Hallandale	1,663
Miramar	878
Dania	648
Total	30,739

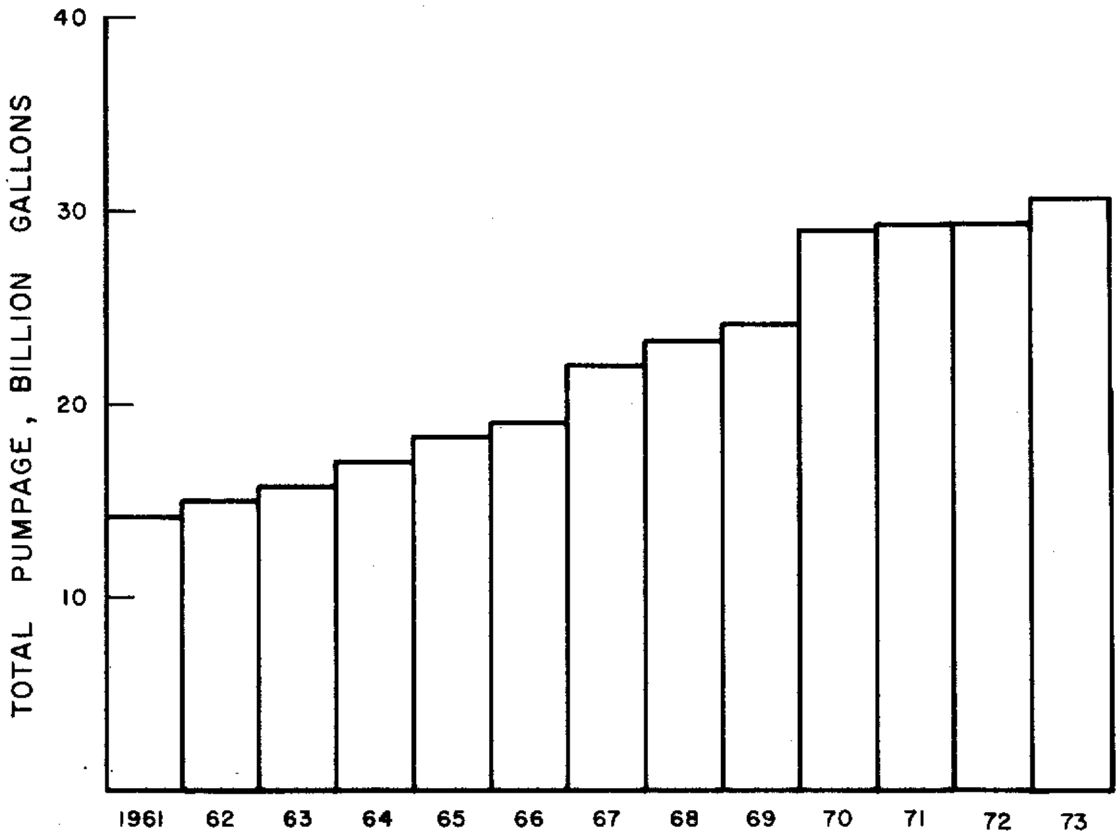


Figure 41.--Annual pumpage from the Fort Lauderdale, Hollywood, Pompano, Hallandale, Deerfield Beach, Dania, and Miramar municipal wells, 1961-73.

The water system of Fort Lauderdale, the largest in Broward County, has a treatment capacity of 60 mgd (million gallons per day). The average demand in 1973 was 42.7 mgd, but the demand exceeded 60 mgd during the dry period in April. Monthly pumpages at Fort Lauderdale are generally highest during the dry season (December - April) because of heavy water use for lawn irrigation and increased demands caused by the influx of tourists (fig. 42).

SUMMARY

Flow in FCD Canals in Broward County is regulated on a daily basis to obtain optimum ground-water levels and storage for each season and to provide flood protection. A series of secondary canals in the county are regulated by the Broward Water Resources Department. Both agencies work together to effectively manage the county's water resources.

The major source of recharge to the Biscayne aquifer and surface-flow system in Broward County is rainfall. The average water-year rainfall in Broward County, based on 30 years of record at a coastal and an inland station, is 58.60 inches. Rainfall averaged 49.08 inches during the 1973 water year.

The amount of fresh ground water potentially available in the aquifer is determined by the recharge to and discharge from the aquifer and the quantity available from storage. Infiltration of rainfall through surface materials and seepage from controlled canals and the conservation areas constitute the recharge. Discharge from the aquifer occurs by evapotranspiration, by ground-water flow to canals and the ocean, and by pumping from wells. Rainfall is the major source of recharge, thus, area-wide water levels fluctuate chiefly in response to variations in rainfall. During the wet season, water levels in the aquifer are high; during the dry season, water levels are low. Rainfall during the 1973 water year was 16 percent below average, consequently, water levels were slightly below average during most of the year. Water levels during the peak of the 1973 dry season were almost as low as during the peak of the record low dry season in 1971.

