UNITED STATES
DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY

# HYDROLOGIC CONDITIONS IN BROWARD COUNTY, FLORIDA 1976

OPEN-FILE REPORT 79-1258

Prepared in cooperation with
BROWARD COUNTY, CITIES OF FORT LAUDERDALE, HOLLYWOOD, HALLANDALE, AND POMPANO BEACH
AND
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

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By T. R. Beaven

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Tallahassee, Florida

1979

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, SECRETARY

GEOLOGICAL SURVEY

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# HYDROLOGIC CONDITIONS IN BROWARD COUNTY, FLORIDA, 1976

By T. R. Beaven

## ABSTRACT

Rainfall is the major source of recharge to the Biscayne aquifer and surface-flow system in Broward County. During the 1976 water year rainfall was 3.6 percent below average. Water levels in the Pompano Beach and Dixie well fields were lower during the peak of the 1976 dry season than at the peak of the record low dry season in 1971.

Broward County's freshwater supply is chiefly dependent on release into the major canal network during droughts. Flow was variable in the major canals during the 1976 water year when compared to the 1962-75 averages. Cypress Creek, Middle River, and Snake Creek Canal at S-29 had greater flow than the 1962-75 averages. Flows in Plantation Canal and South New River were equal to the 1962-75 average, while Hillsboro, North New River Canal, and Snake Creek Canal at N.W. 67th Avenue had flow below the long-term averages.

The concentrations of principal mineral constituents in surface water in Broward County were within limits established by Florida State Water Standards, with the exception of iron at one station. Total coliforms were equal to or within permissible limits for Class III water and water for public supply in Broward canals at all sites during the 1976 water year. Fecal coliform did not exceed the permissible limit for public water supply at any of the sites during the 1976 water year.

There are 32 municipal and privately owned utilities in Broward County supplying a resident population of over 832,000 and a peak tourist season population of over 1,000,000. During 1976 the 13 largest suppliers pumped 49.544 billion gallons, an average of 135.4 million gallons per day.

## INTRODUCTION

This report, the sixth of an annual series, presents hydrologic data in Broward County (fig. 1) for the 1976 water year. The 1976 water year is the 12-month period from October 1, 1975 through September 30, 1976. Data are compared with long-term records of rainfall, ground water, surface water, and water quality from stations located throughout Broward County. Significant hydrologic changes and events are summarized on the basis of the long-term trends where possible.

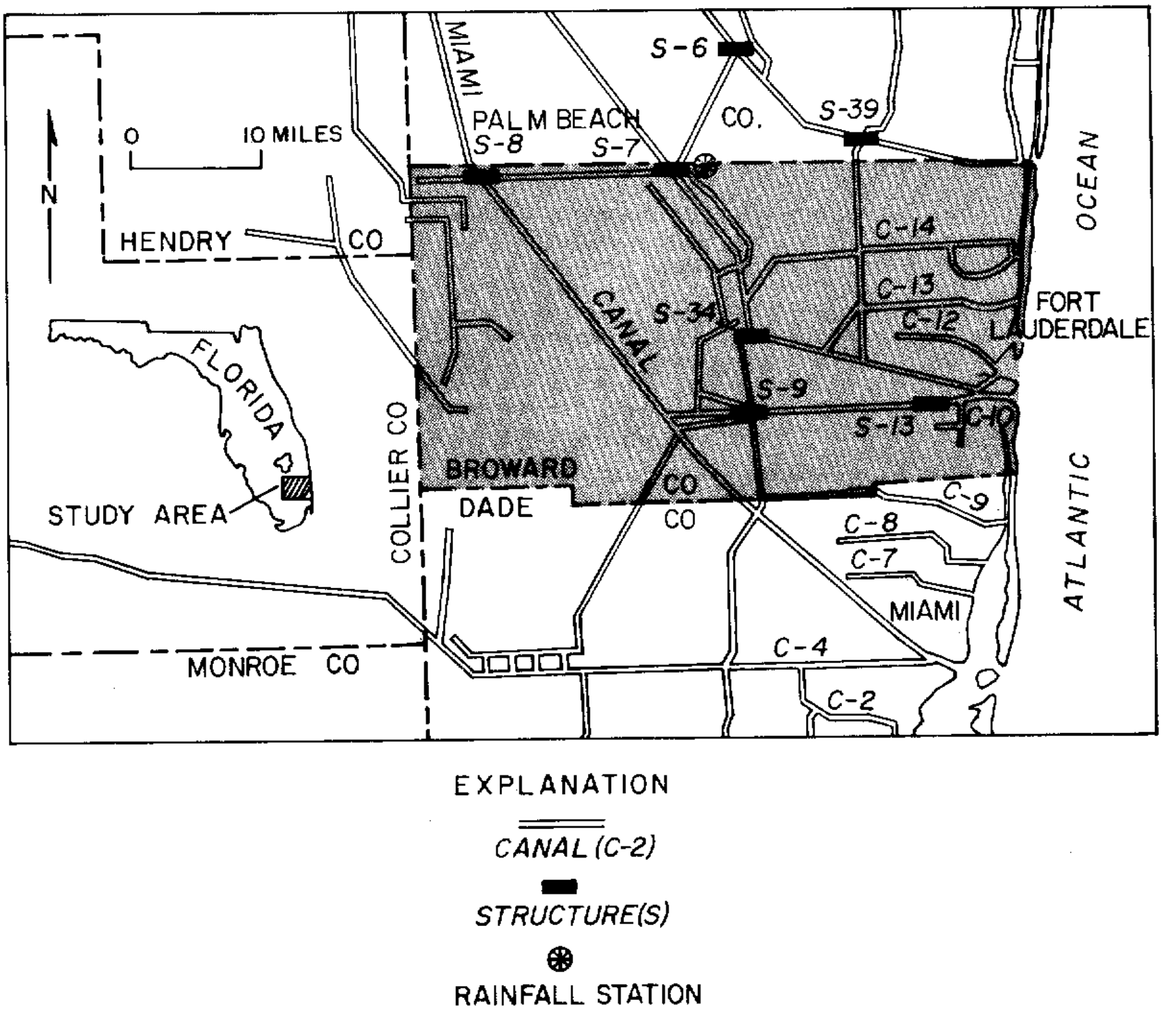



Figure 1.—Location of Broward County

Management of water resources is affected by antecedent hydrologic conditions, the most important of which is areal distribution of rainfall. A second significant factor in water management in south Florida is the effect of drainage canals, controls on canals, or diversions from canals which may cause permanent changes in the distribution of water as it moves over and through the land.

Deficiencies in rainfall and the attendant reduced freshwater heads in the aquifer may allow water with relatively higher concentrations of dissolved solids to move inland from the ocean through the canals and recharge the aquifers. On the upstream side of canal structures, where they exist, the water quality may be impaired by high levels of nutrients and organic material. Below or downstream of the structures, water is frequently brackish or saline.

This report was prepared as part of the cooperative program of water-resources investigations between the U.S. Geological Survey and the Broward County Board of Commissioners. Liaison with the Board of Commissioners was maintained through the Water-Resources Department and the Environmental Quality Control Board of Broward County. In addition, a large part of the data in the report was collected as part of cooperative investigations with the South Florida Water Management District, and the cities of Fort Lauderdale, Hollywood, Hallandale, and Pompano Beach.

For use of those readers who may prefer to use metric units rather than inch-pound units, the conversion factors and abbreviations for the terms used in this report are listed below:

| Multiply inch-pound unit | By | To obtain metric (SI) unit |
|---|---|---|
| | Length | |
| inch (in) | 25.4 | millimeter (mm) |
| | .0254 | meter (m) |
| foot (ft) | .3048 | meter (m) |
| mile (mi) | 1.609 | kilometer (km) |
| | Volume | |
| gallon (gal) | 3.785 | liter (L) |
| | $3.785 \times 10^{-3}$ | cubic meter ($m^3$) |
| million gallons (Mgal) | 3785 | cubic meters ($m^3$) |
| | $3.785 \times 10^{-3}$ | cubic hectometers ($hm^3$) |

Flow

| | | |
|---|---|---|
| cubic foot per second ($ft^3/s$) | 28.32 | liter per second (L/s) |
| | .02832 | cubic meter per second ($m^3/s$) |
| gallon per minute (gal/min) | .06309 | liter per second (L/s) |
| | $6.309x10^{-15}$ | cubic meter per second ($m^3/s$) |
| million gallons per day (Mgal/d) | .04381 | cubic meters per second ($m^3/s$) |

Transmissivity

| | | |
|---|---|---|
| million gallons per day per foot (Mgal/d/ft) | .0124 | meters squared per day ($m^2/d$) |

## WATER MANAGEMENT

A principal means of water management in south Florida consists of regulating the amount and direction of water flow through canal systems. Canals may be classed as primary and secondary. The South Florida Water Management District (SFWMD) operates and maintains the primary canals, which are designed to help regulate ground-water levels and provide flood protection by scheduling water flow to and from storage in the conservation areas and to the sea. Secondary canals, maintained and operated by the Broward County Water Resources Department, are used for land drainage. The cooperation of the two agencies provides an effective overall management system.

Decisions regarding the distribution of water throughout the canal system are based on prevailing hydrologic conditions. Excess water from heavy precipitation during the wet season is backpumped into the conservation areas for storage or discharged into the ocean through control structures (dams). Water is released from storage during the dry season and is transported through the canal system to recharge the Biscayne aquifer in high use areas.

## RAINFALL

Rainfall records are tabulated from three stations in Broward County. Two are coastal stations located in Pompano Beach and Fort Lauderdale (fig. 2). The third is an inland station located at the S-7 pump station on North New River Canal (fig. 1).

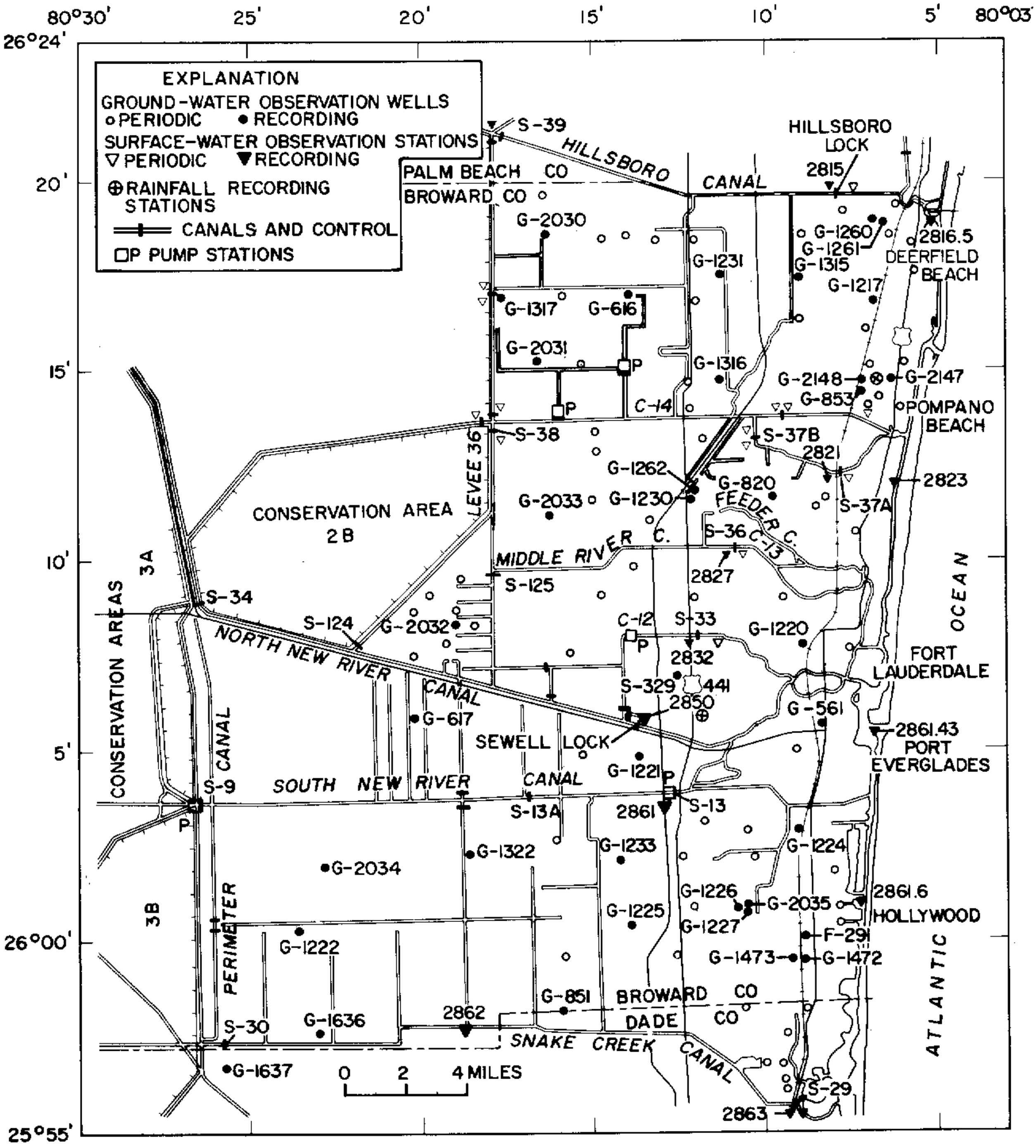



Figure 2.--Surface-water observation stations, rainfall stations, and observation wells in Broward County

The 1976 water year average rainfall for Broward County was 55.28 inches. This was 2.07 inches or 3.6 percent below the 33-year average (1943-75) of 57.35 inches (Table 1). The 33-year average for the three stations varied from 51.47 inches at the North New River Canal inland station to 60.29 inches for the two coastal stations, a difference of 8.82 inches.

The North New River Canal station received 46.19 inches of rain during the 1976 water year, 5.28 inches or 10.3 percent less than the 33-year average for that station, while the Pompano Beach station received 59.32 inches for a deficiency of 1.81 inches or 3.0 percent. Rainfall at the Fort Lauderdale stations for the same period was 60.34 inches, an increase of 0.88 inch or 1.5 percent when compared with the station's 33-year average of 59.46 inches.

The distribution of monthly rainfall for the 1976 water year is similar to the long-term average (fig. 3). Although the distribution of rainfall within each year varies, the period of tropical storm activity, May through October, may account for as much as 80 percent of the yearly total. The May through October period accounted for over 75 percent of the rainfall during the 1976 water year. The maximum deviation from the long-term monthly average occurred in May when rainfall exceeded the average by 4.43 inches at the coastal stations, and 5.99 inches at the inland station. July and September rainfall was more than 3 inches below the long-term average at the coastal stations. October and June rainfall was more than 3 inches below average at the inland station. Rainfall was close to the 33-year monthly averages during the remainder of the water year.

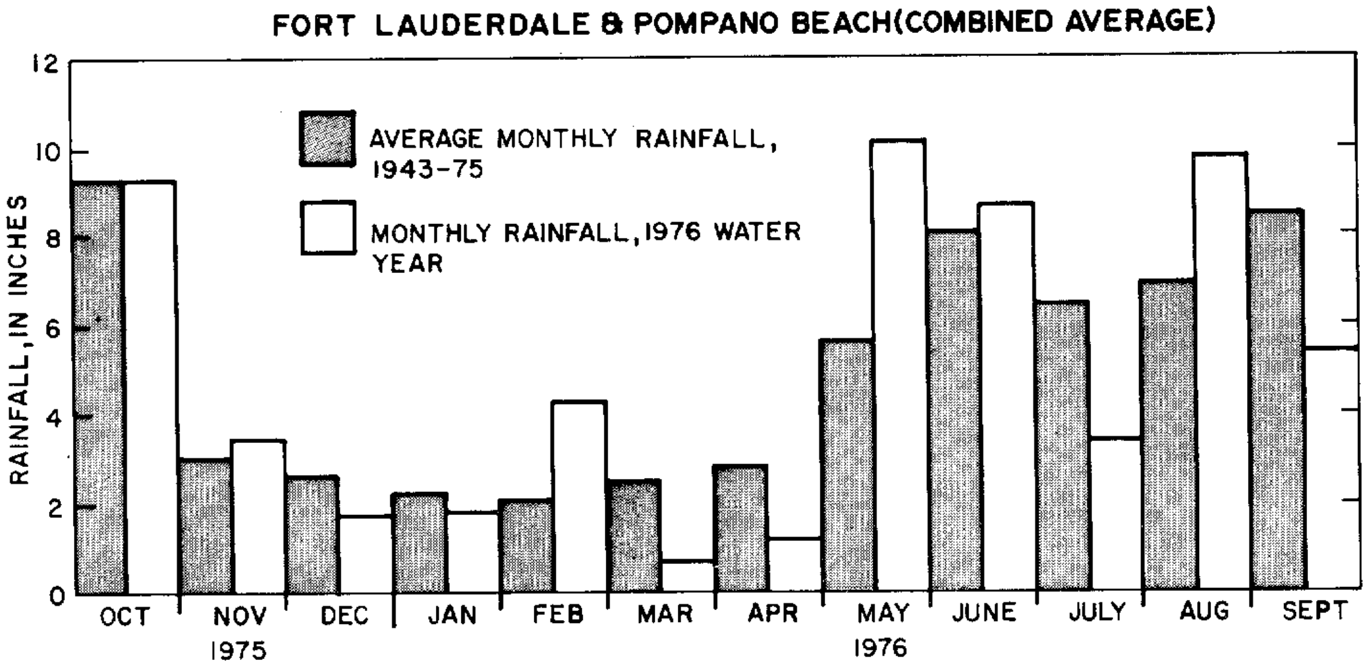
## GROUND WATER

Ground water is water in the zone of saturation--the subsurface zone in which all voids, including joints, fissures, solution holes, interstices, and crevices, are filled with water. Geologic units are called aquifers if they contain saturated permeable material capable of yielding significant quantities of ground water to wells and springs. The Biscayne aquifer is the primary source of fresh ground water for Broward County.

In Broward County the Biscayne aquifer is composed chiefly of permeable limestone, sandstone, and sand ranging in age from the late Miocene through Pleistocene (Sherwood and others, 1973). The aquifer is wedge-shaped with an east-west orientation. It extends to a depth of more than 200 feet below land surface along the coastal areas. The base of the aquifer decreases in depth to the west and intersects land surface near the Broward-Collier County line. Beneath the Biscayne aquifer, highly impermeable beds of marine sediment, interspersed with occasional pockets of marl, extend to considerable depths.

Table 1.--Summary of rainfall data by stations

| Location | 1976 water year | Water year average (1943-75) |
|---|---|---|
| Coastal sector: | | |
| Fort Lauderdale | 60.34 | 59.46 |
| Pompano | 59.32 | 61.13 |
| Average | 59.83 | 60.29 |
| Inland sector: | | |
| North New River Canal at S-7 | 46.19 | 51.47 |
| Average of above stations | 55.28 | 57.35 |



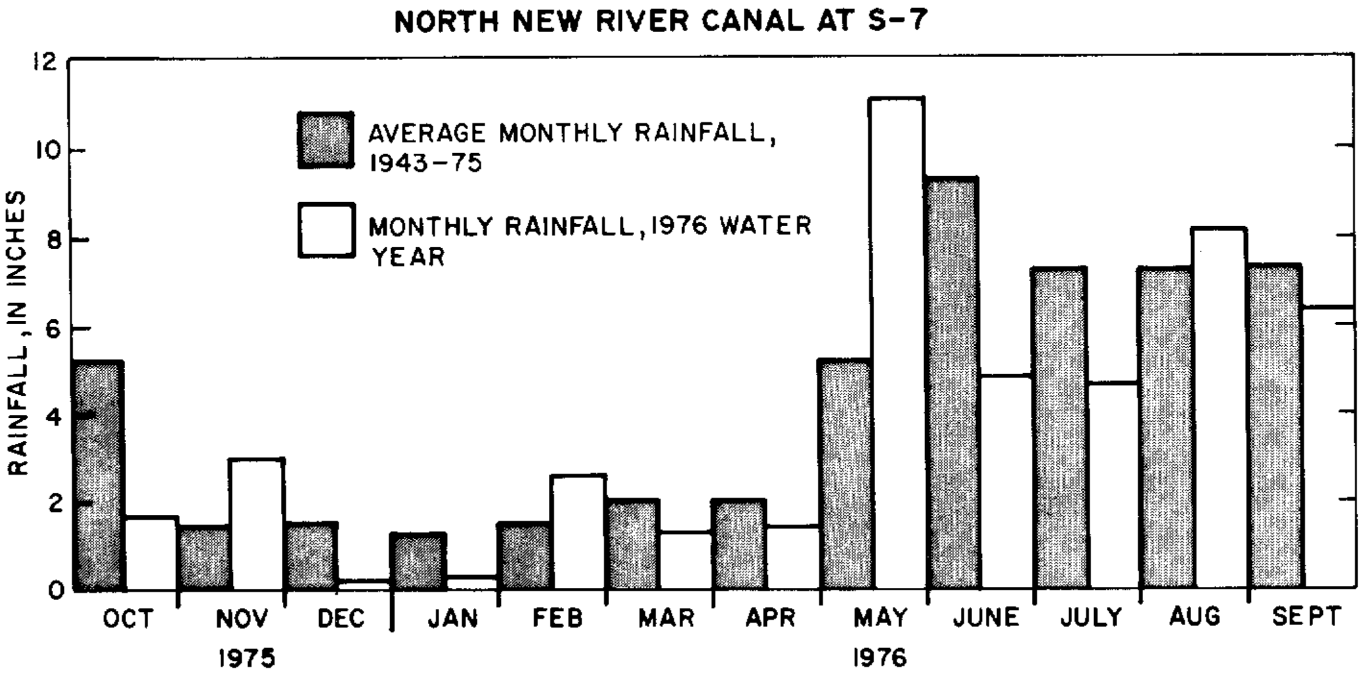




Figure 3.—Monthly rainfall for the 1976 water year and the average monthly rainfall, 1943-75 at Fort Lauderdale, Pompano Beach, and North New River Canal at S-7

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

Water-level fluctuations in the Biscayne aquifer of Broward County are monitored in wells located throughout the county (fig. 2). Thirty-seven wells have continuous recording instruments for measuring water level. Seven of the wells monitor the effects of pumping in high yield well fields.

Water levels in the Biscayne aquifer respond rapidly to variations in rainfall because of the high permeability of the limestone. This is reflected by observation well hydrographs in Broward County. Figure 4 shows the hydrographs for well G-561 during the 1976 water year and for the period of record. Figure 4 also shows rainfall records for the same periods.

The general trend of five well hydrographs (figs. 4-8) for the 1976 water year shows the recession of water levels between November and April. In May increasing rainfall is reflected as recharge begins to raise the water levels. Small deflections on the well hydrographs correspond to periods of minor rainfall, while more intensive rainfall peaks compare with the higher peaks of the well hydrographs.

Extreme high-water and low-water levels for the previous years on record are shown as +'s on each well hydrograph. Although none of the extreme high-water levels were exceeded during the 1976 water year, four wells dropped below extreme low-water levels. Water levels in well F-291 dropped to 0.60 foot (datum is mean sea level) in February, 0.05 foot below the prior extreme low level for the month (fig. 5). Also during February, well G-1220 recorded water levels of 1.64 feet. This was 0.11 foot below the previous low (fig. 6). Well G-616 recorded a new low of 8.41 feet in July, a reduction of 0.06 foot from the preceding low water record of 8.47 feet (fig. 7). In well G-617 the water level declined to a new extreme of 3.21 feet in September, a reduction of 0.09 foot from the antecedent low (fig. 8).

Although a quantitative relationship between the long-term hydrographs and monthly rainfall was beyond the scope of this report, the records show that years with high rainfalls correlate positively with years of high water levels. Note especially the years 1948, 1952-54, 1957-60, 1965-69. Similarily, those years showing lesser rainfall accumulations are reflected by low peaks with more pronounced and deeper troughs in the hydrograph.

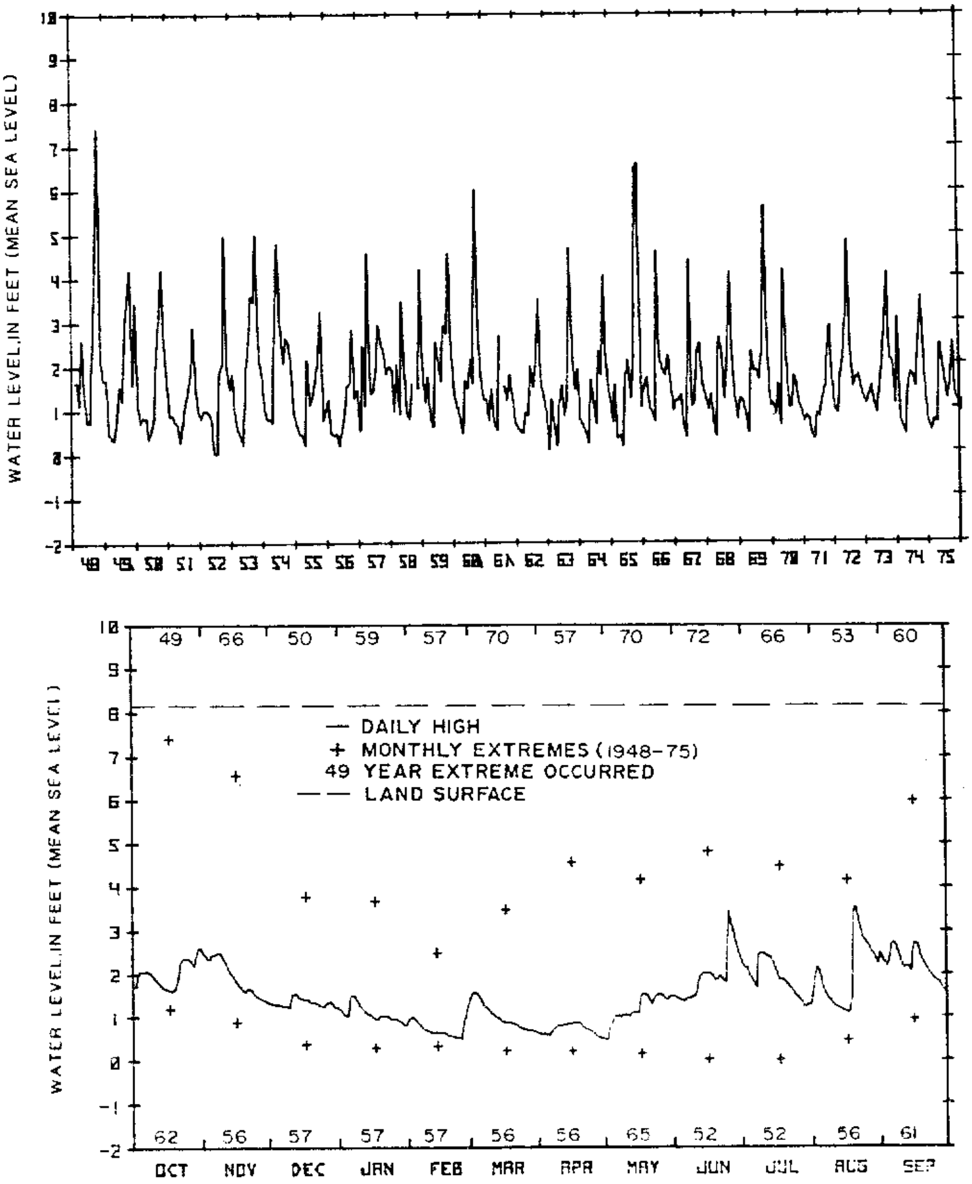
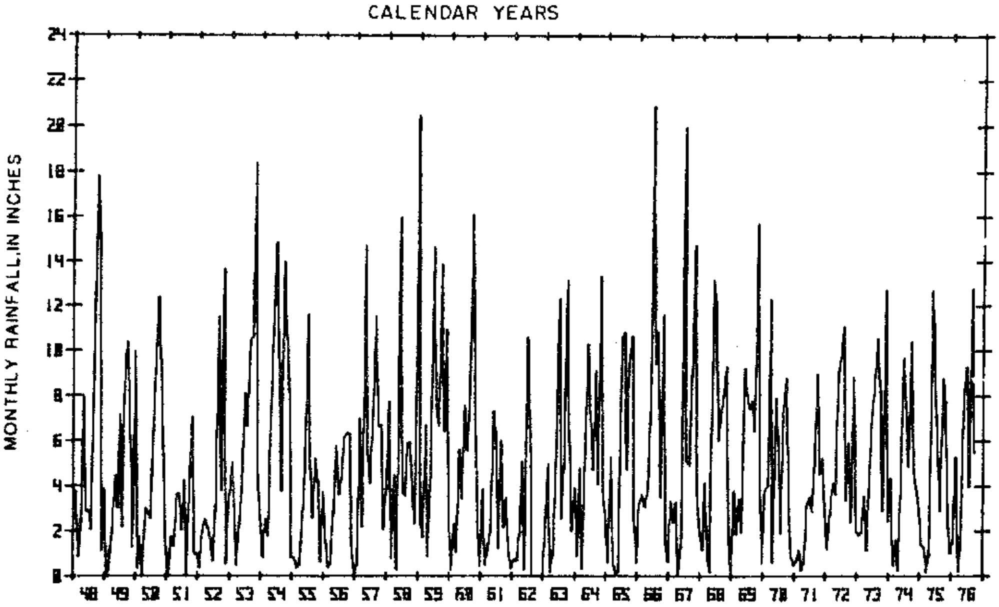



Figure 4.--Well G-561 and rainfall at Fort Lauderdale for the 1976 water year and 1948-75 calendar years



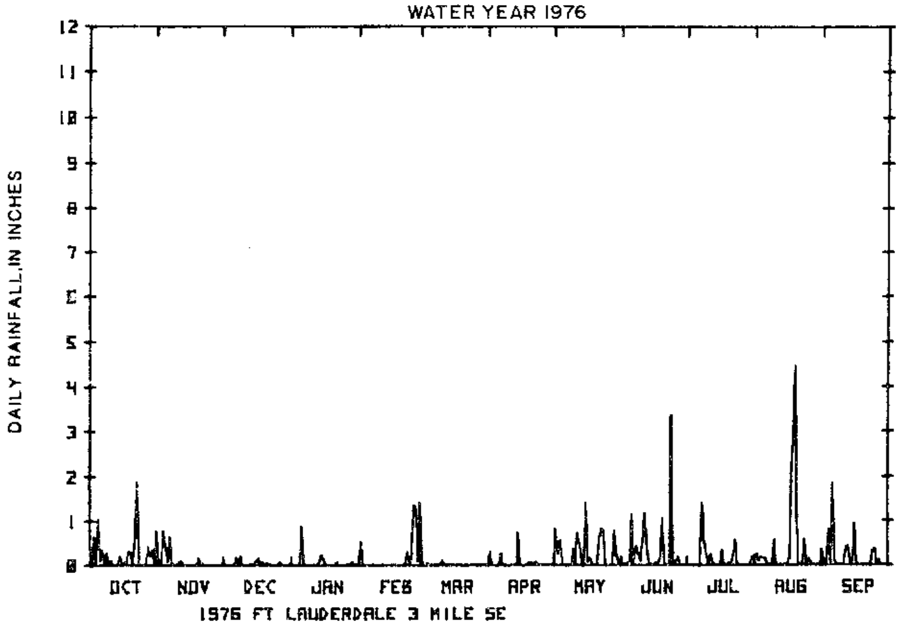




Figure 4.--Well G-561 and rainfall at Fort Lauderdale for the 1976 water year and 1948-75 calendar years (Cont'd)

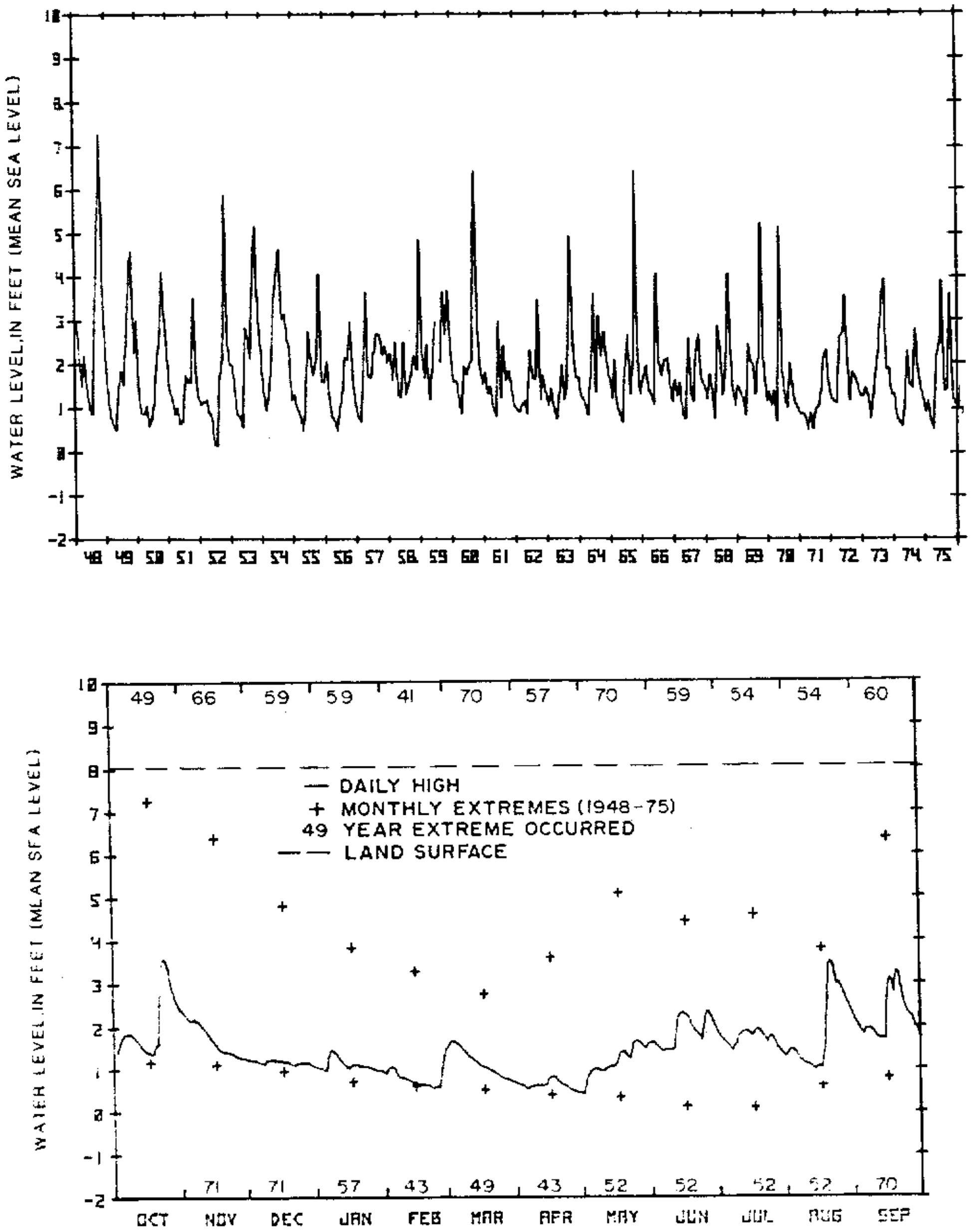
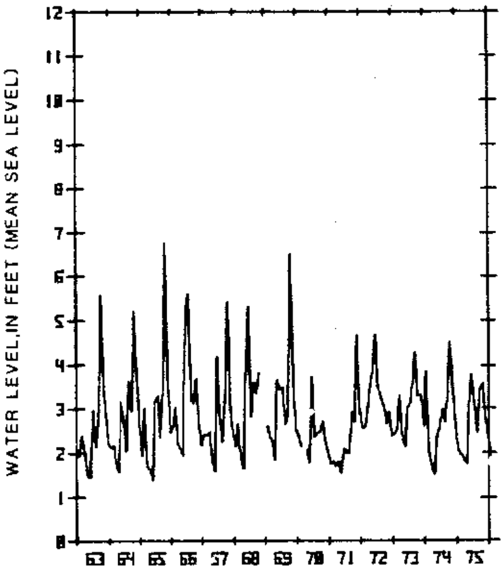



Figure 5.—Well F-291 for the 1976 water year and 1948-75 calendar years



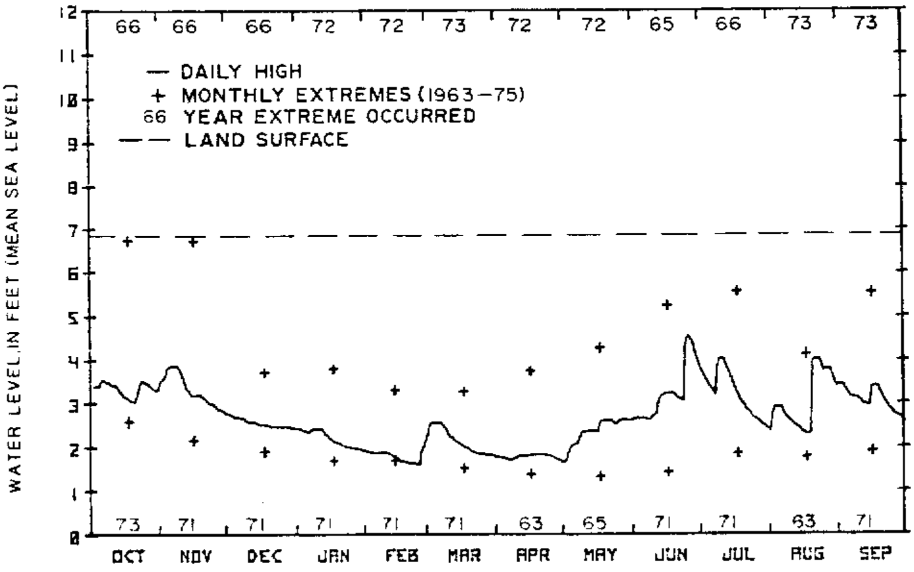




Figure 6.—Well G-1220 for the 1976 water year and 1963-76 calendar years

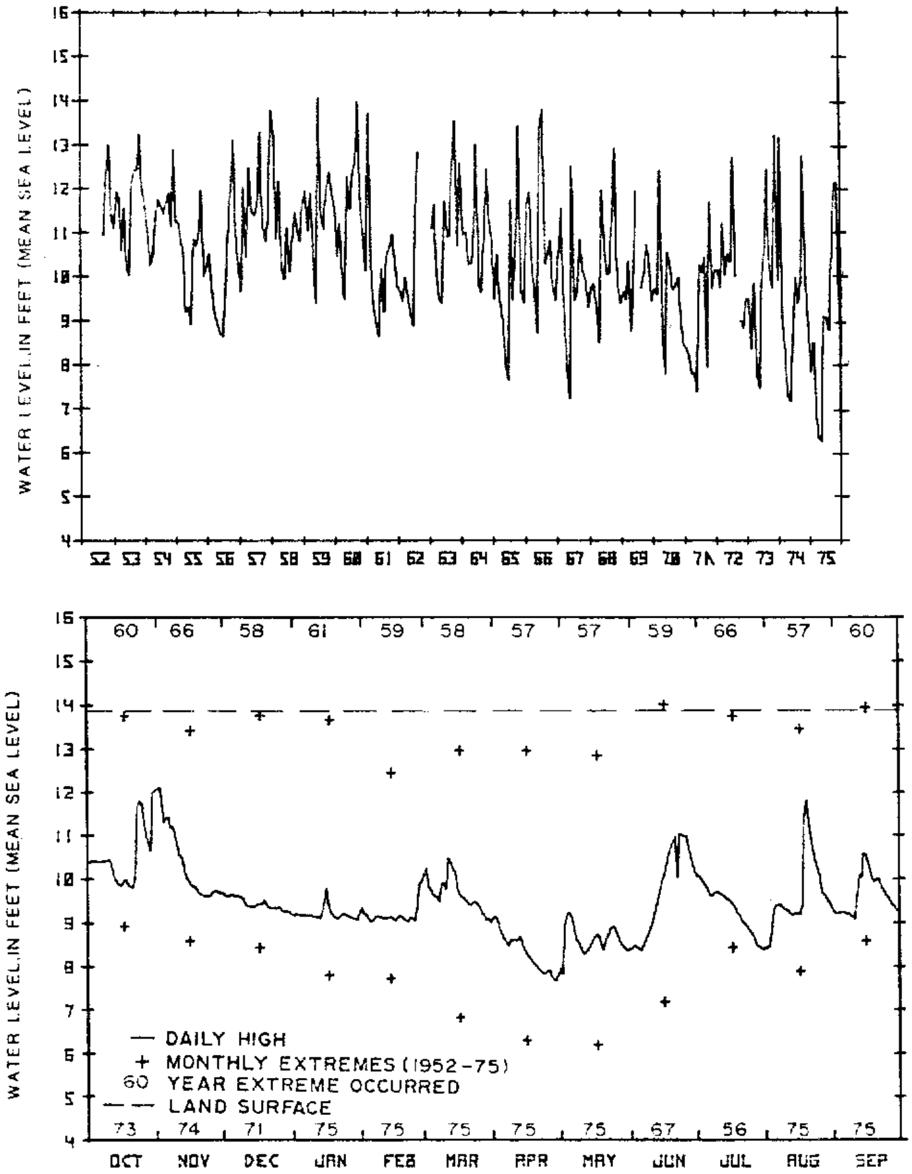



Figure 7.—Well G-616 and rainfall at Fort Lauderdale for the 1976 water year and 1952-75 calendar years

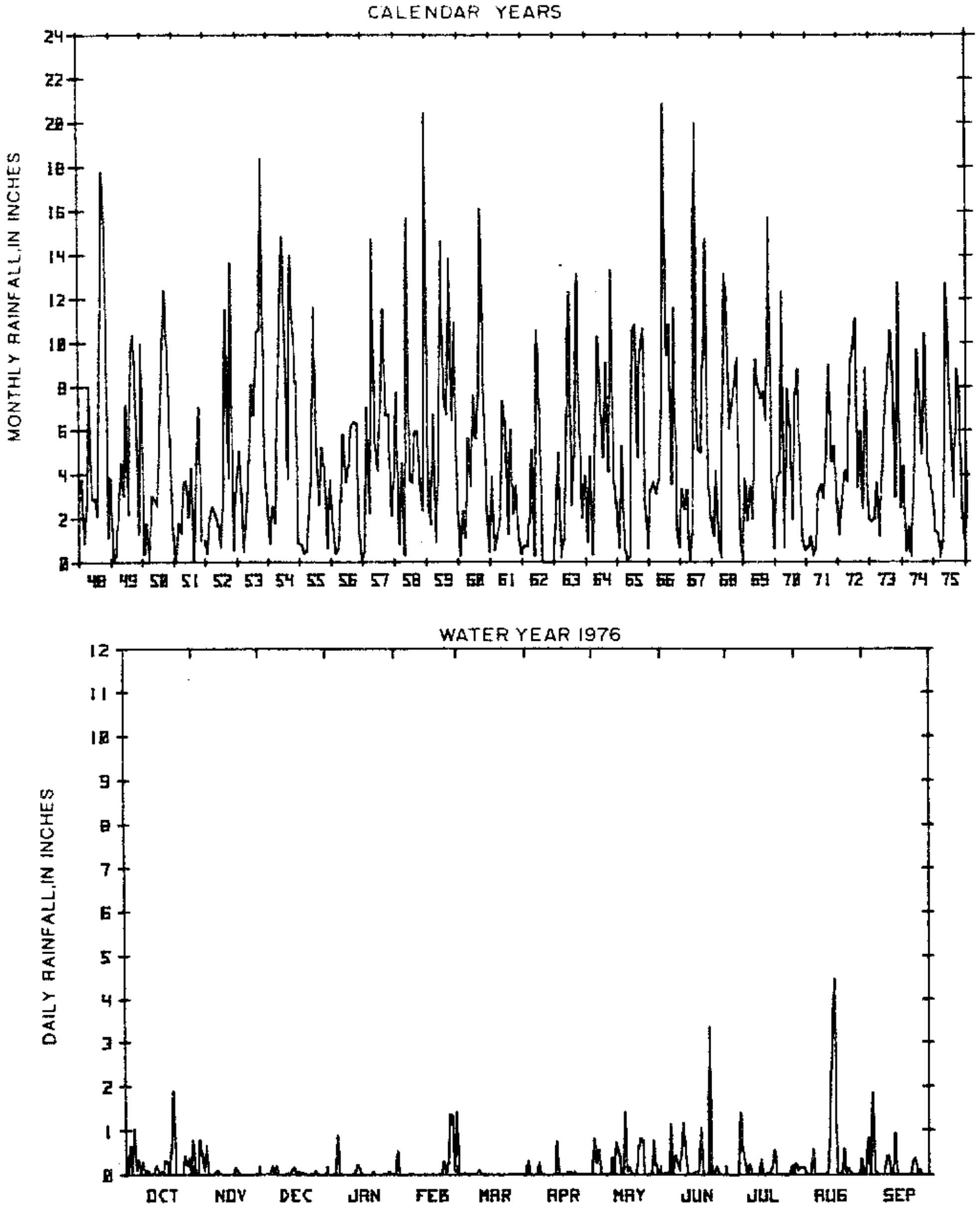



Figure 7.—Well G-616 and rainfall at Fort Lauderdale for the 1976 water year and 1952-75 calendar years (Cont'd)

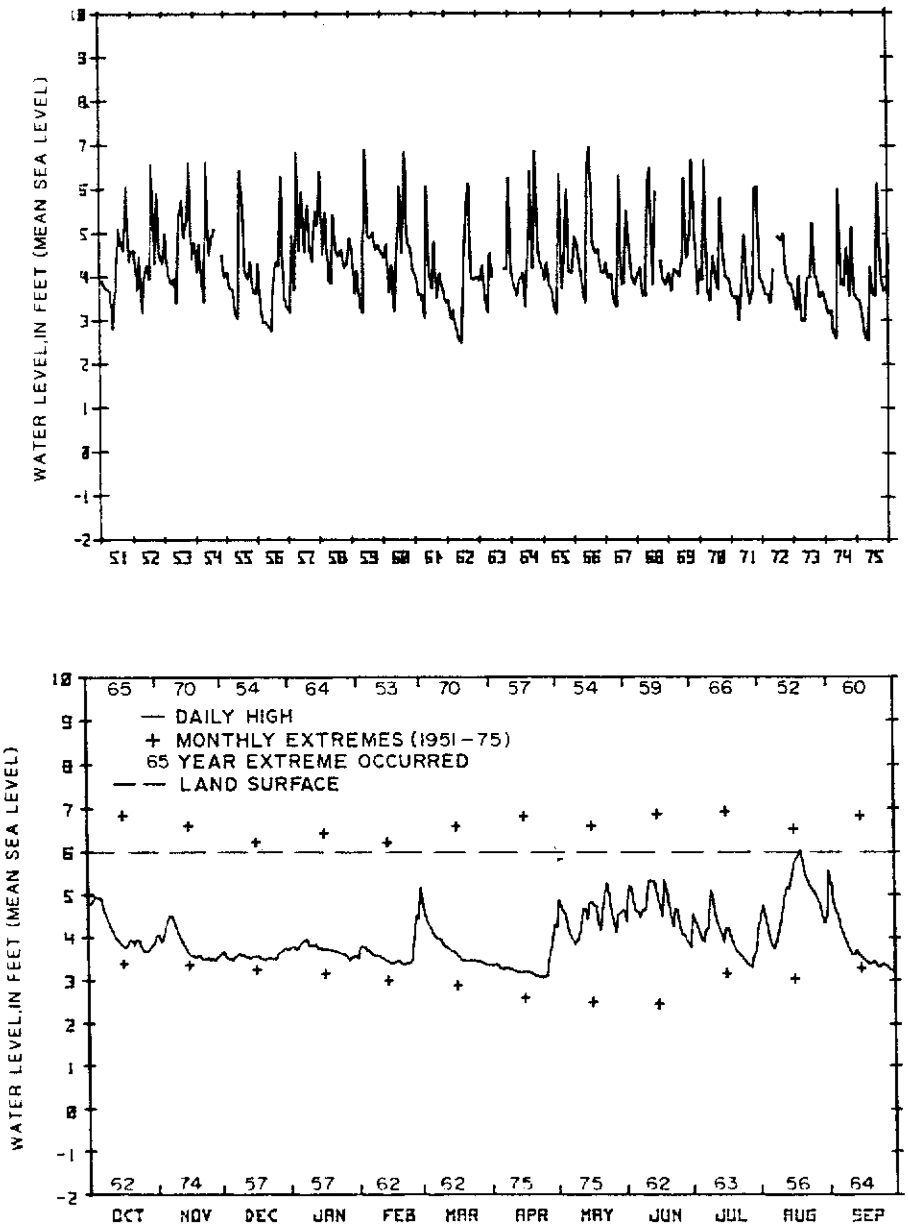



Figure 8.—Well G-617 for the 1976 water year and 1948-75 calendar years

Water-level contour maps indicate the configuration of the water table, the hydraulic gradient, and the general direction of ground-water flow. Water levels in Broward County observation wells are measured during wet and dry seasons to obtain extreme aquifer conditions for the year. These conditions are then compared to record low water levels.