Water management in Broward County is dependent on the FCD Canal network (primary) throughout the county, the conservation areas to the west, and Lake Okeechobee northwest of the county (fig. 1). The water conservation areas and Lake Okeechobee serve to impound water for use in the coastal area during the dry periods to recharge the aquifer and maintain high fresh water heads to prevent salt-water intrusion. During droughts Broward County's fresh-water supply is chiefly dependent on releases into the major canal network. Flow in all the major canals except Middle River and Plantation during the 1973 water year was far below the average for 1962-72. In October 1972, the beginning of the 1973 water year, rainfall was 7.59 inches below average and was

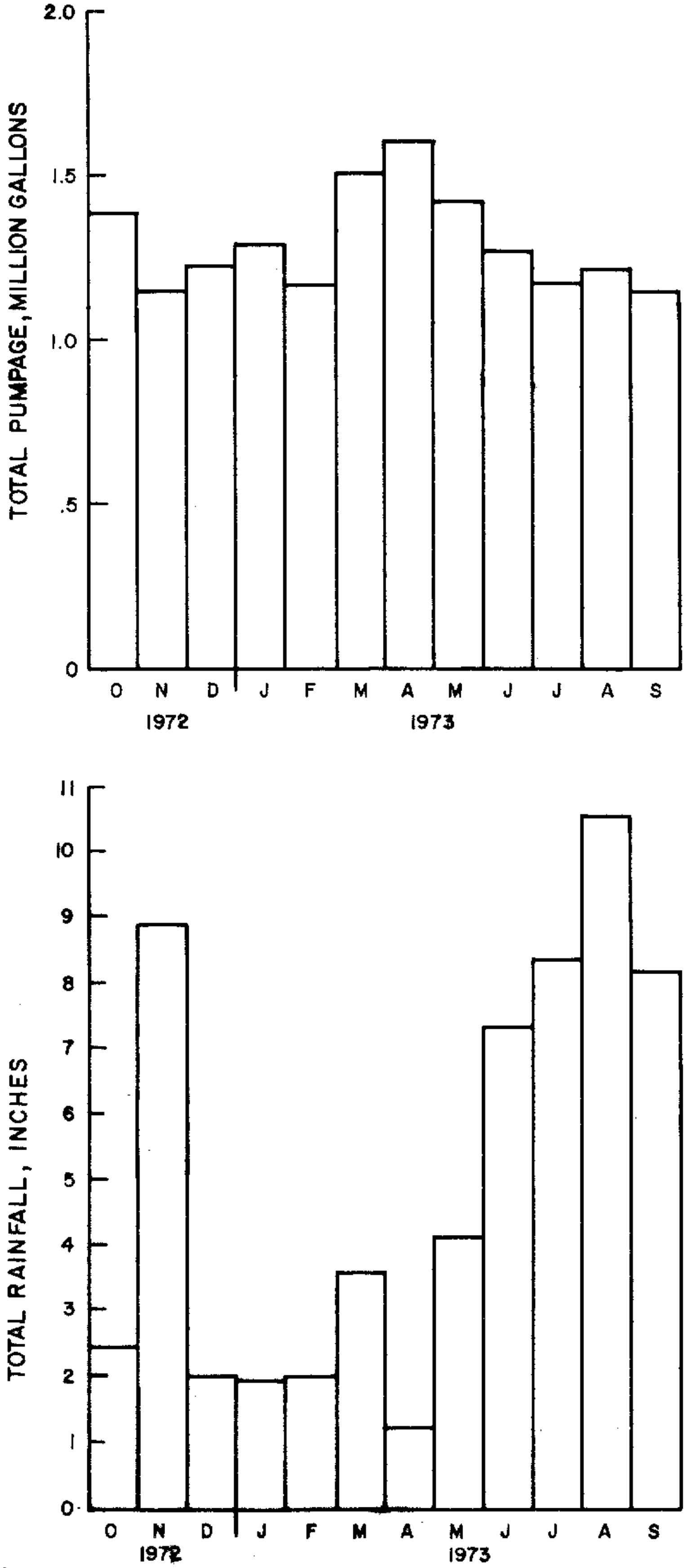


Figure 42.--Monthly pumpage from the Fort Lauderdale Dixie and Prospect municipal wells, and monthly rainfall at Fort Lauderdale, 1973 water year.

probably the reason for low flows during the first part of the year.

In general, the concentrations of the principal cations and anions in surface water in Broward County are within the limits established by Florida State Water Standards. The chief threat to surface-water quality in urban areas is man-made contamination. Typical indicators of man-made contaminants are nitrogen and phosphorus, detergents, bacteria, and pesticides. Bacteriological parameters include BOD and total and fecal coliforms and are probably the best indicators of contamination. Total coliforms exceeded the permissible limits for Class III waters and waters for public supply in Broward canals except at site 43 in Snake Creek Canal during the 1973 water year.

All public supplies in Broward County are derived from wells that are developed in the Biscayne aquifer. There are 32 municipal and privately owned utilities in Broward County that supply a permanent population of 828,000 and a peak tourist season population of about 1,000,000. During 1973 the seven largest suppliers pumped 30,739 billion gallons, an increase of 1.582 billion gallons from 1972.

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