Record high water levels occurred on November 1, 1965 (1966 water year), as the result of several days of heavy rainfall during a hurricane (fig. 9). Record low levels on May 5, 1971, (fig. 10) resulted from several months of deficient rainfall coinciding with heavy withdrawals from wells. However, water levels in some Broward County observation wells did not reach extremes in either November 1965 or May 1971.

Ground-water levels for the 1976 low water period (fig. 11) in Broward County (not including well fields) were near May 1971 levels along the coastal areas but ranged 1-2 feet higher in the proximity of the Florida Turnpike to 2 feet higher in the western reaches.

Water levels were below average in the Dixie, Pompano Beach, Hollywood, and Hallandale well fields for the May 1976 low water period, but above average for the Prospect well field (figs. 12 to 20). Selected wells show water levels in the well fields were higher May 6, 1976, than on May 5, 1971, during the period of extreme low water and ranged from 0.28 foot higher at Hallandale to 2.72 feet higher at the Fort Lauderdale Prospect well field.

The cities of Fort Lauderdale (Dixie and Prospect well fields) and Pompano Beach are Broward County's major water suppliers. The Prospect well-field pumpage of 205.7 Mgal represents a 10 percent increase for the 7-day period ending May 7, 1976, over the 7-day period ending May 5, 1971. The Dixie well field pumpage decreased to 86.7 Mgal, 17 percent of the 1971 pumpage. The total pumpage for the combined Fort Lauderdale well fields increased 1 Mgal or 0.3 percent for the same 7-day period. The Pompano well-field pumpage was 105.9 Mgal, a decrease of 16 percent.

Water levels in the Hollywood and Hallandale well fields on May 7, 1976, (figs. 18 and 19) were higher than the record low-water levels on May 5, 1971, (fig. 10). The transmissivity of the aquifer in the Hollywood and Hallandale area is extremely high, about 2.0 Mgal/d/ft. Therefore, the effect of pumping at the well fields is dispersed over a large area, and drawdowns in the immediate vicinity of the wells are generally less than 0.2 foot.

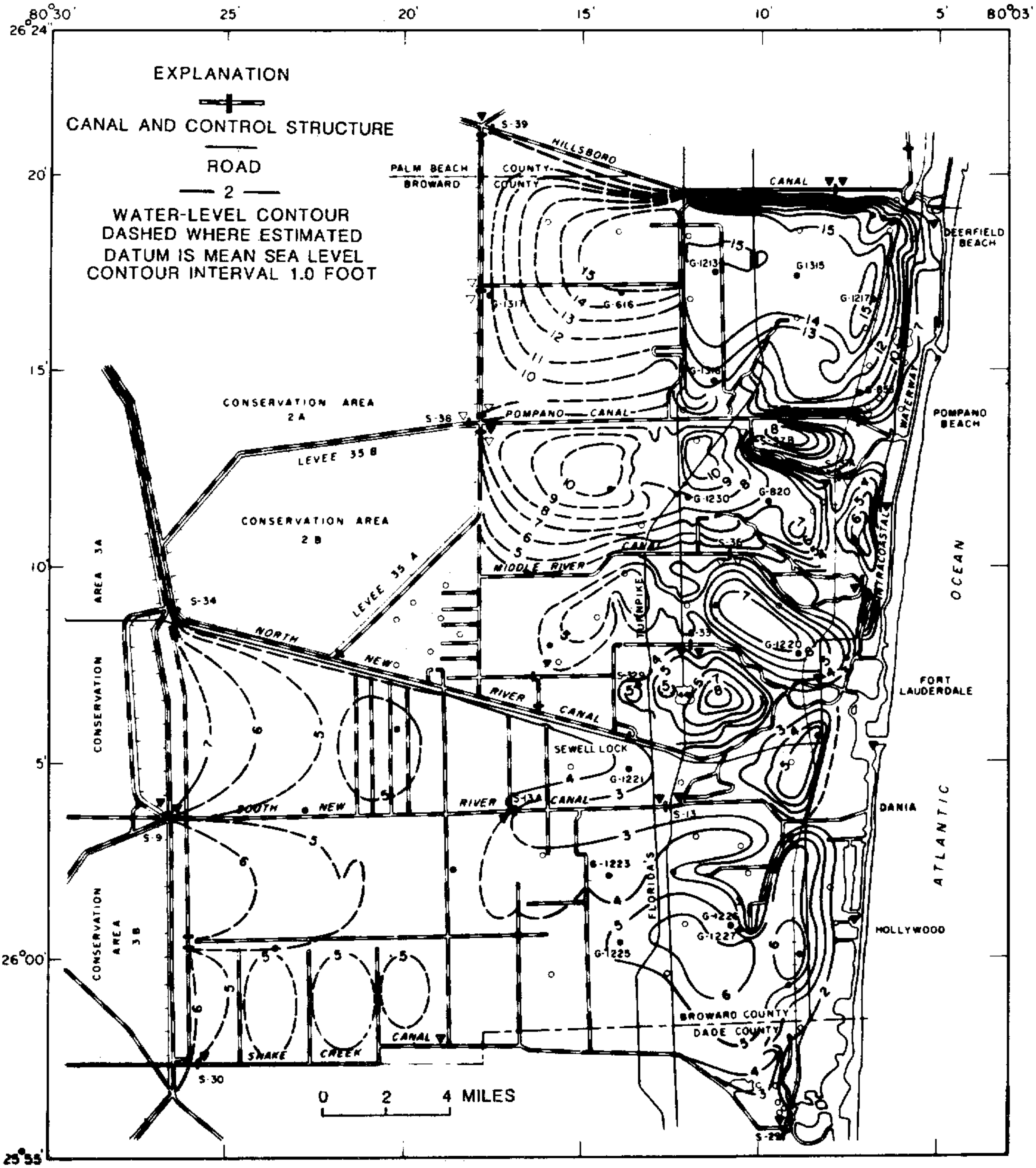



Figure 9.—Eastern Broward County during record high-water levels, November 1, 1965

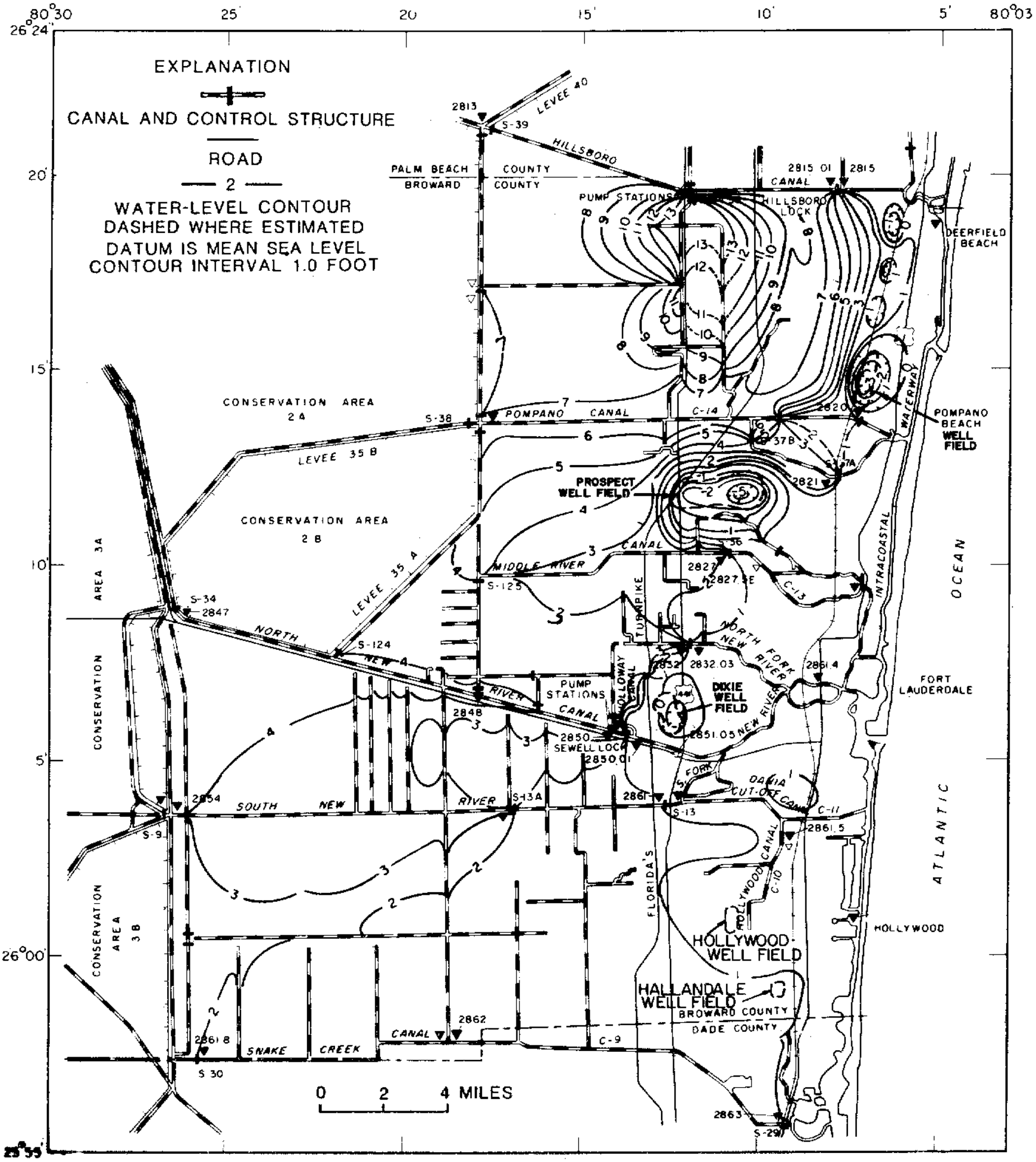



Figure 10.--Eastern Broward County during record low-water levels, May 5, 1971

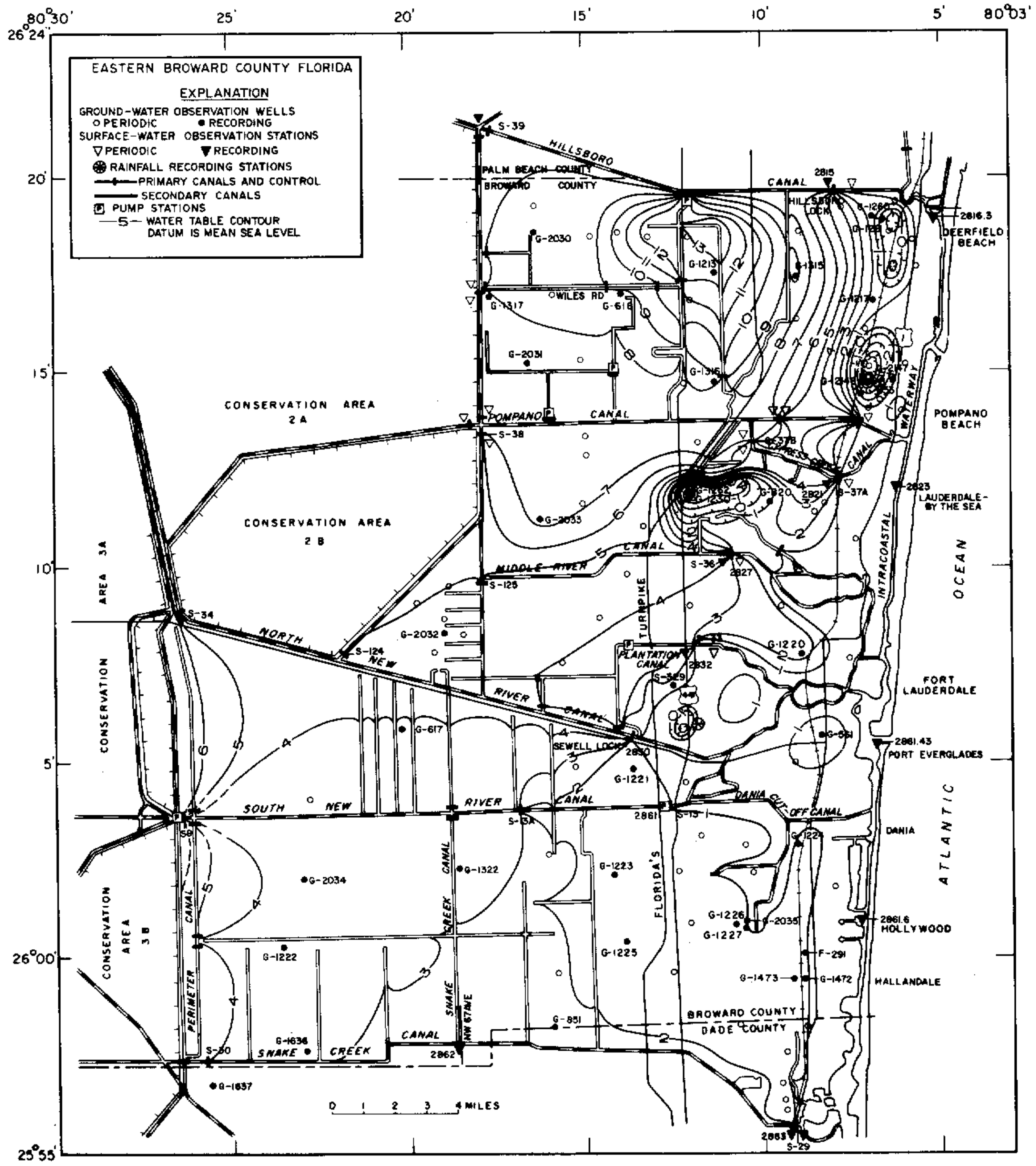



Figure 11.—Eastern Broward County during low-water levels, levels, May 5, 1976

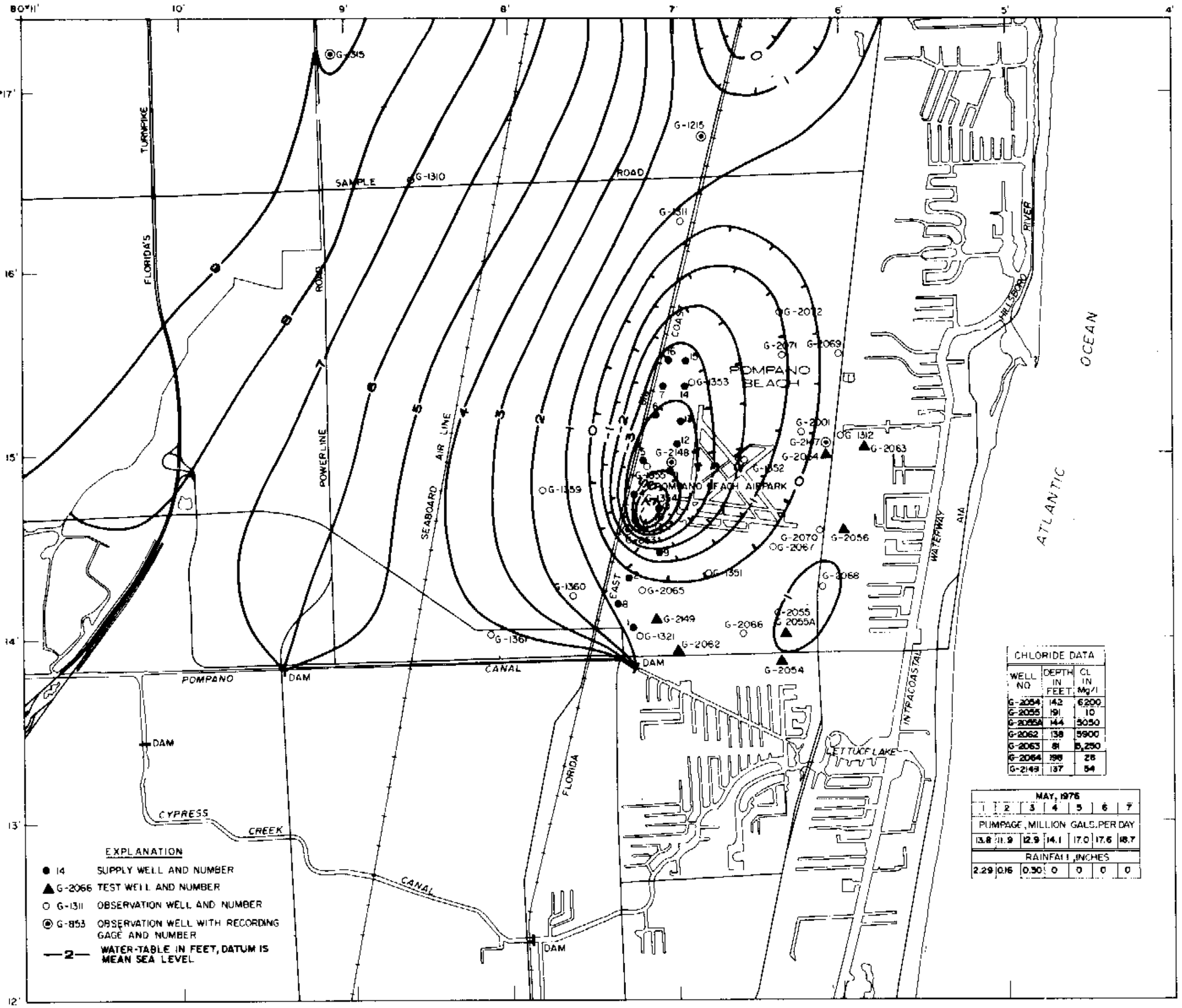



Figure 12.--Pompano Beach well field and surrounding area during low-water levels, May 7, 1976

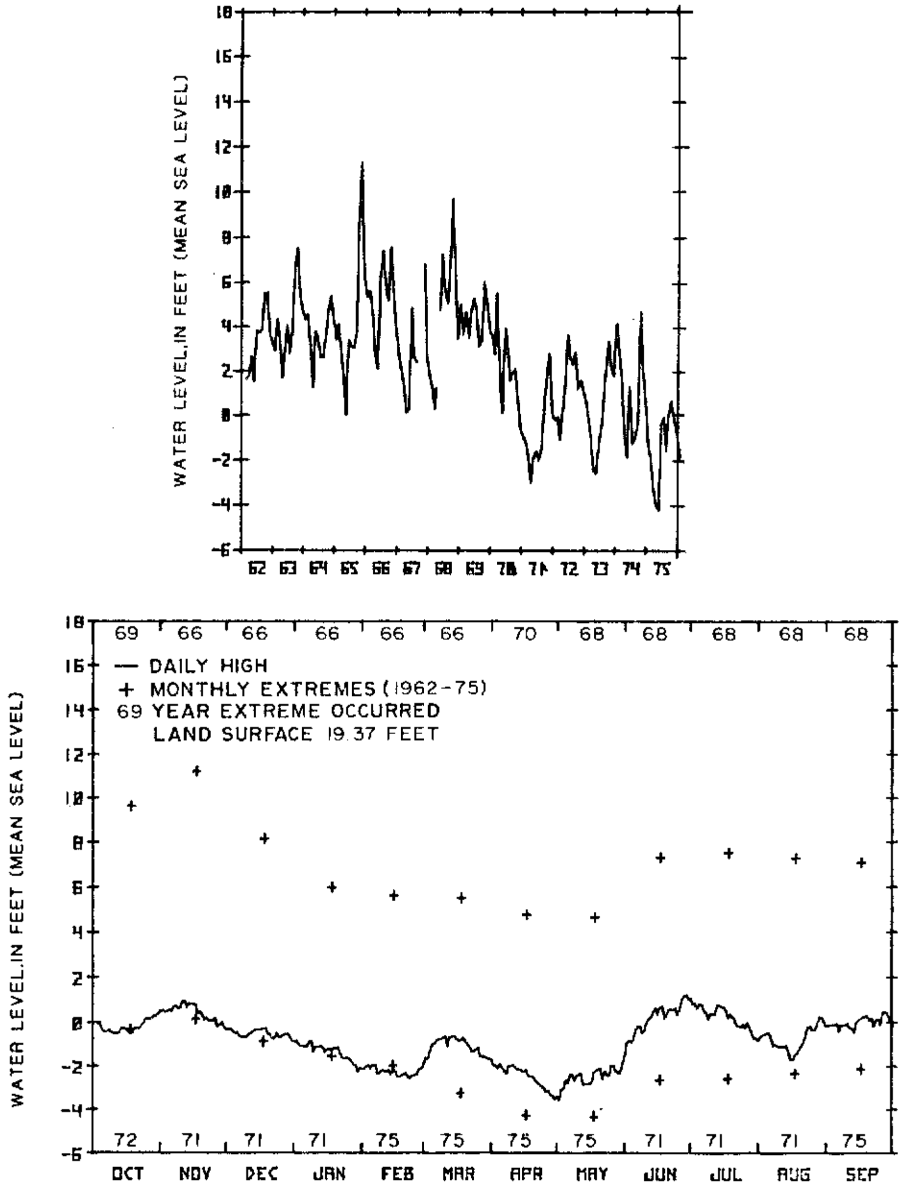
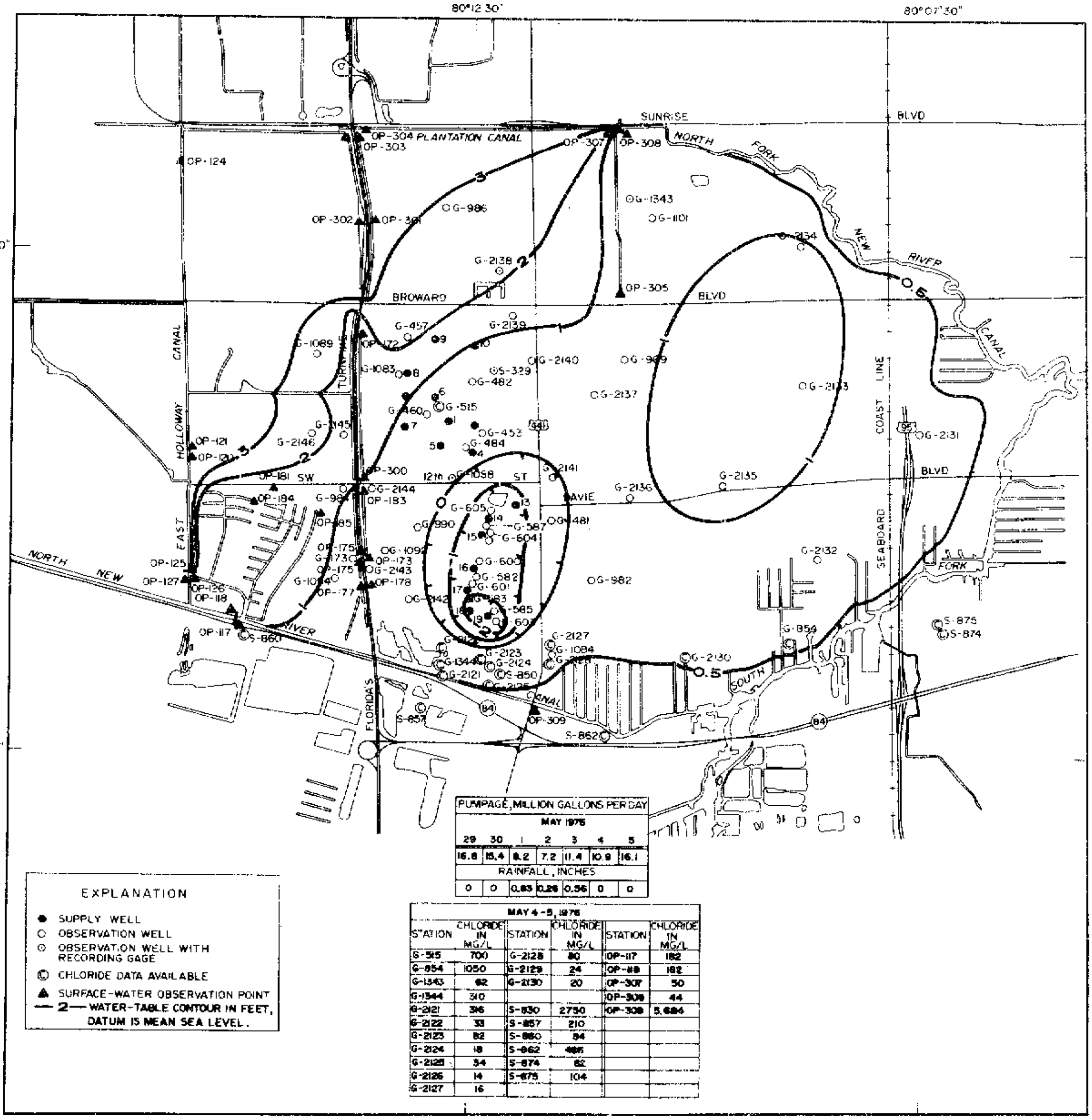



Figure 13.--Pompano Beach well G-853, for the 1976 water year and 1962-75 calendar years




| PUMPAGE, MILLION GALLONS PER DAY | | | | | | |
|---|---|---|---|---|---|---|
| MAY 1976 | | | | | | |
| 29 | 30 | 1 | 2 | 3 | 4 | 5 |
| 16.8 | 15.4 | 8.2 | 7.2 | 11.4 | 10.9 | 16.1 |
| RAINFALL, INCHES | | | | | | |
| 0 | 0 | 0.83 | 0.26 | 0.56 | 0 | 0 |

| MAY 4-5, 1976 | | | | | |
|---|---|---|---|---|---|
| STATION | CHLORIDE IN MG/L | STATION | CHLORIDE IN MG/L | STATION | CHLORIDE IN MG/L |
| G-515 | 700 | G-2128 | 80 | OP-117 | 182 |
| G-854 | 1050 | G-2129 | 24 | OP-118 | 182 |
| G-1343 | 62 | G-2130 | 20 | OP-307 | 50 |
| G-1344 | 310 | | | OP-308 | 44 |
| G-2121 | 316 | S-850 | 2750 | OP-309 | 5,684 |
| G-2122 | 33 | S-857 | 210 | | |
| G-2123 | 82 | S-860 | 54 | | |
| G-2124 | 18 | S-862 | 486 | | |
| G-2125 | 34 | S-874 | 62 | | |
| G-2126 | 14 | S-875 | 104 | | |
| G-2127 | 16 | | | | |

Figure 14.—Fort Lauderdale Dixie well field and surrounding area during low-water levels, May 5, 1976

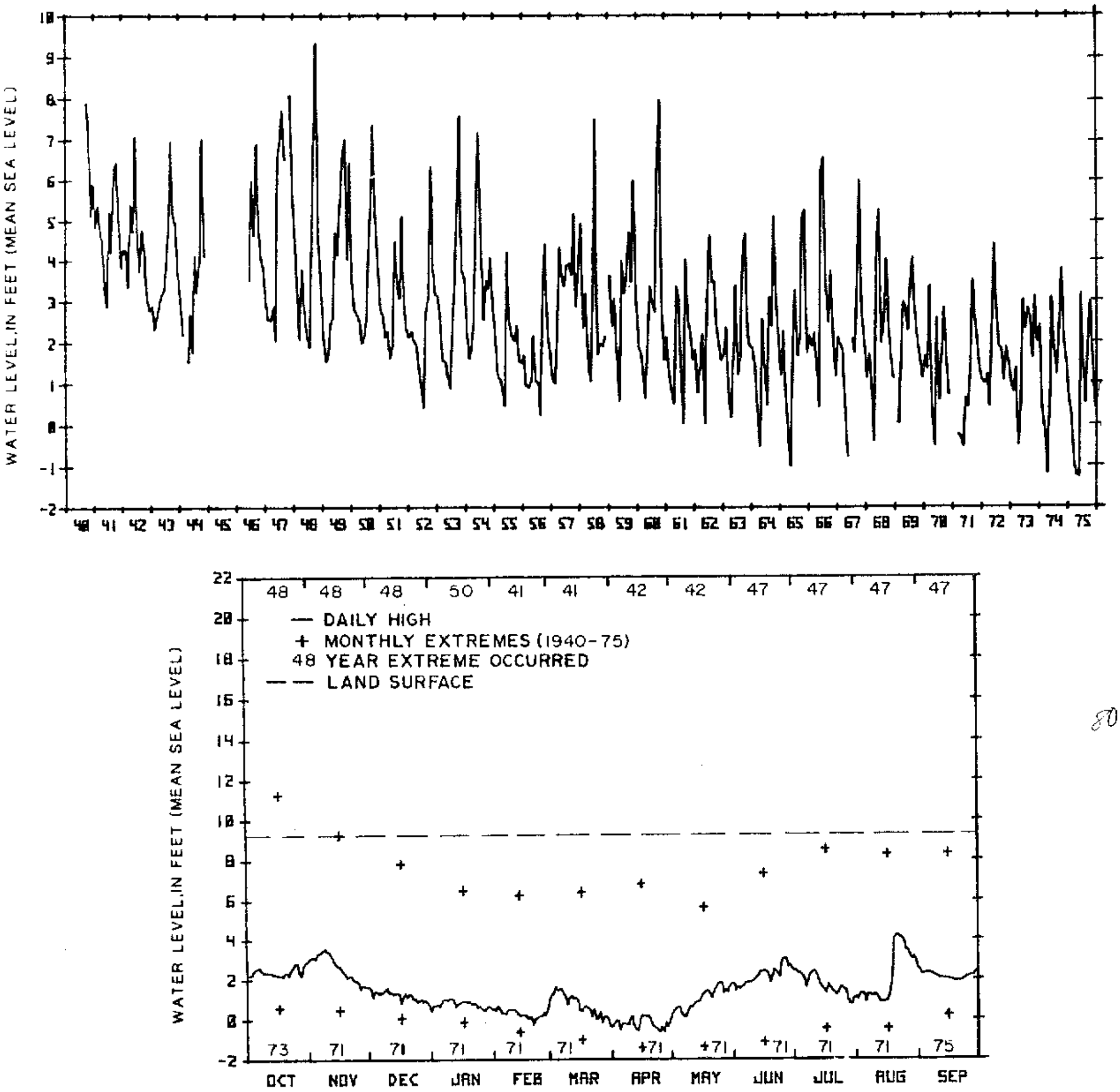
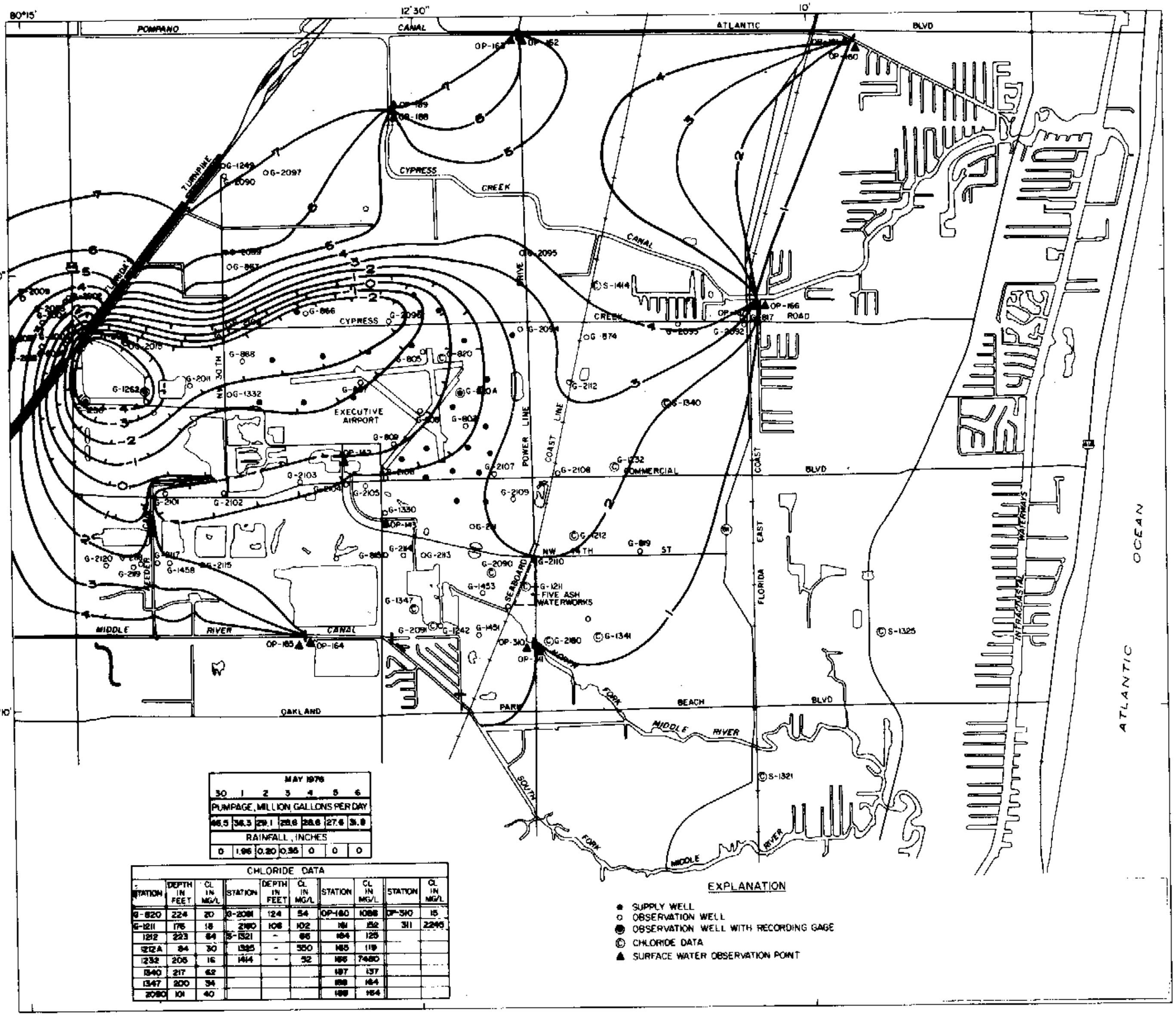



Figure 15.—Fort Lauderdale Dixie well S-329, for the 1976 water year and 1940-75 calendar years




| MAY 1976 | | | | | | |
|---|---|---|---|---|---|---|
| 30 | 1 | 2 | 3 | 4 | 5 | 6 |
| PUMPAGE, MILLION GALLONS PER DAY | | | | | | |
| 46.5 | 36.3 | 29.1 | 28.6 | 28.6 | 27.6 | 31.0 |
| RAINFALL, INCHES | | | | | | |
| 0 | 1.96 | 0.20 | 0.35 | 0 | 0 | 0 |

CHLORIDE DATA

| STATION | DEPTH IN FEET | CL IN MG/L | STATION | DEPTH IN FEET | CL IN MG/L | STATION | CL IN MG/L | STATION | CL IN MG/L |
|---|---|---|---|---|---|---|---|---|---|
| G-820 | 224 | 20 | G-2091 | 124 | 54 | OP-160 | 1088 | OP-310 | 15 |
| G-1211 | 176 | 18 | 2110 | 106 | 102 | 161 | 152 | 311 | 2246 |
| 1212 | 223 | 64 | S-1321 | - | 66 | 164 | 125 | | |
| 1212A | 84 | 30 | 1325 | - | 550 | 165 | 119 | | |
| 1232 | 205 | 16 | 1414 | - | 52 | 166 | 7480 | | |
| 1340 | 217 | 62 | | | | 187 | 137 | | |
| 1347 | 200 | 34 | | | | 188 | 164 | | |
| 2090 | 101 | 40 | | | | 189 | 164 | | |

Figure 16.--Fort Lauderdale Prospect well field and surrounding area during low-water levels, May 6, 1976

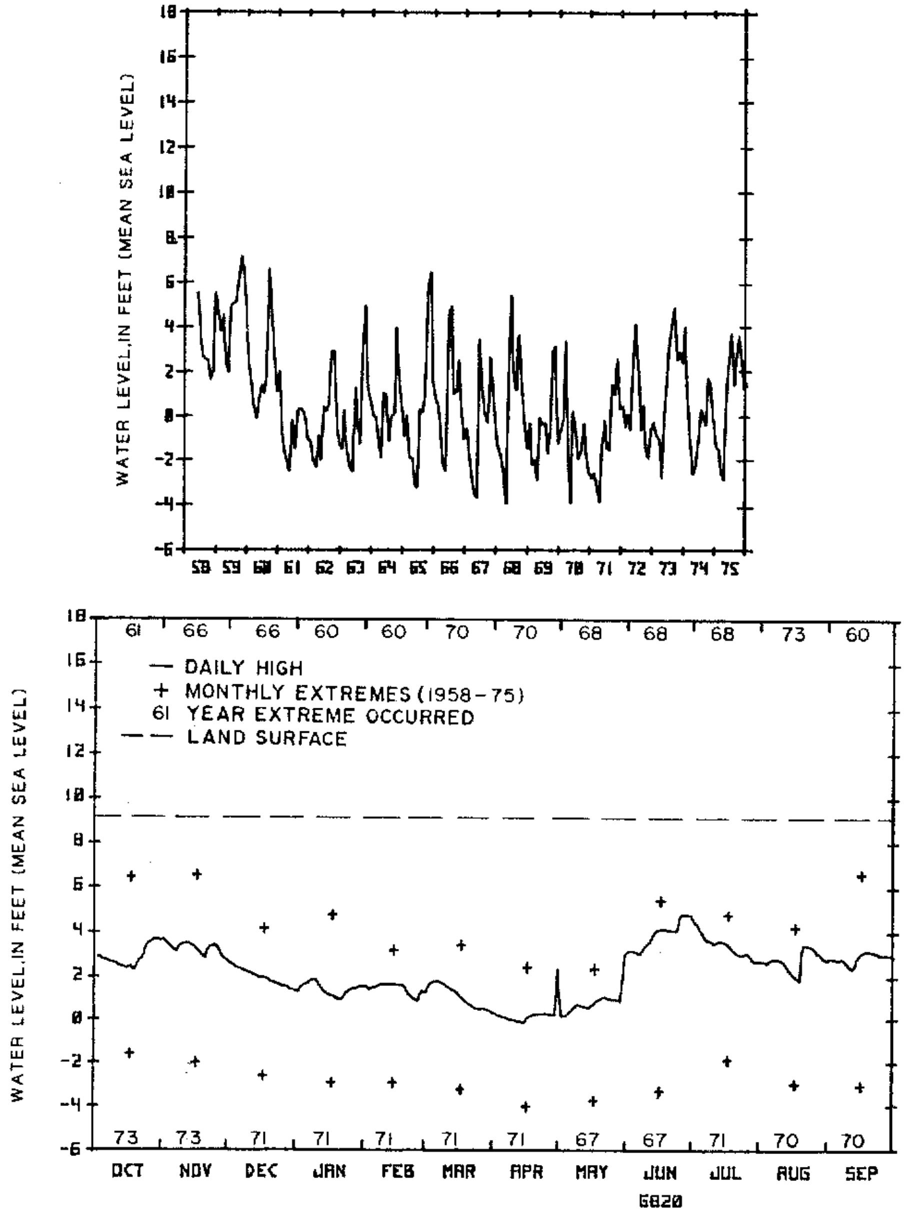
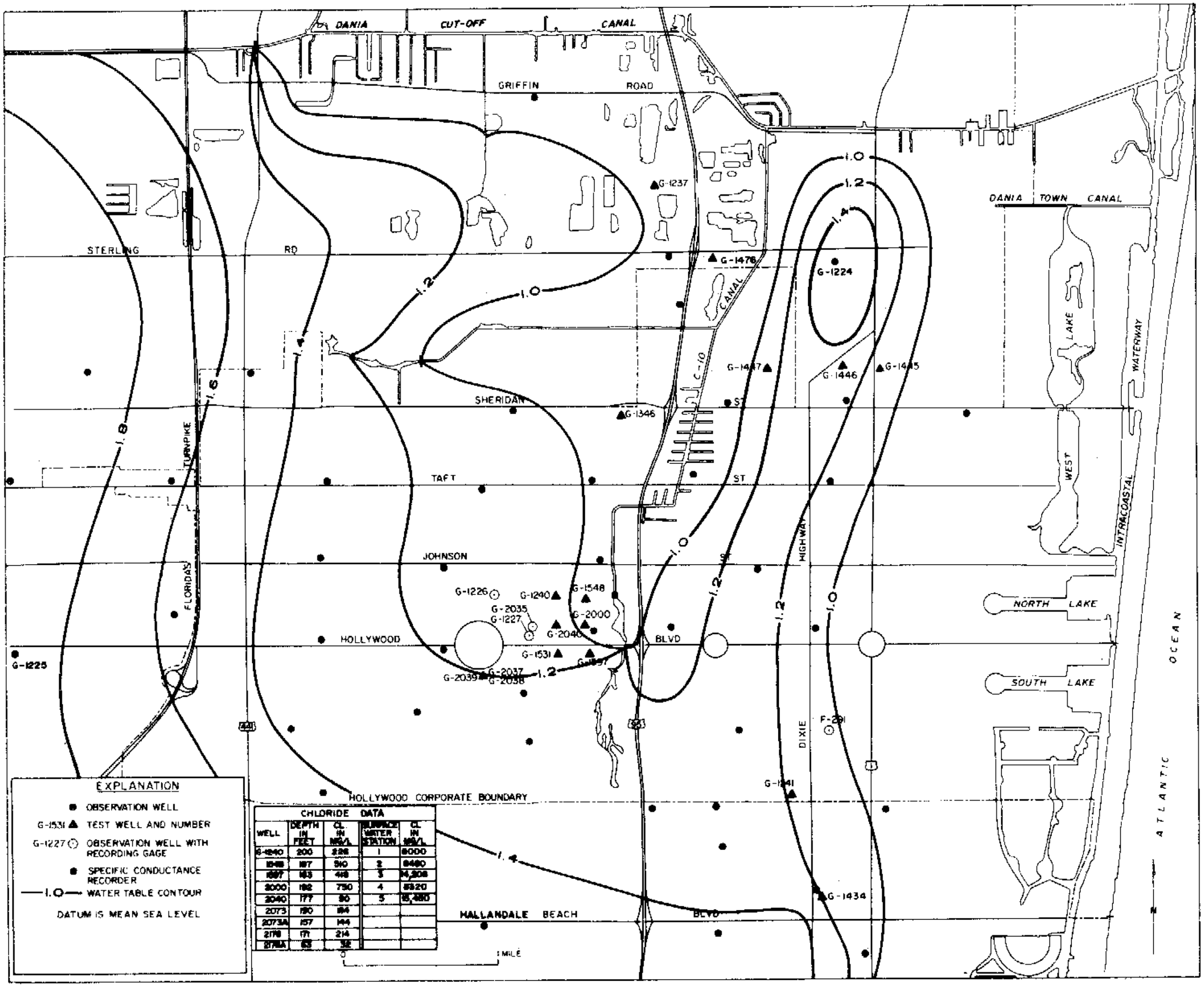
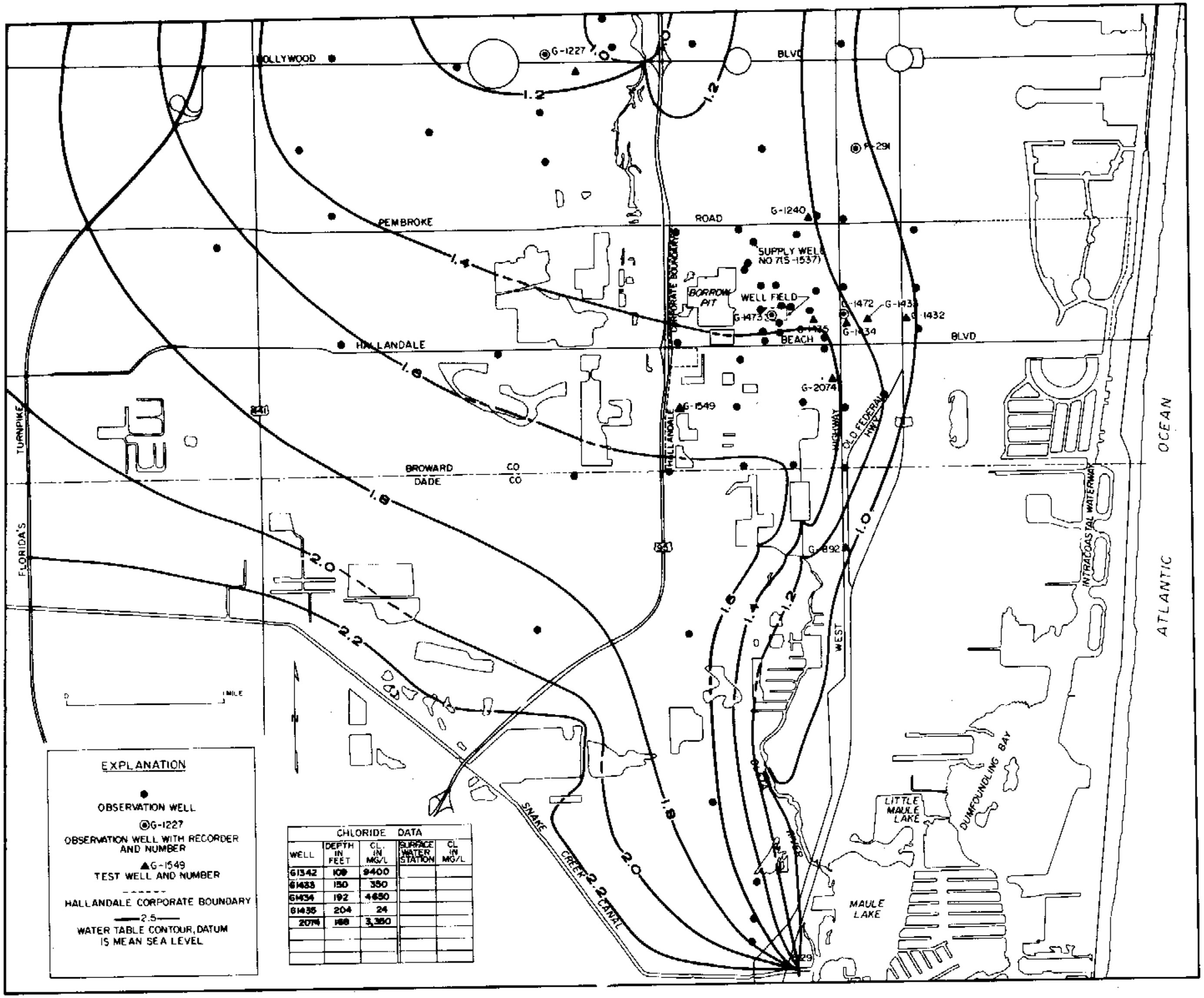



Figure 17.—Fort Lauderdale Prospect well G-820 for the 1976 water year and 1958-75 calendar years




| WELL | DEPTH IN FEET | CL IN MG/L | SURFACE WATER STATION | CL IN MG/L |
|---|---|---|---|---|
| G-1240 | 200 | 226 | 1 | 8000 |
| 1548 | 187 | 510 | 2 | 8480 |
| 1597 | 183 | 448 | 3 | 14,208 |
| 2000 | 182 | 750 | 4 | 8320 |
| 2040 | 177 | 80 | 5 | 15,480 |
| 2073 | 190 | 184 | | |
| 2073A | 157 | 144 | | |
| 2178 | 171 | 214 | | |
| 2178A | 63 | 32 | | |

Figure 18.--Hollywood well field and surrounding area during low-water levels, May 7, 1976




CHLORIDE DATA

| WELL | DEPTH IN FEET | CL. IN MG/L | SURFACE WATER STATION | CL IN MG/L |
|---|---|---|---|---|
| G1342 | 109 | 9400 | | |
| G1433 | 150 | 350 | | |
| G1434 | 192 | 4650 | | |
| G1435 | 204 | 24 | | |
| 2074 | 188 | 3,380 | | |
| | | | | |
| | | | | |
| | | | | |

Figure 19.—Hallandale well field and surrounding area during low-water levels, May 7, 1976

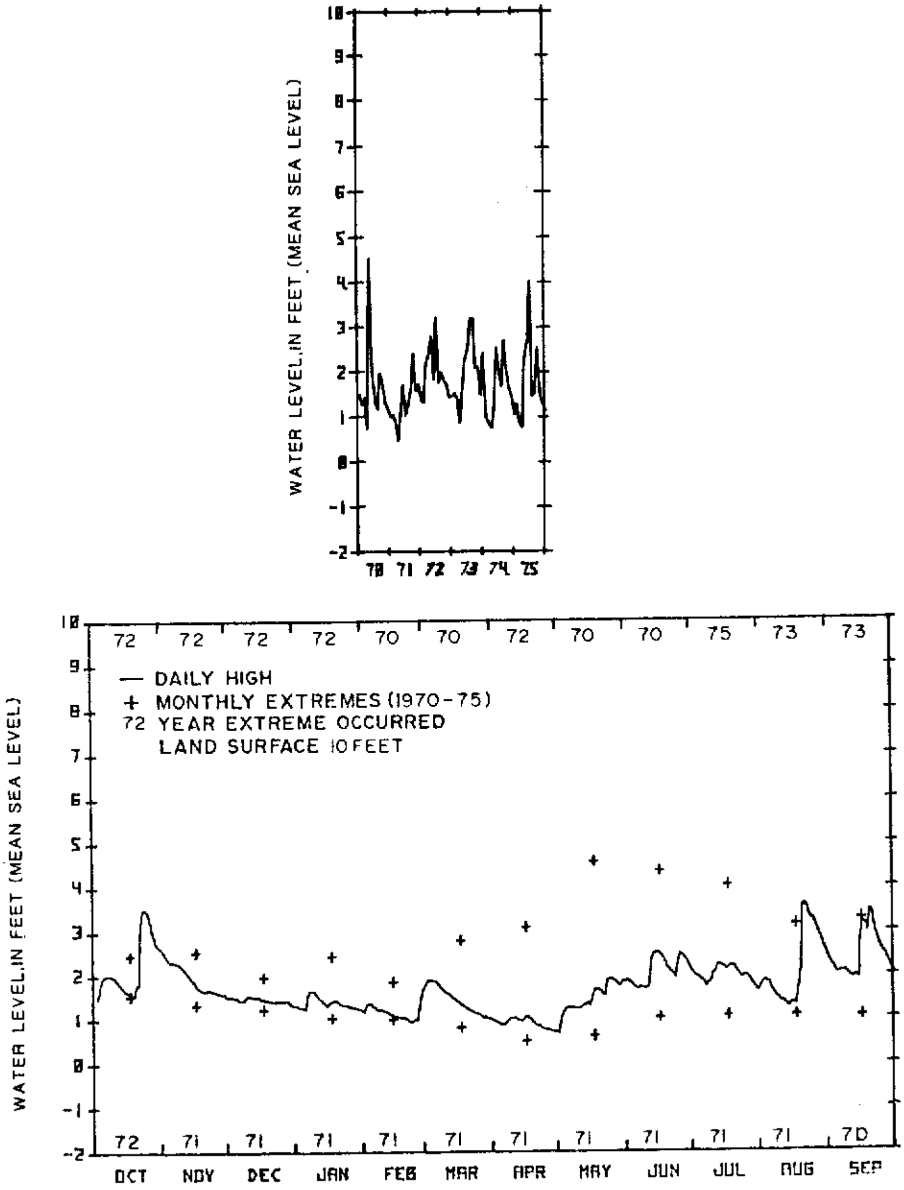



Figure 20.—Hallandale well G-1473, for the 1976 water year and 1970-75 calendar years

## SURFACE WATER

Surface-water discharges in Broward County depended on the intensity and duration of rainfall until the water-management system was established. Major modifications to the regional canal system in Broward County began about 1953 and were virtually complete by 1962. Since then, the modifications have provided increased control during runoff extremes and improved the duration of moderate or optimum flows.

Broward County's freshwater supply depends upon the regional water-management system and canal network during drought conditions. Water conservation areas in the western and central sections of Broward County (fig. 1) impound water for use in the coastal areas and Everglades National Park during dry periods. Water from conservation areas is used to recharge coastal aquifers in times of heavy freshwater use and to maintain high freshwater heads along the coast in order to prevent saltwater intrusion. Storage in the conservation areas comes from direct rainfall and from upgradient sections of the management areas and Lake Okeechobee. Another source of water for storage is backpumping of excess water from the coastal areas to the management area at pump station S-9 on the South New River Canal (fig. 2).

Stage and discharge records were obtained at seven continuous recording surface-water gaging stations (fig. 2) on Broward County canals and at one station in Dade County on Snake Creek Canal at N.W. 67th Avenue (station 2863) near the Broward County line. All of the stations, except station 2863, are located at the easternmost control structure. Tidal fluctuations in the Intracoastal Waterway are recorded at four stations.

### 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 N.W. 67th Avenue where deflection meters are used. Determining flows in the highly controlled canal system was greatly aided by the cooperation of the South Florida Water Management District and Broward Water Resources Department who furnished logs of control changes.

Discharge measurements were periodically made in the canals at stream-gaging stations to determine if the stage-discharge or the stage deflection-discharge relation remained constant. Measurements were made at all gaging stations in Broward County during the 1976 water year. For the stations discussed in the following paragraphs, 1976 monthly mean discharges are compared to 1962-75 mean discharge values. The same data were used to compile flow duration curves for comparison with 1976 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 1976 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 1976 water year.

## Hillsboro Canal

Hillsboro Canal is one of the major canals in the SFWMD 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. Water released at S-39 enters Broward County 10 miles west of Deerfield Beach and travels east to the lock and dam where it is regulated through the lock chamber and five spillways that constitute the dam.

The yearly mean discharge of 172 $ft^3/s$ at the Hillsboro Lock and Dam for the 1976 water year (fig. 21) was 19 percent below the average discharge (213 $ft^3/s$) for 1962-75. Monthly mean discharges during the 1976 water year, with the exception of November, February, May, and August, were below the mean monthly discharges for 1962-75. Daily discharge exceeded 400 $ft^3/s$, 17 percent of the time during 1962-75 and 11 percent of the time during 1976. The stage at the lock and dam was held 6 feet above msl during most of the 1976 water year (fig. 22) to replenish the aquifer, prevent saltwater encroachment, and provide irrigation water for the farms to the west.

## Pompano Canal (C-14) and Cypress Creek Canal

Pompano Canal (fig. 2) is a primary canal that extends 12 miles east from Levee 36 Canal (structure S-38) to Pompano Beach, and then 2 miles southeast 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 extending north of the canal. Three miles west of Pompano Beach, Pompano Canal joins Cypress Creek Canal. Flow from Pompano Canal 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-37A and S-37B.

The yearly mean discharge of 124 $ft^3/s$ in Cypress Creek Canal (fig. 23) for the 1976 water year is 7 $ft^3/s$ (6 percent) more than the average discharge for 1963-75. Monthly mean discharges from February through June were far below the mean monthly discharges for 1962-75. The stage at S-37A was held above 3.0 feet msl during the 1976 water year (fig. 24) to replenish the aquifer in the area of the Fort Lauderdale Prospect well field.

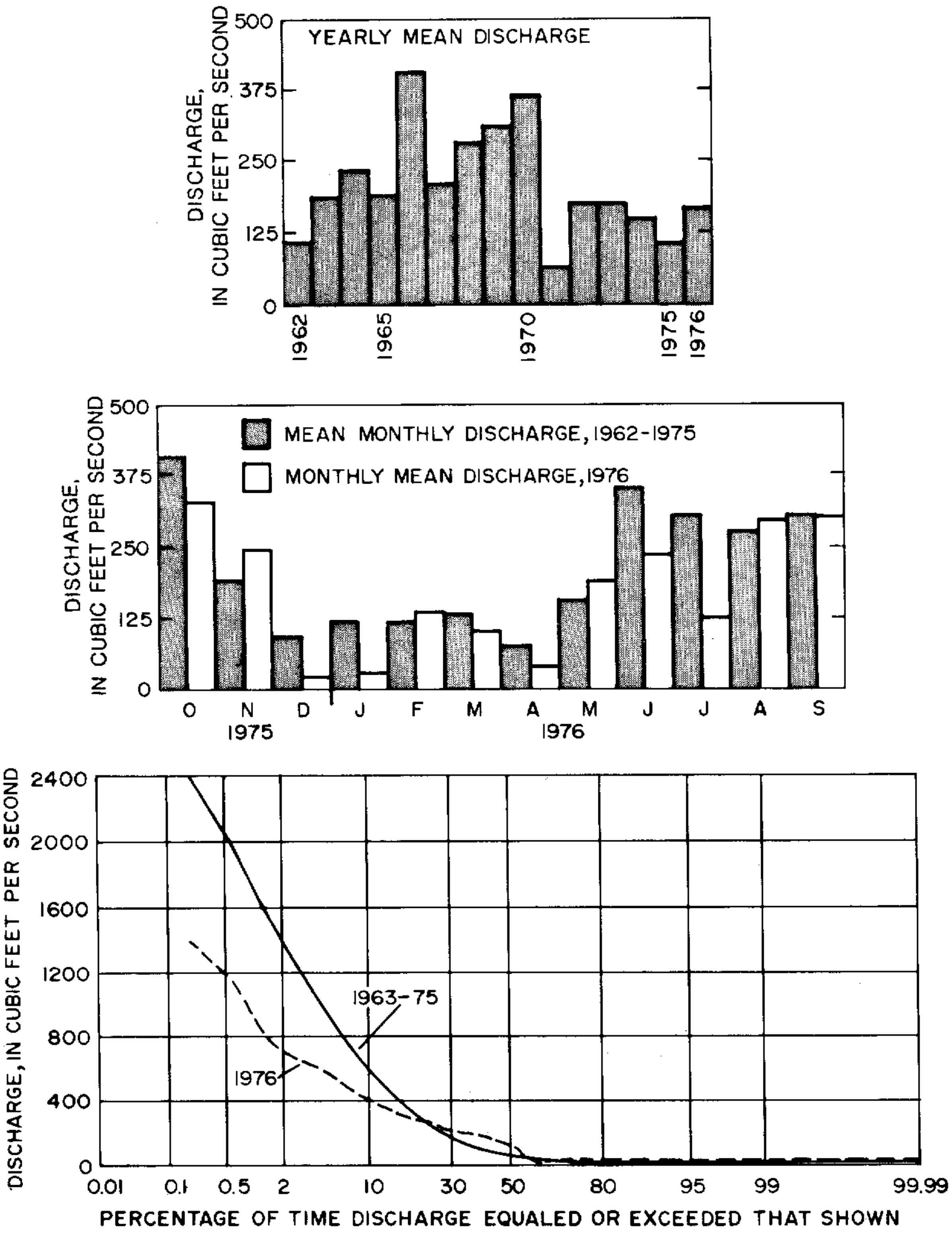
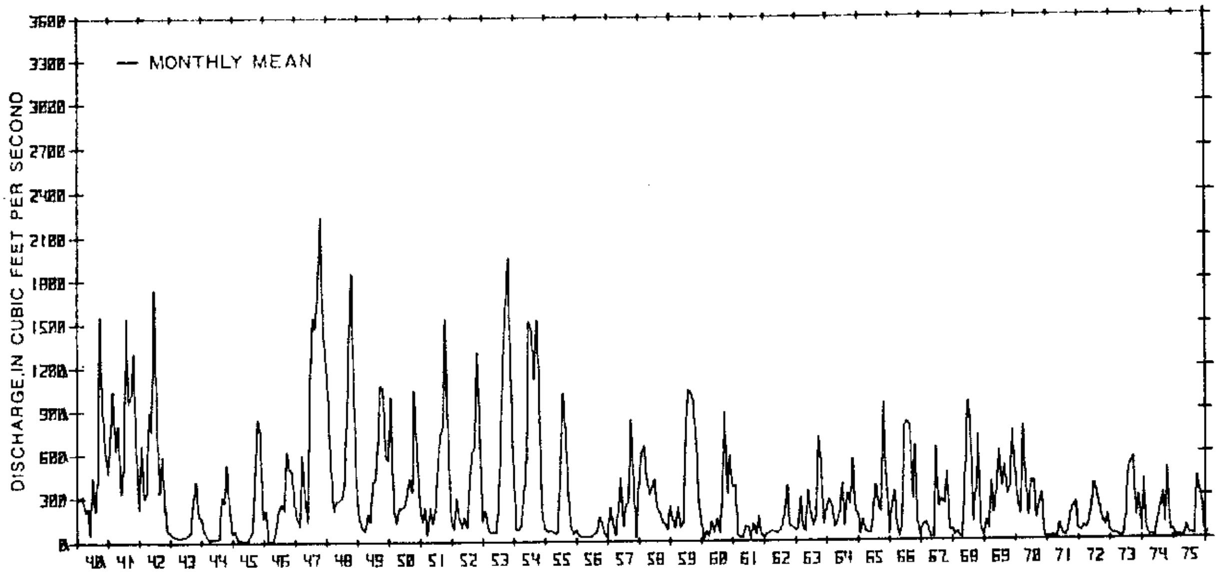



Figure 21.—Discharge data and flow-duration curves for Hillsboro Canal near Deerfield Beach (lock and dam)



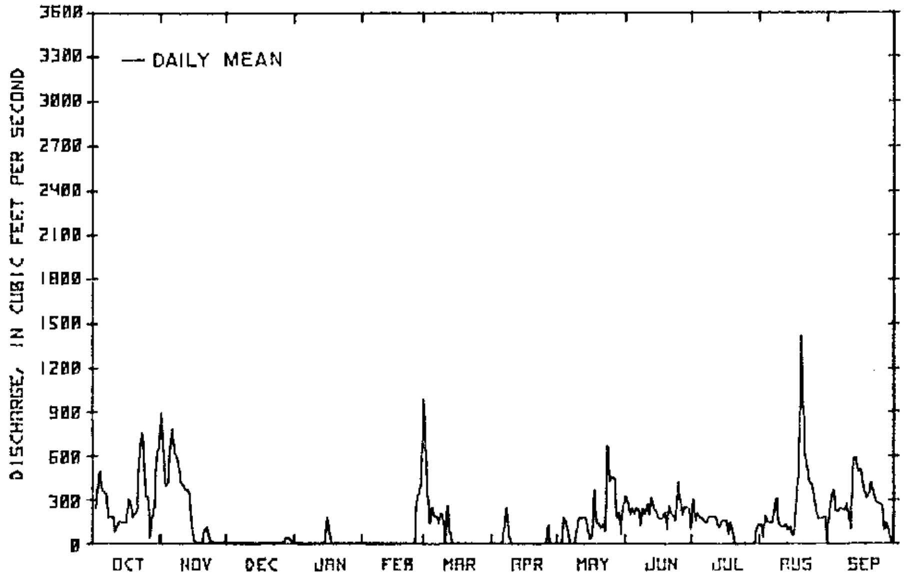
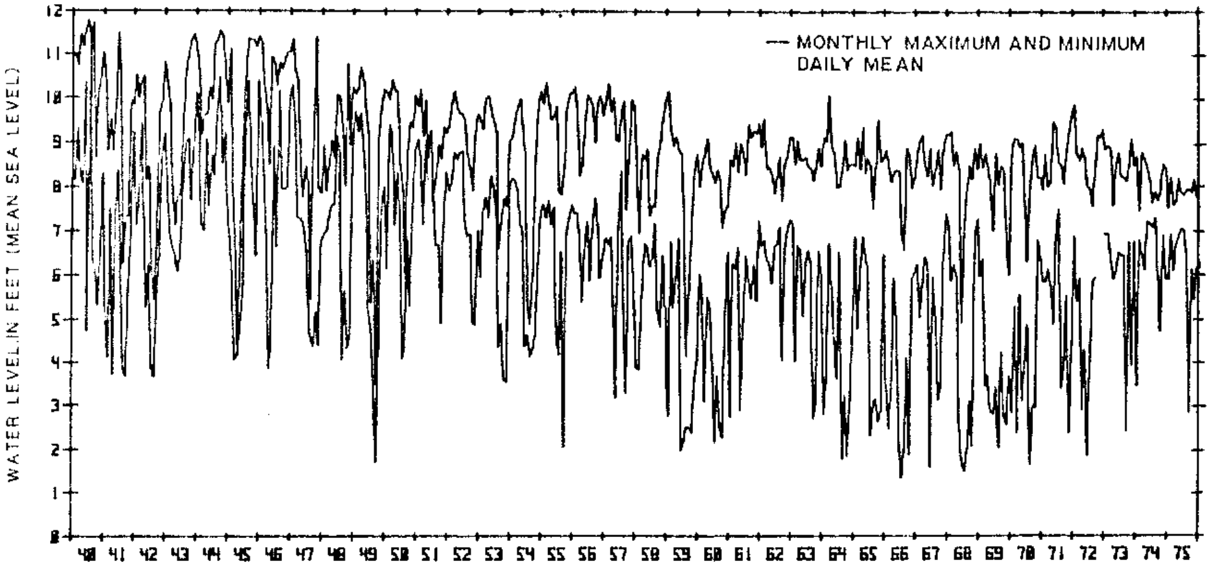




Figure 22.--Hillsboro Canal near Deerfield (lock and dam) for the 1976 water year and 1940-75 water years



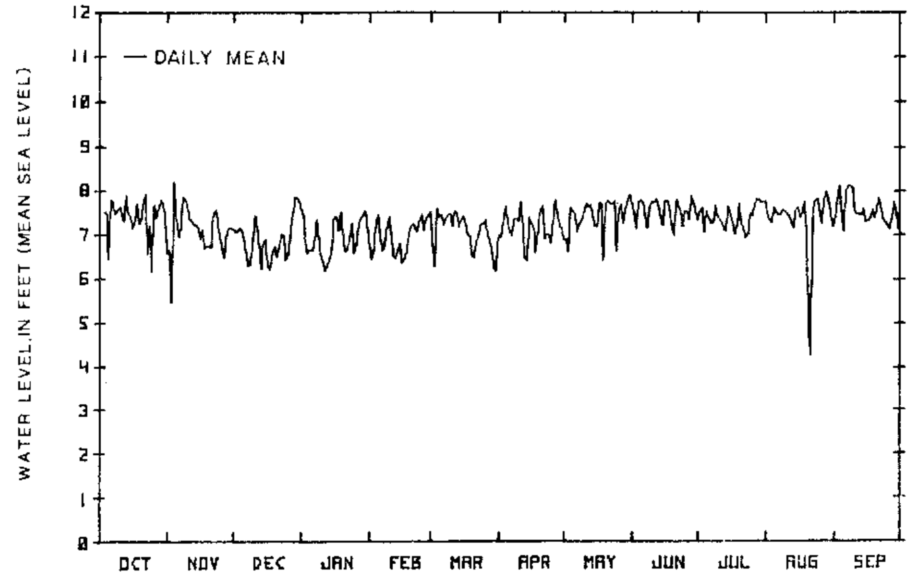




Figure 22.—Hillsboro Canal near Deerfield Beach (lock and dam) for the 1976 water year and 1940-75 water years (Cont'd)

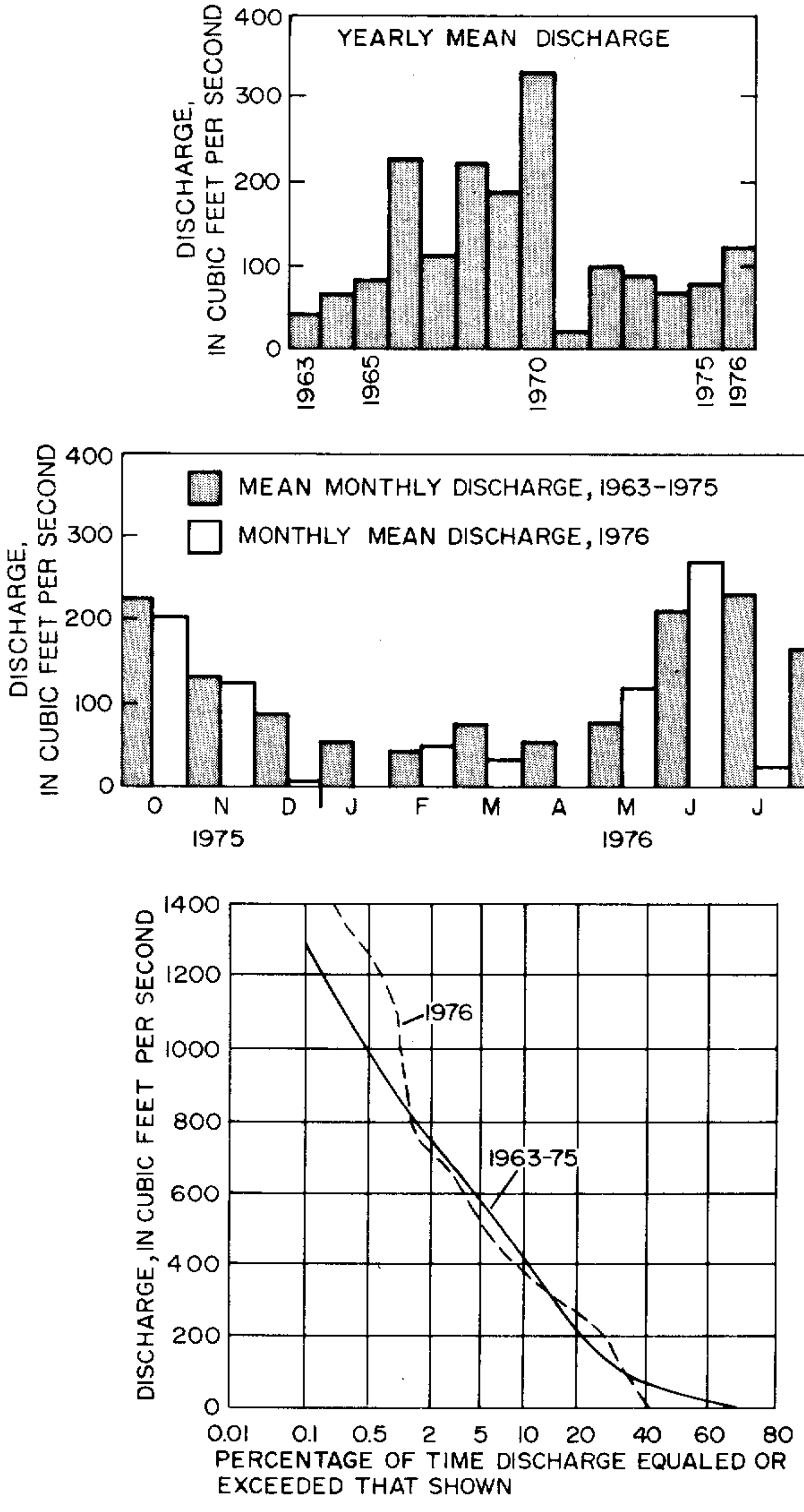



Figure 23.--Discharge data and flow-duration curves for Cypress Creek Canal at S-37A, near Pompano Beach

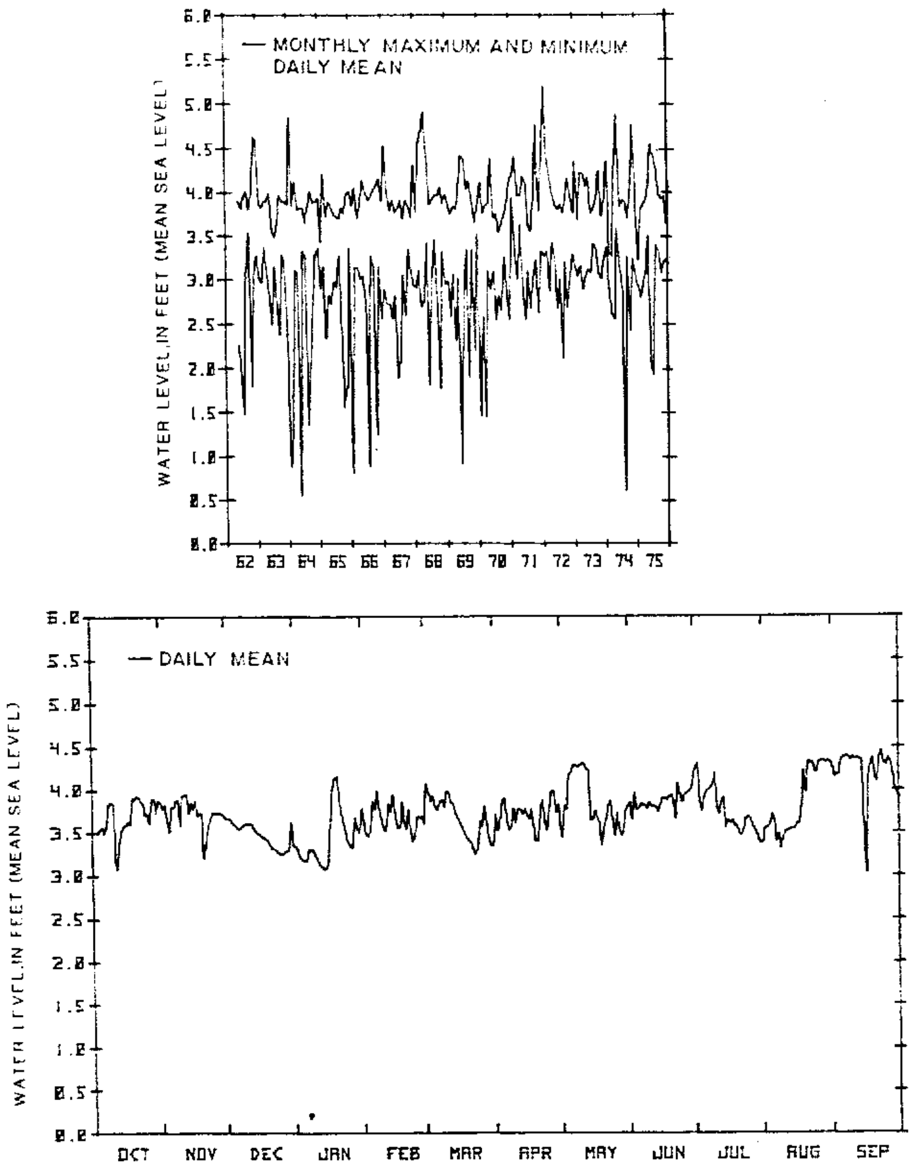
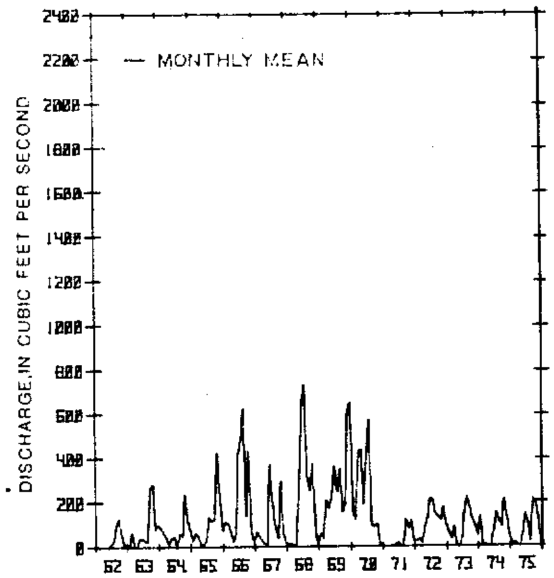



Figure 24.—Cypress Creek Canal at S-37A, near Pompano Beach for the 1976 water year and 1963-75 water years



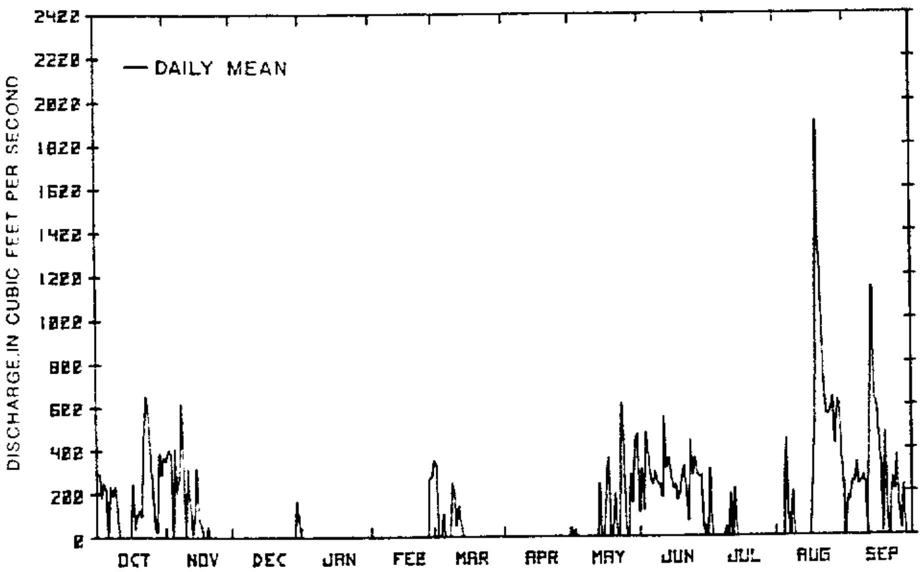




Figure 24.--Cypress Creek Canal at S-37A, near Pompano Beach for the 1976 water year and 1963-75 water years (Cont'd)

## 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 located 1.5 miles east of U.S. Highway 441. Flow downstream of the control is affected by tidal fluctuations. A bypass 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, then eastward for about 1.5 miles by means of connected borrow pits. The canal was constructued to replenish the aquifer in the Prospect well field.

The yearly mean discharge in Middle River Canal at S-36 near Fort Lauderdale for the 1976 water was 93.9 $ft^3/s$ (fig. 25), 25.2 percent above the 1962-75 average of 26.7 $ft^3/s$. The increase in yearly mean discharge, based on monthly mean discharges, is the result of increased rainfall during the wet season and releases from the conservation areas during the dry season. Prior to 1976, the greatest yearly mean discharge was 66.2 $ft^3/s$ in 1975. Much of the 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 feet msl during most of the 1976 water year (fig. 26) to facilitate replenishment of the aquifer and to prevent saltwater encroachment in 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 structure 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 1976 at S-33 was 23 $ft^3/s$ (fig. 27), which equals the average discharge for 1963-75. Because of the concentration of effluent wastes and stagnant conditions that result in Plantation Canal, a continuous flow is desirable. Flow occurred 51 percent of the time during 1976 compared to 69 percent during 1963-75. The stage at S-33 was held at about 3 feet msl during most of the 1976 water year (fig. 28) to prevent saltwater intrusion.

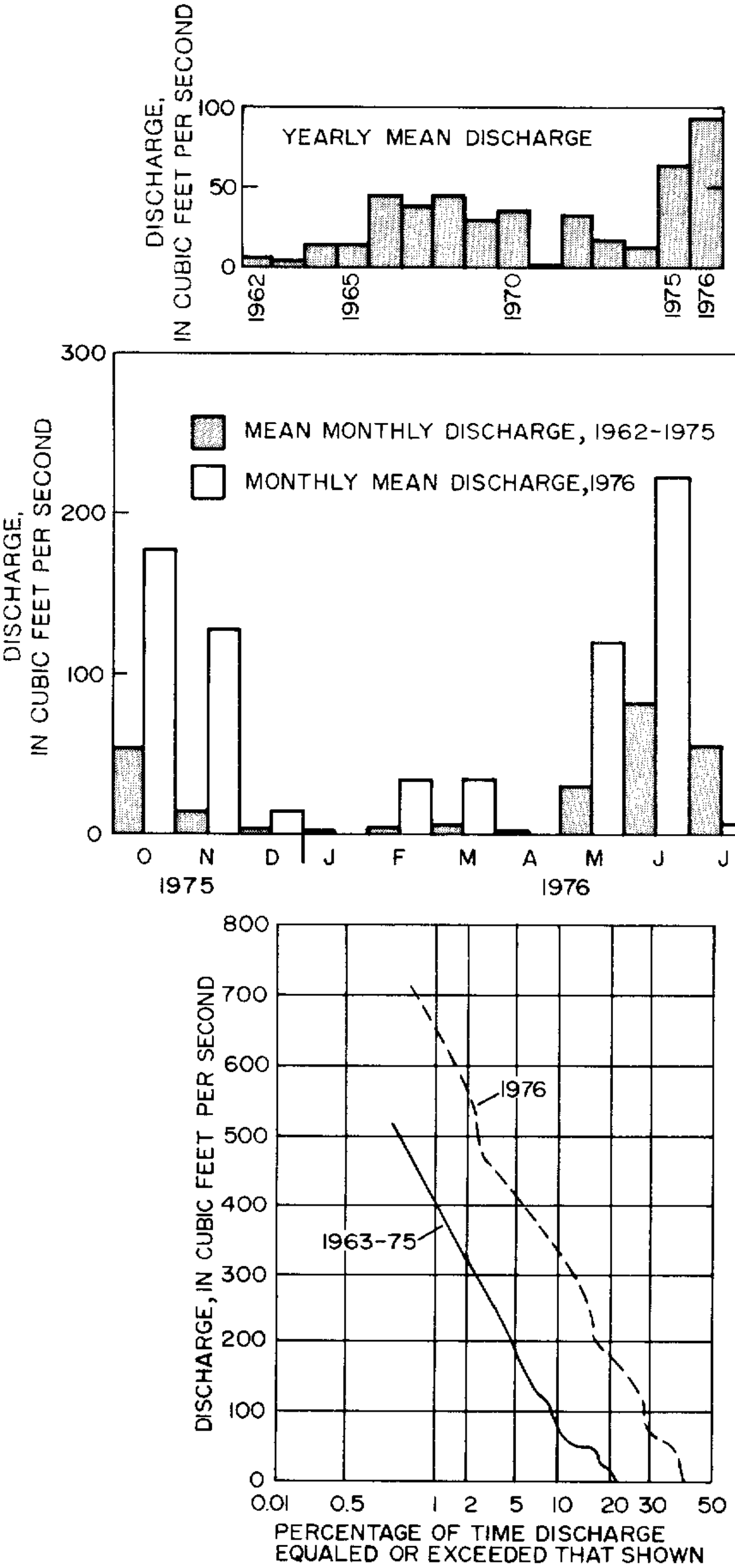



Figure 25.--Discharge data and flow-duration curves for Middle River Canal at S-36, near Fort Lauderdale

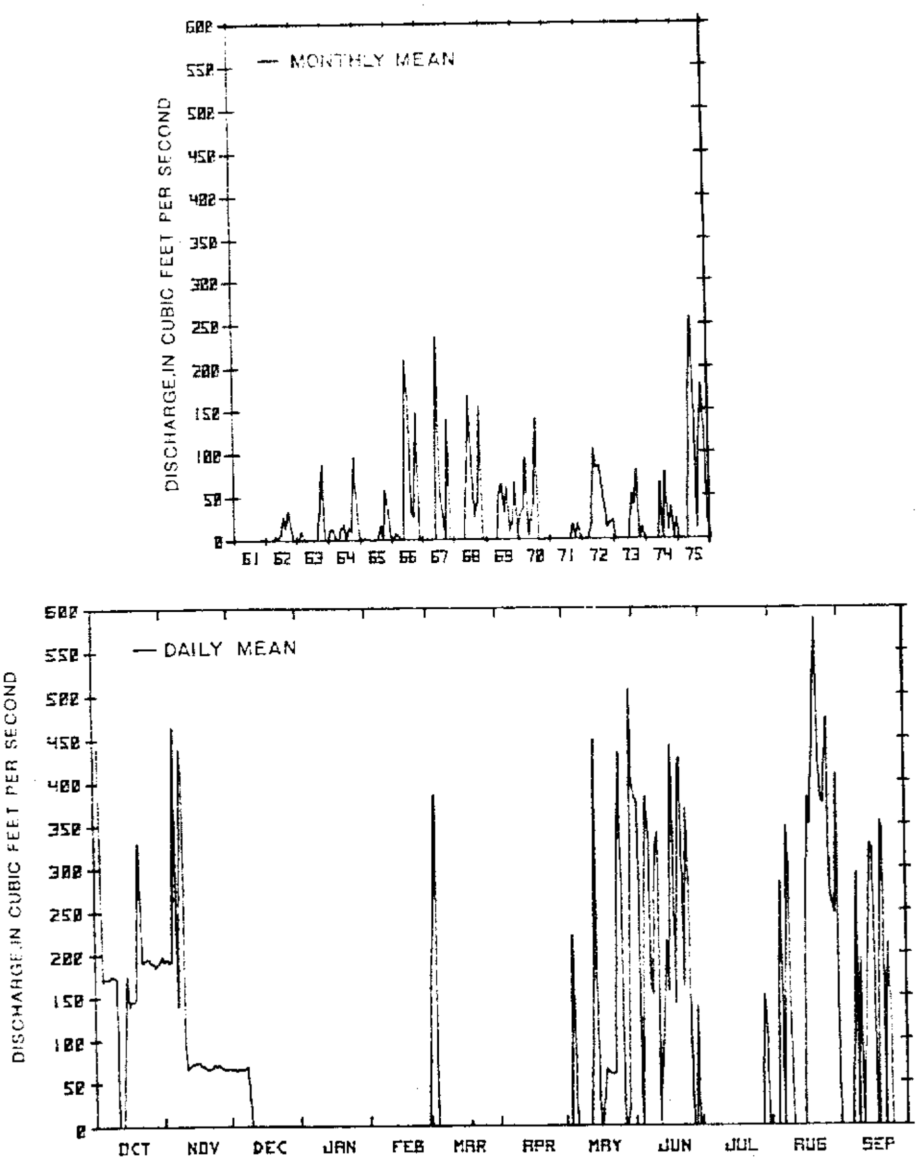



Figure 26.--Middle River Canal at S-36, near Fort Lauderdale for the 1976 water year and 1962-75 water years

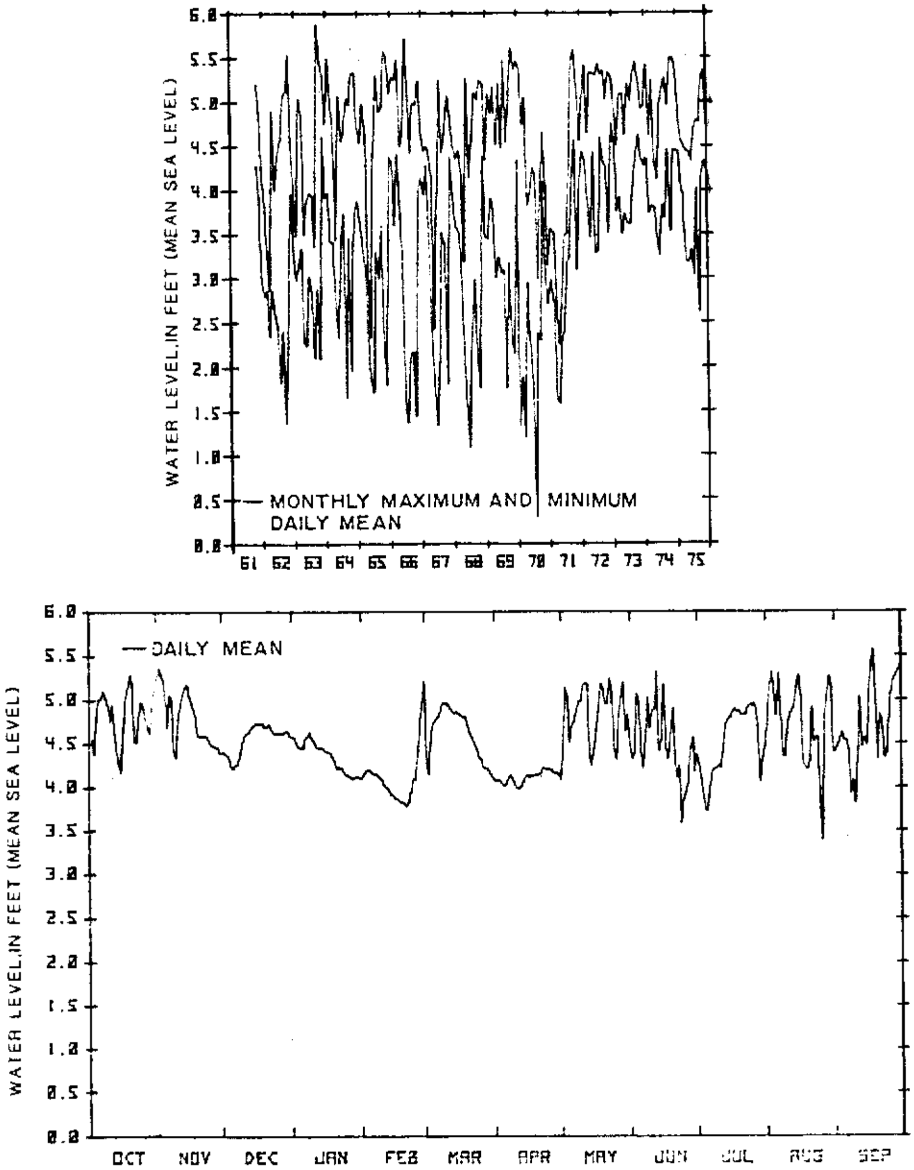



Figure 26.--Middle River Canal at S-36, near Fort Lauderdale for the 1976 water year and 1962-75 water years (Cont'd)

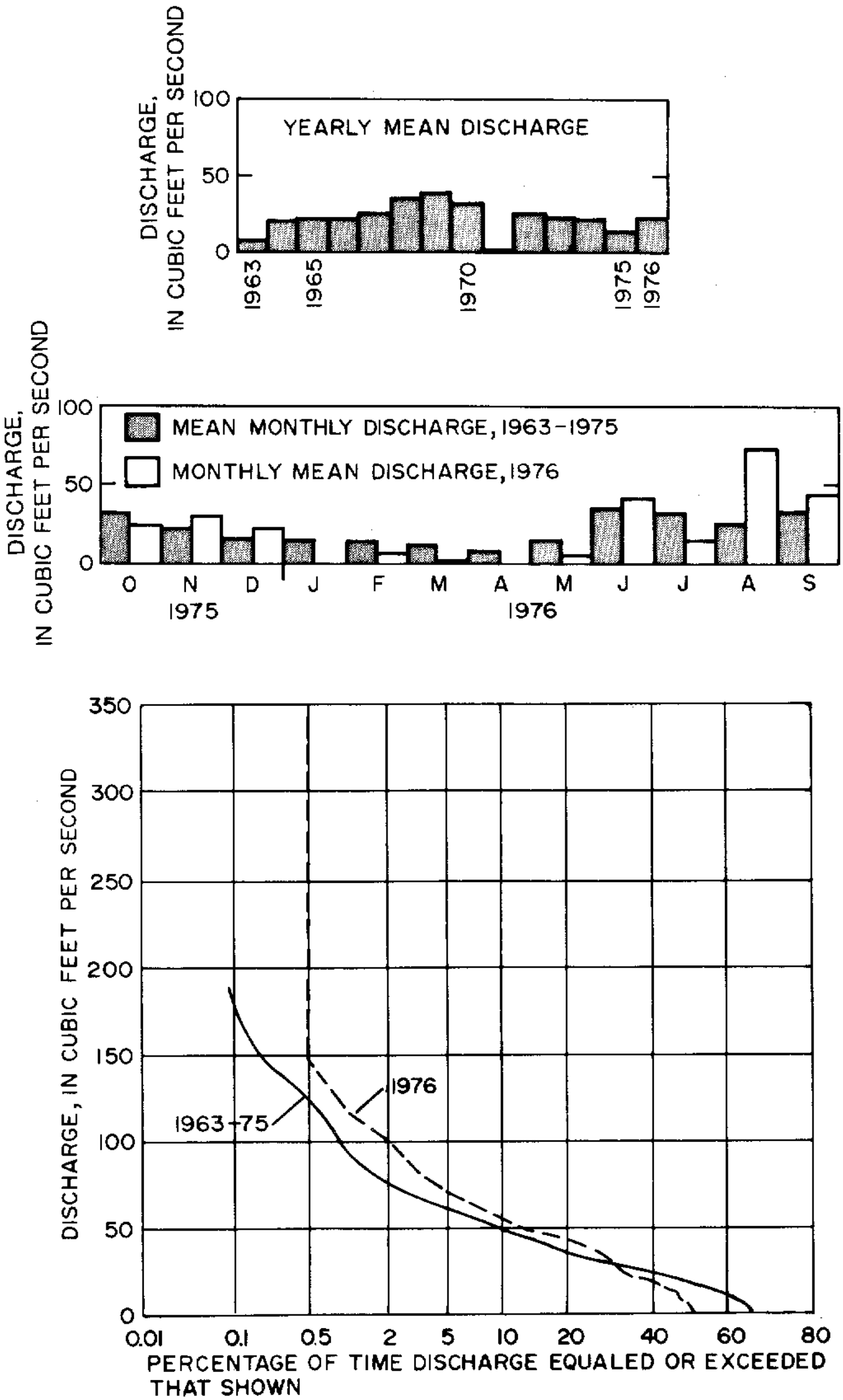



Figure 27.--Discharge data and flow-duration curves for Plantation Road Canal at S-33, near Fort Lauderdale

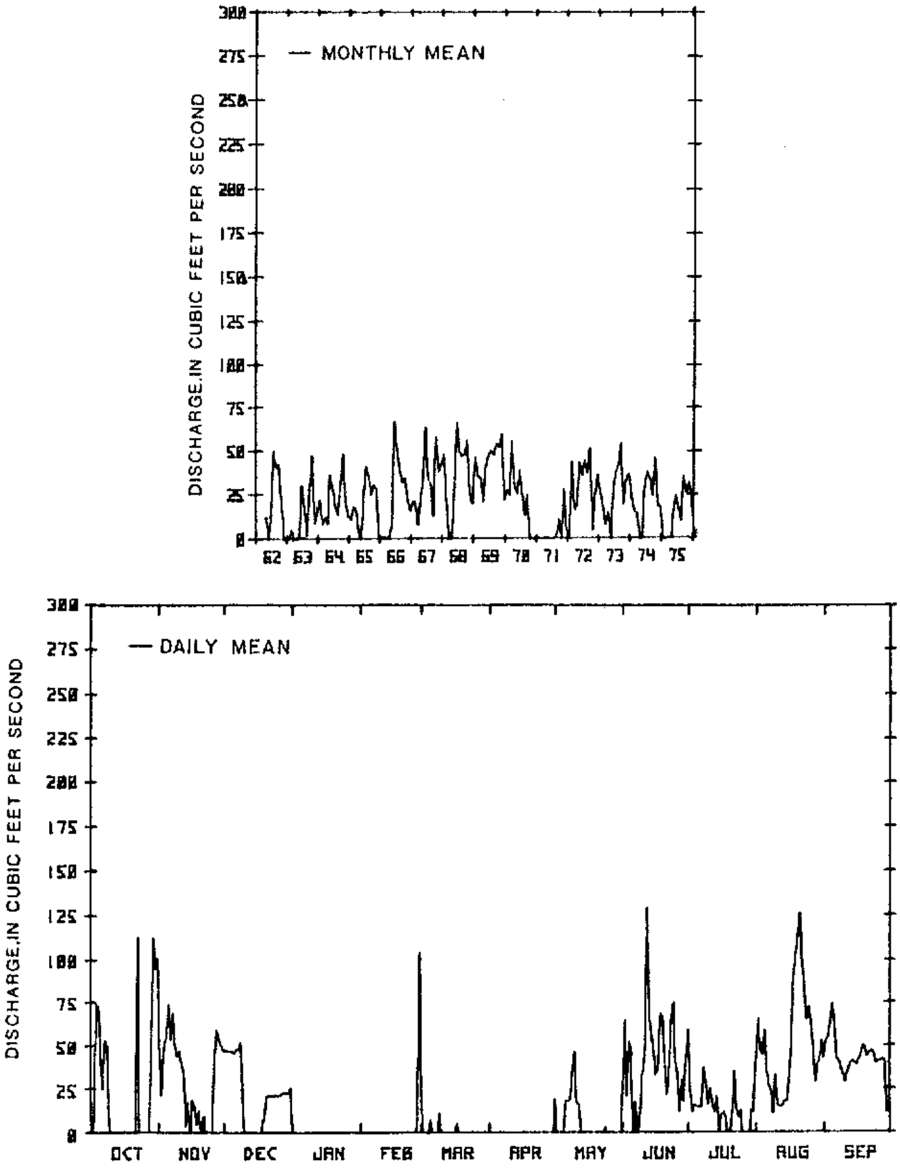
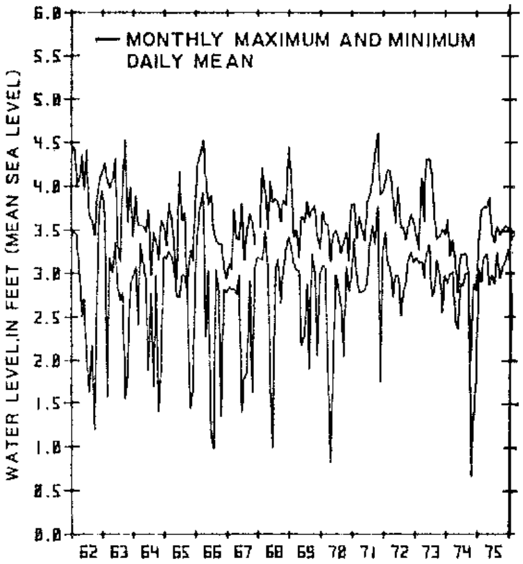



Figure 28.--Plantation Road Canal at S-33, near Fort Lauderdale for the 1976 water year and 1962-75 water years



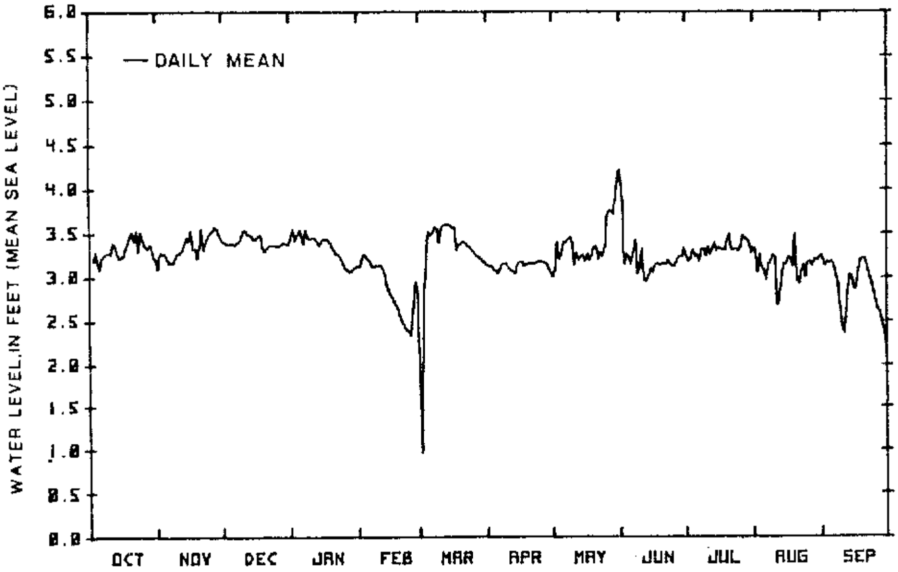




Figure 28.--Plantation Road Canal at S-33, near Fort Lauderdale for the 1976 water year and 1962-75 waters years (Cont'd)

## North New River Canal

North New River Canal (fig. 1) is a primary canal and one of the major canals in the SFWMD network. The canal is 60 miles long, extending south 30 miles from the southeastern tip of Lake Okeechobee 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 gates. In Area 2A the canal is divided into two segments, the upper part of which is separated from the lower by levees. South of S-34 the canal turns east and extends 14 miles to the Sewell Lock and Dam and thence to the ocean.

The yearly mean discharge at the Sewell Lock and Dam was 116 $ft^3/s$ for the 1976 water year (fig. 29), 99 $ft^3/s$ less than the average discharge for 1962-75. The flow-duration curves in figure 20 indicate that 50 percent of the time, discharge equalled or exceeded 50 $ft^3/s$ in 1976 and 100 $ft^3/s$ during 1963-75. The stage at the lock and dam was at 3 feet msl during most of the 1976 water year (fig. 30).

## 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. 2). The canal extends east from S-9 for 18 miles, where it is divided into the Dania Cutoff 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 1976 was 148 $ft^3/s$ (fig. 31), which equals the average discharge for 1962-75. Flow was below the mean monthly discharge for 1962-75 during October-February and April of the 1976 water year. The flow-duration curves in figure 31 indicate that 50 percent of the time discharge equalled or exceeded 110 $ft^3/s$ in 1976 and 140 $ft^3/s$ in 1962-75.

The stage at S-13 on the easternmost reach of the canal was above 1.5 feet msl (fig. 32) during most of the 1976 water year. 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 msl most of the time.

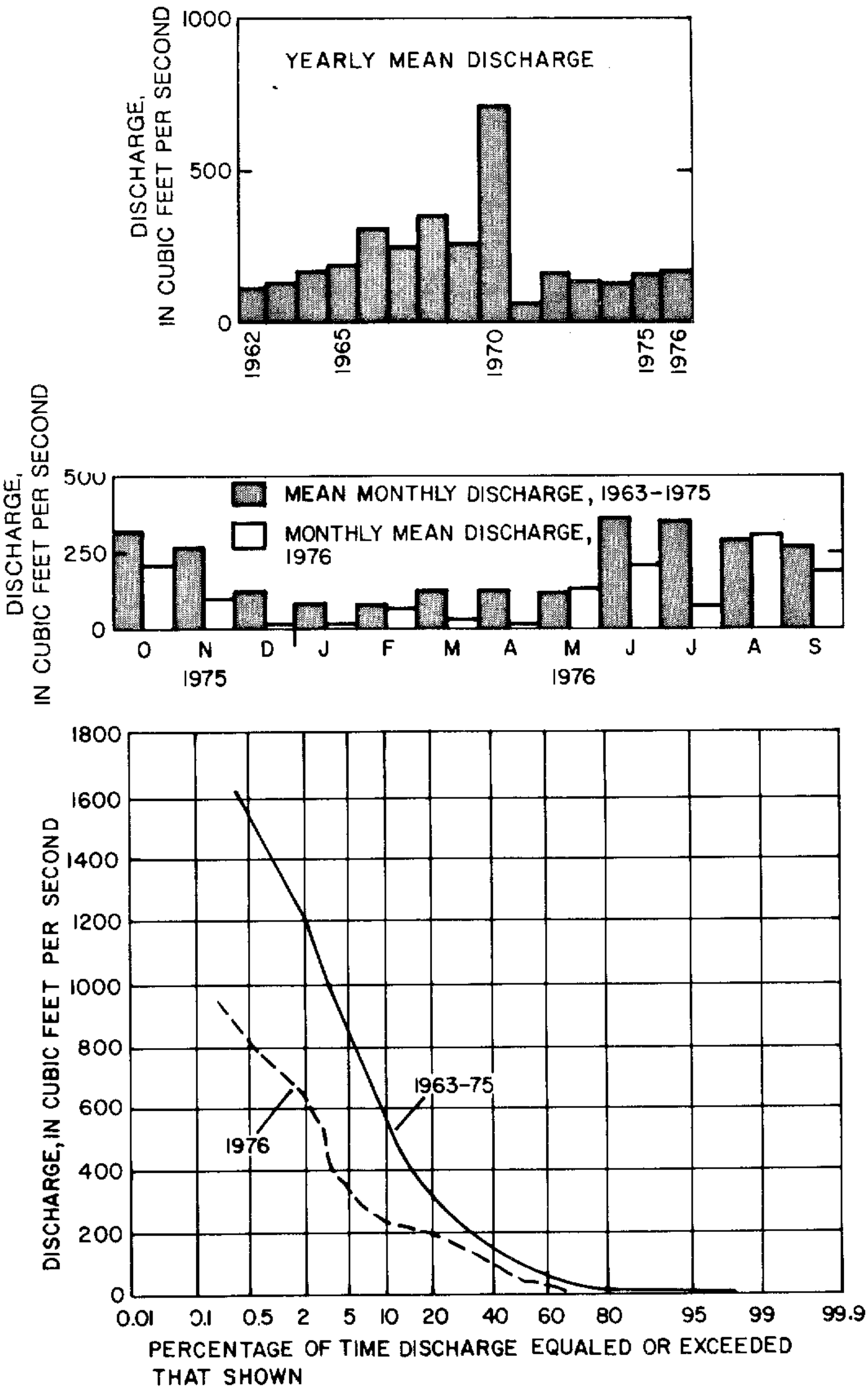



Figure 29.--Discharge data and flow-duration curves for North New River Canal near Fort Lauderdale (Sewell Lock and Dam)

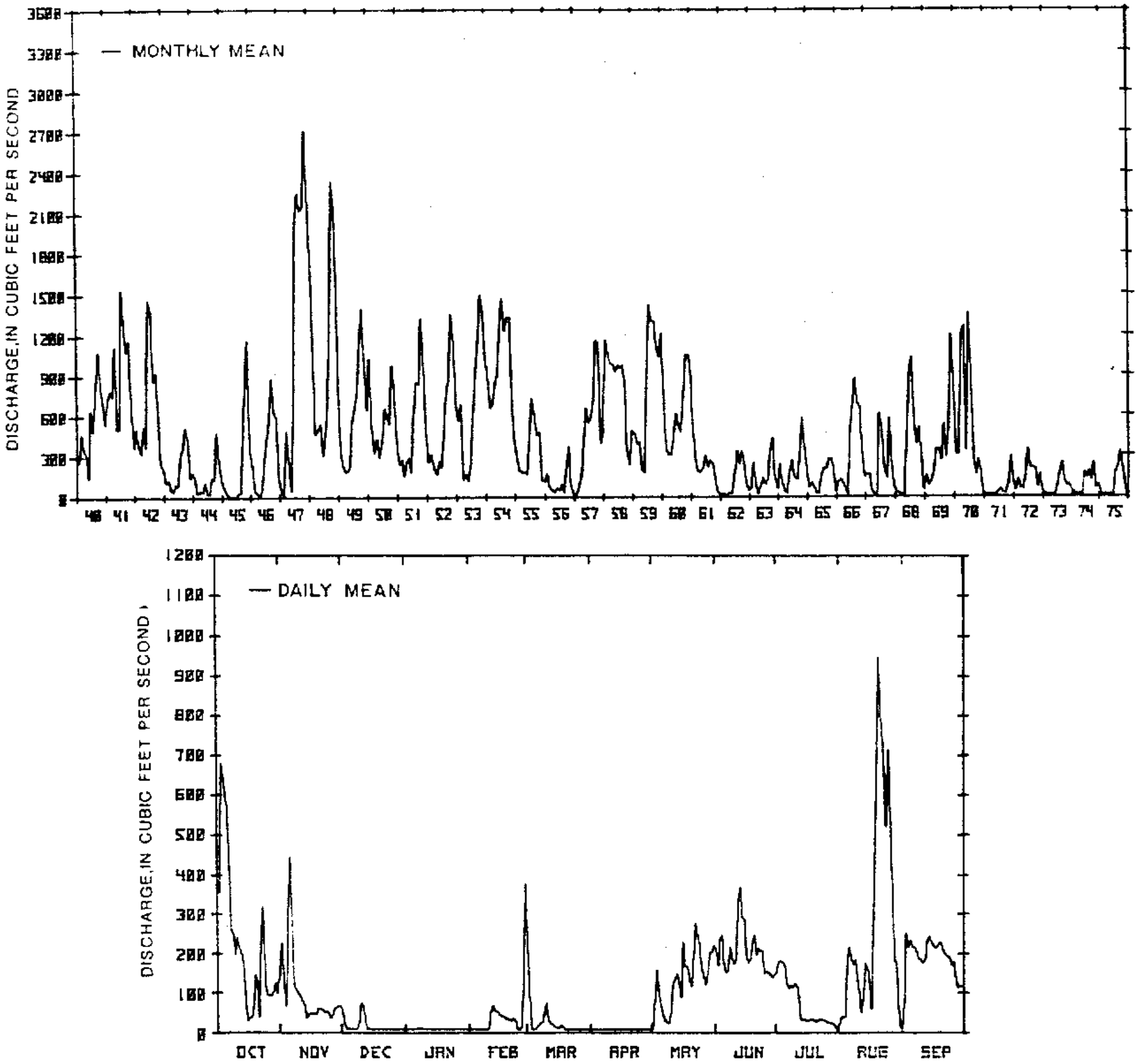



Figure 30.--North New River Canal near Fort Lauderdale (Sewell Lock and Dam) for the 1976 water year and 1940-75 water years

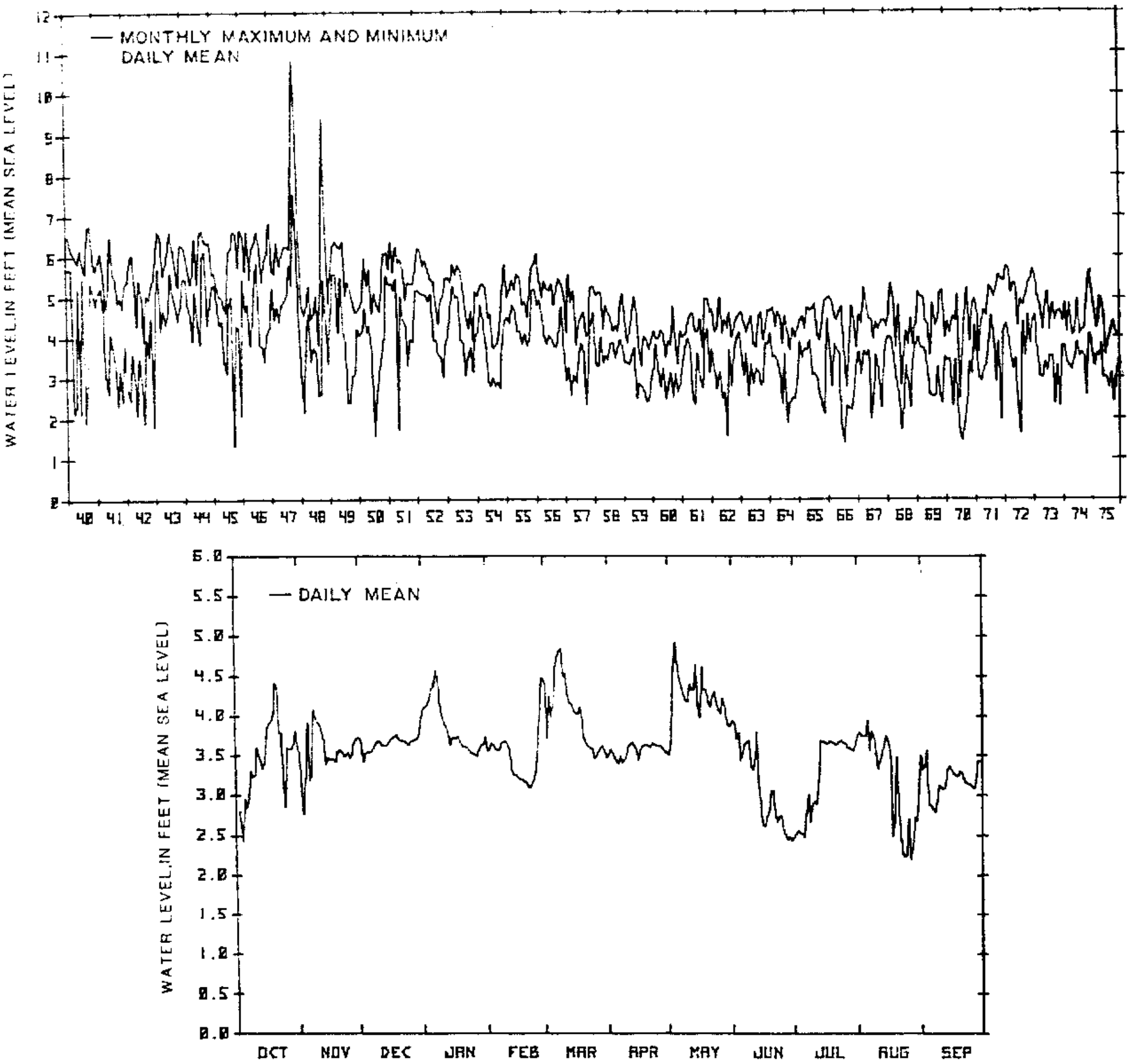



Figure 30.—North New River Canal near Fort Lauderdale (Sewell Lock and Dam) for the 1976 water year and 1940-75 water years (Cont'd)

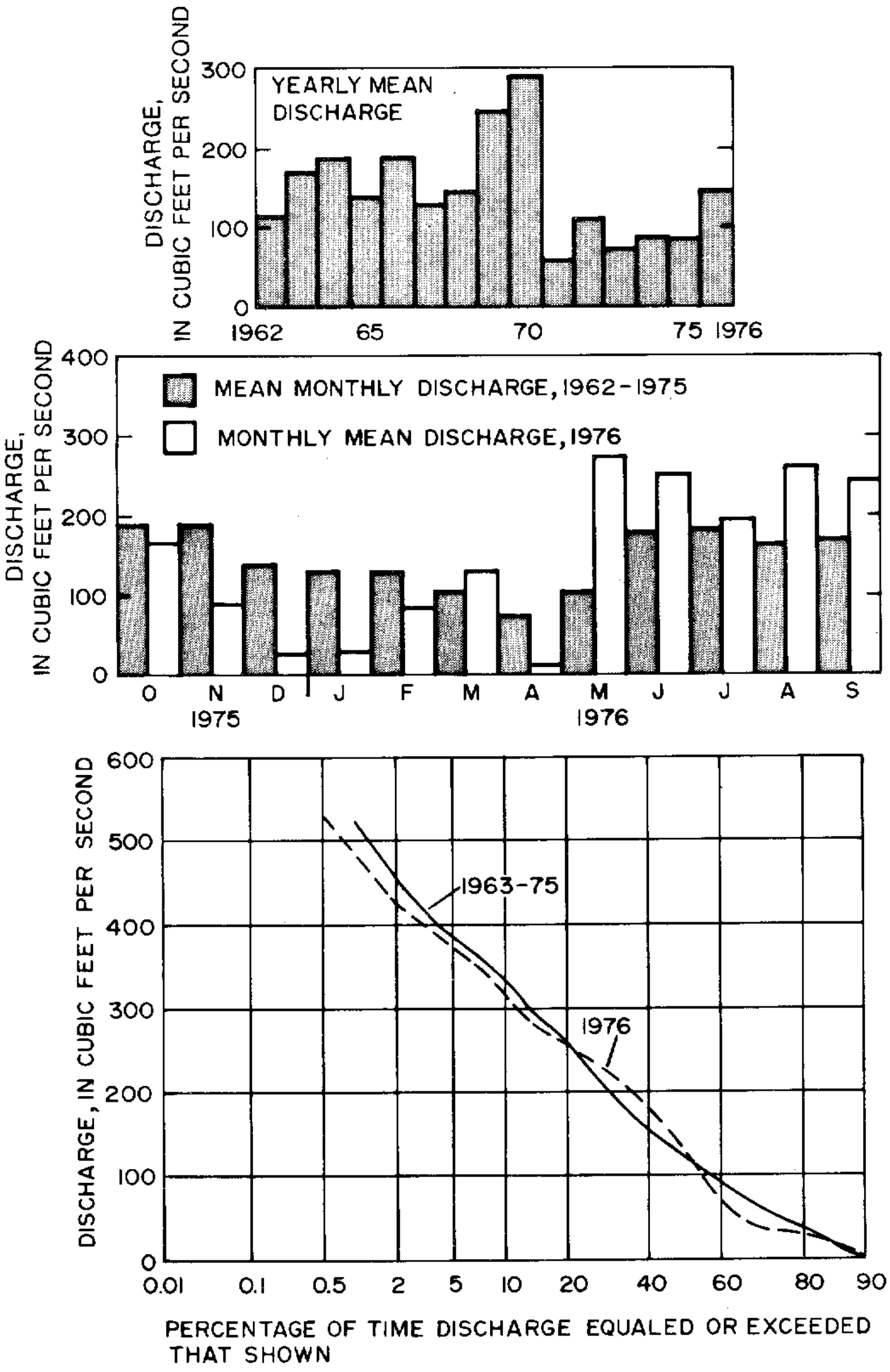
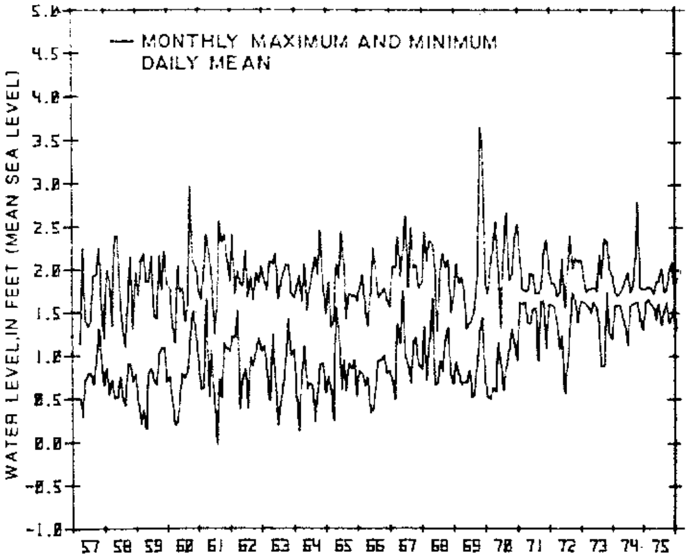



Figure 31.--Discharge data and flow-duration curves for South New River Canal at S-13, near Davie



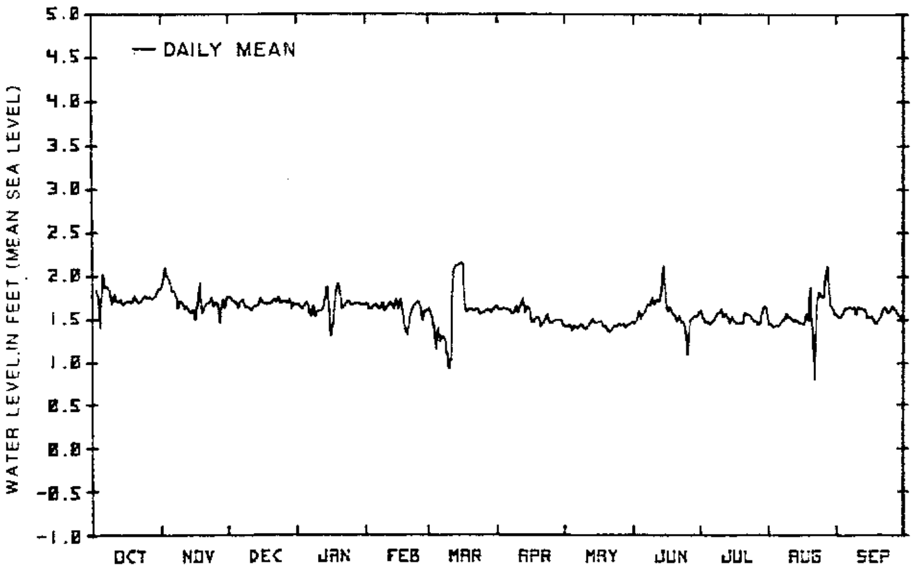
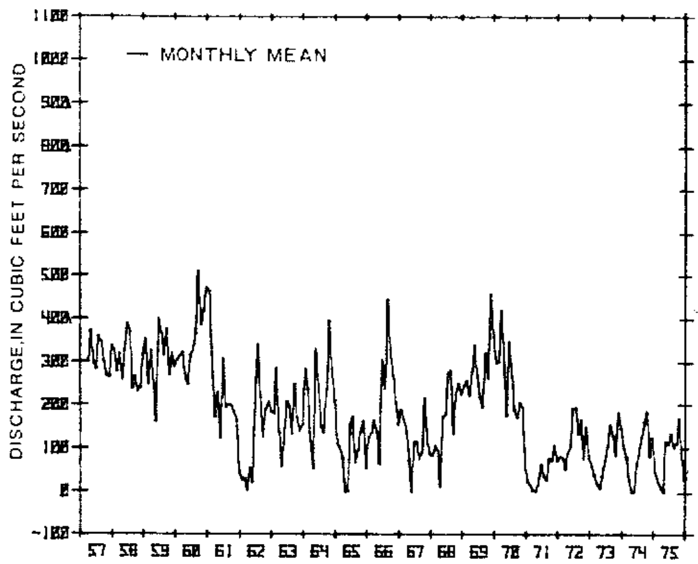




Figure 32.—South New River Canal at S-13, near Davie for the 1976 water year and 1957-75 water years



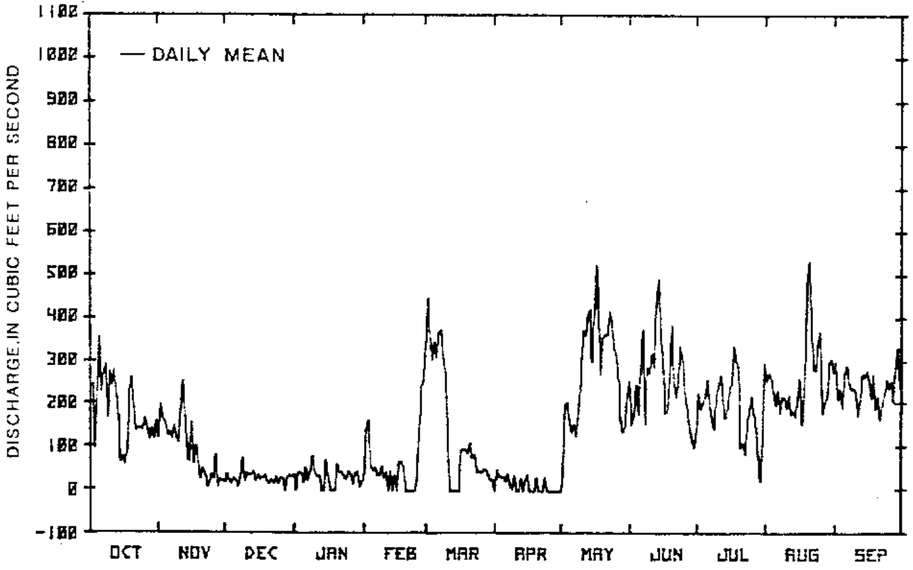




Figure 32.--South New River Canal at S-13, near Davie for the 1976 water year and 1957-75 water years (Cont'd)

## 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, located 0.75 mile east of the Area 3B boundary, and by 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. 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 saltwater encroachment in the coastal area during the dry season.

The yearly mean discharge of 235 $ft^3/s$ (fig. 33) for 1976 at N.W. 67th Avenue was 25 percent below the average discharge of 312 $ft^3/s$ for 1963-75. Monthly mean discharges during the 1976 water year were below the 1963-75 mean monthly averages with the exception of October and September. The flow-duration curves in figure 33 indicate that 50 percent of the time, discharge equalled or exceeded 170 $ft^3/s$ in 1976 and 260 $ft^3/s$ in 1963-75. The stage was held above 2.0 feet msl during most of the 1976 water year (fig. 34).

The yearly mean discharge at S-29 for 1976 was 407 $ft^3/s$ (fig. 35), 6 percent higher than the average discharge of 382 $ft^3/s$ for 1962-75. The flow duration curves indicate that 50 percent of the time, discharge equalled or exceeded 240 $ft^3/s$ in 1976 and 1962-75. The average yearly mean discharge is 172 $ft^3/s$ higher at S-29 than at N.W. 67th Avenue. During extreme dry years the average flow at both stations is about equal because S-29 remains closed through the dry months to maintain high levels in the canal to replenish the aquifer in the areas of adjacent well fields. The stage at S-29 was held at about 2.0 feet msl during most of the 1976 water year (fig. 36).

## 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.

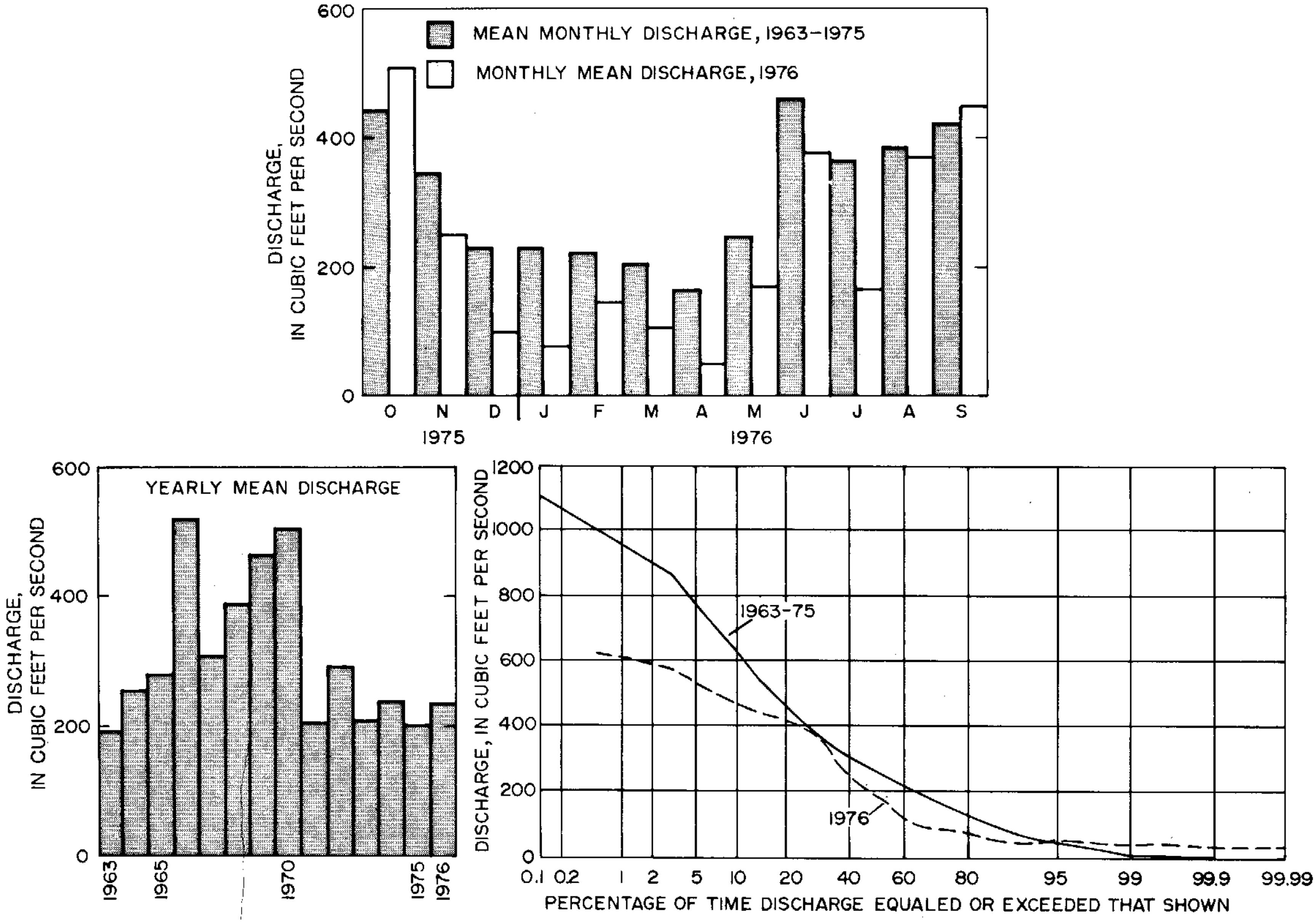



Figure 33.--Discharge data and flow-duration curves for Snake Creek Canal at N.W. 67th Avenue, near Hialeah

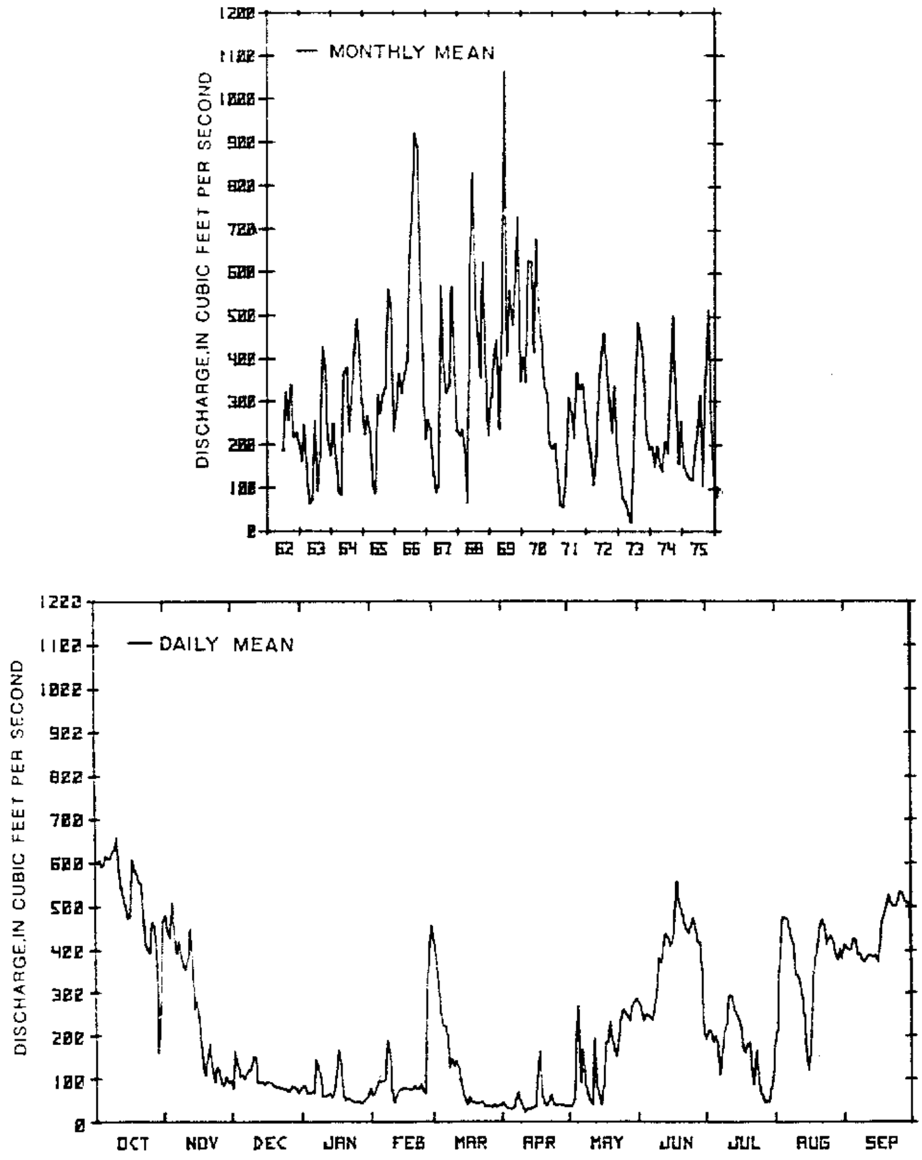
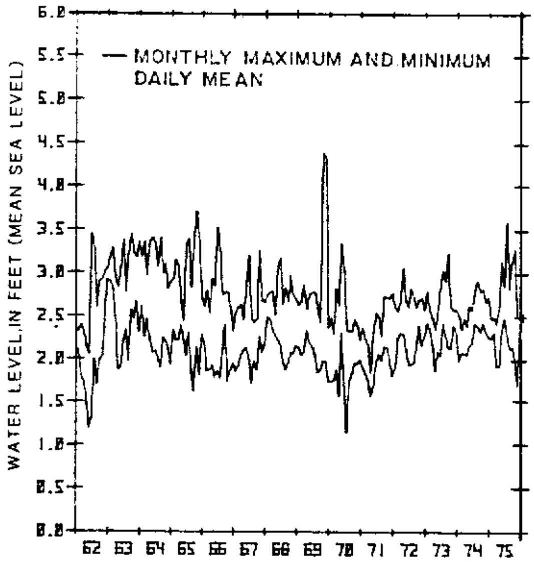



Figure 34.--Snake Creek Canal at N.W. 67th Avenue, near Hialeah, for the 1976 water year and 1962-75 water years



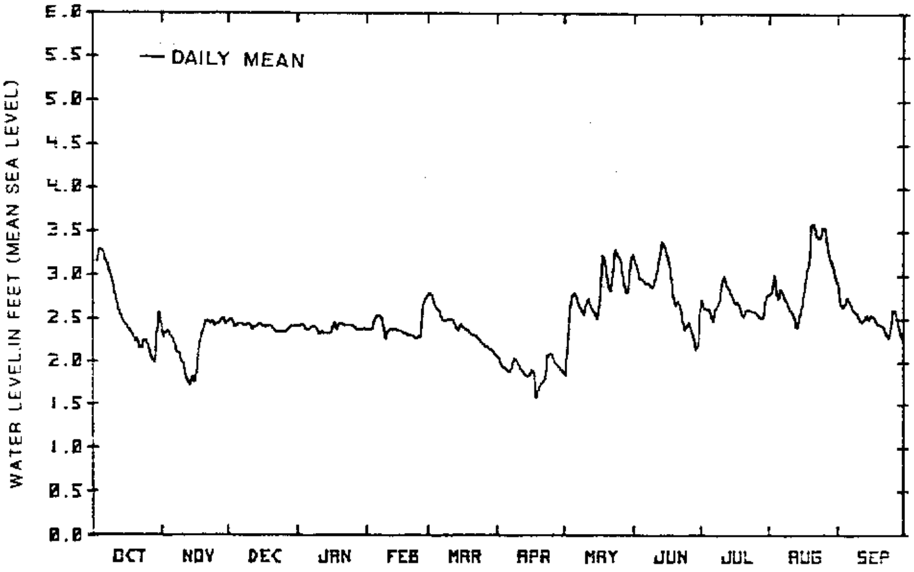




Figure 34.—Snake Creek Canal at N.W. 67th Avenue, near Hialeah for the 1976 water year and 1962-75 water years (Cont'd)

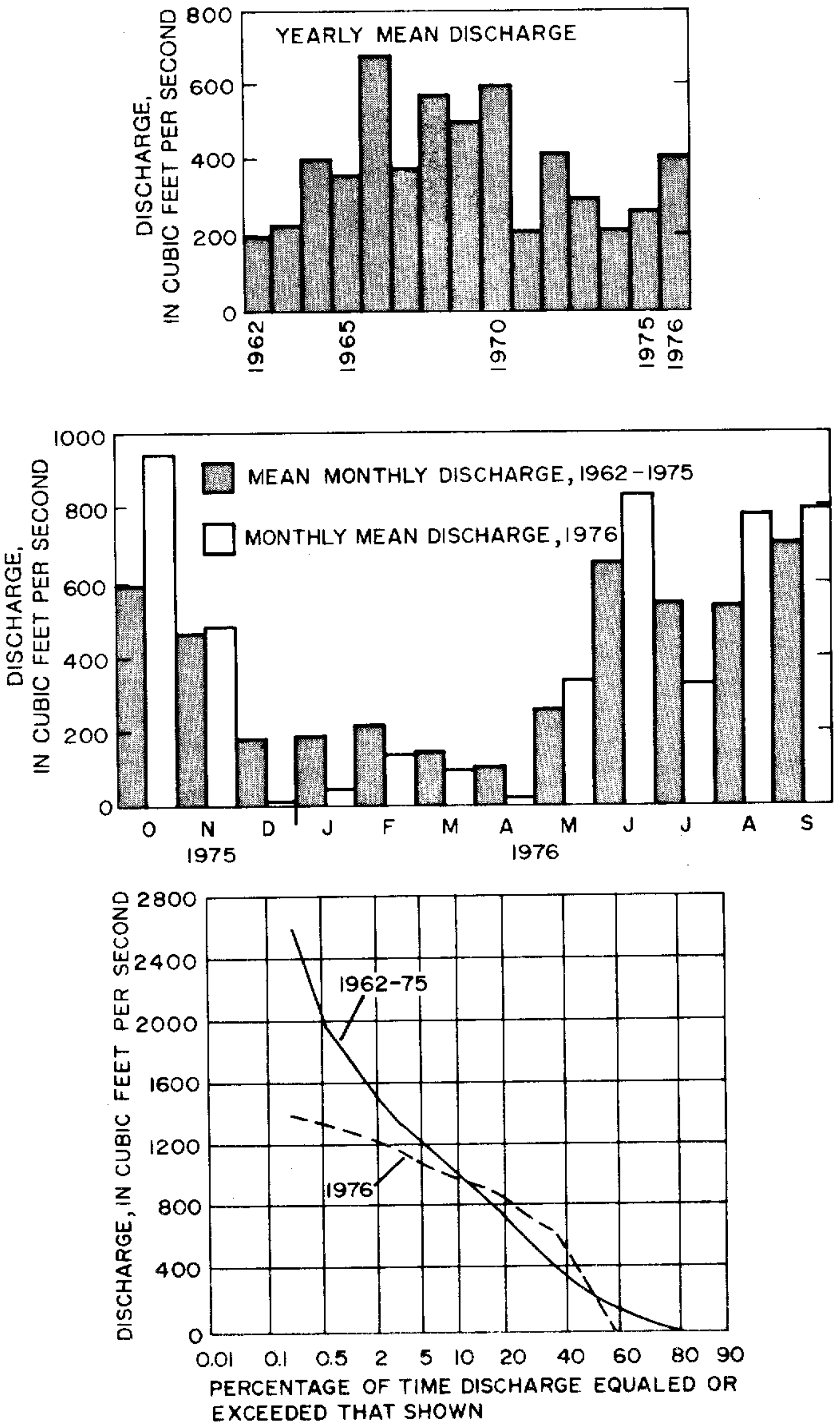



Figure 35.—Discharge data and flow-duration curves for Snake Creek Canal at S-29, at North Miami Beach

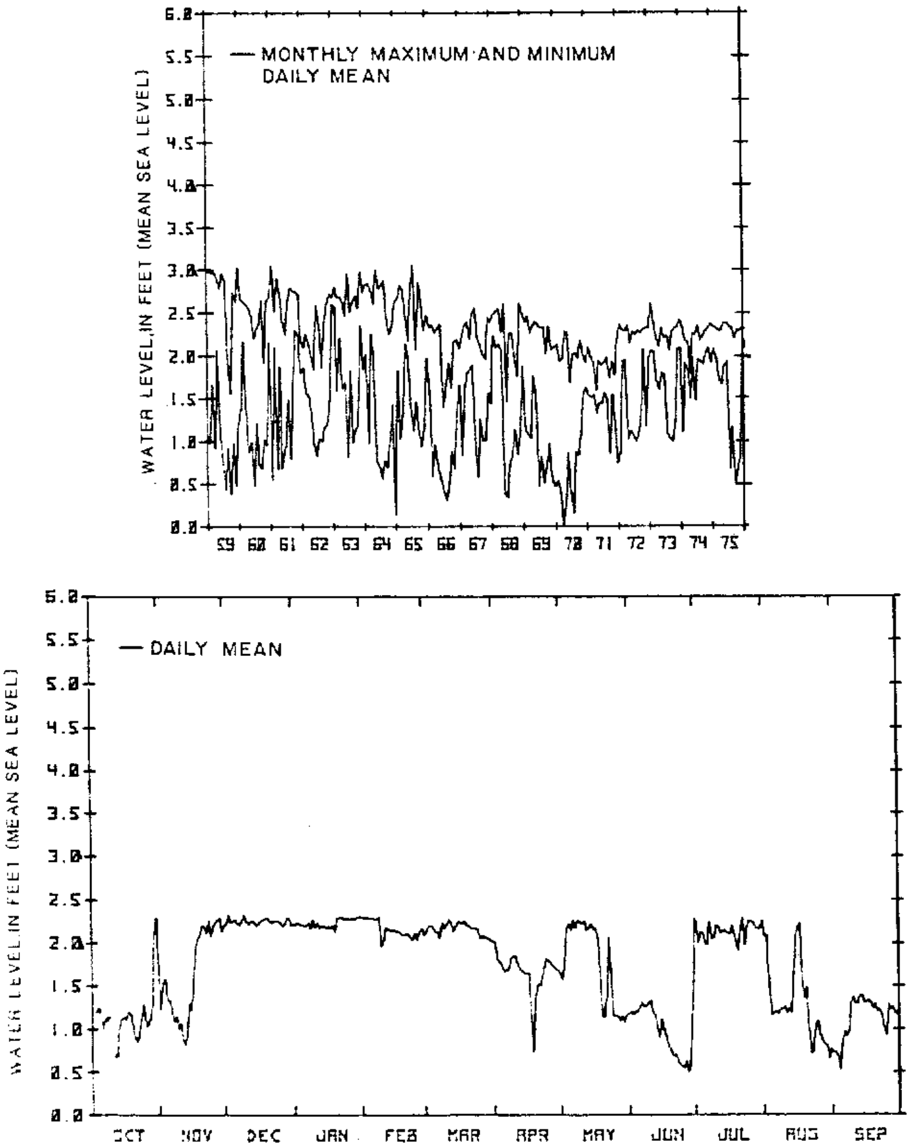



Figure 36.--Snake Creek Canal at S-29, at North Miami Beach for the 1976 water year and 1959-75 water years

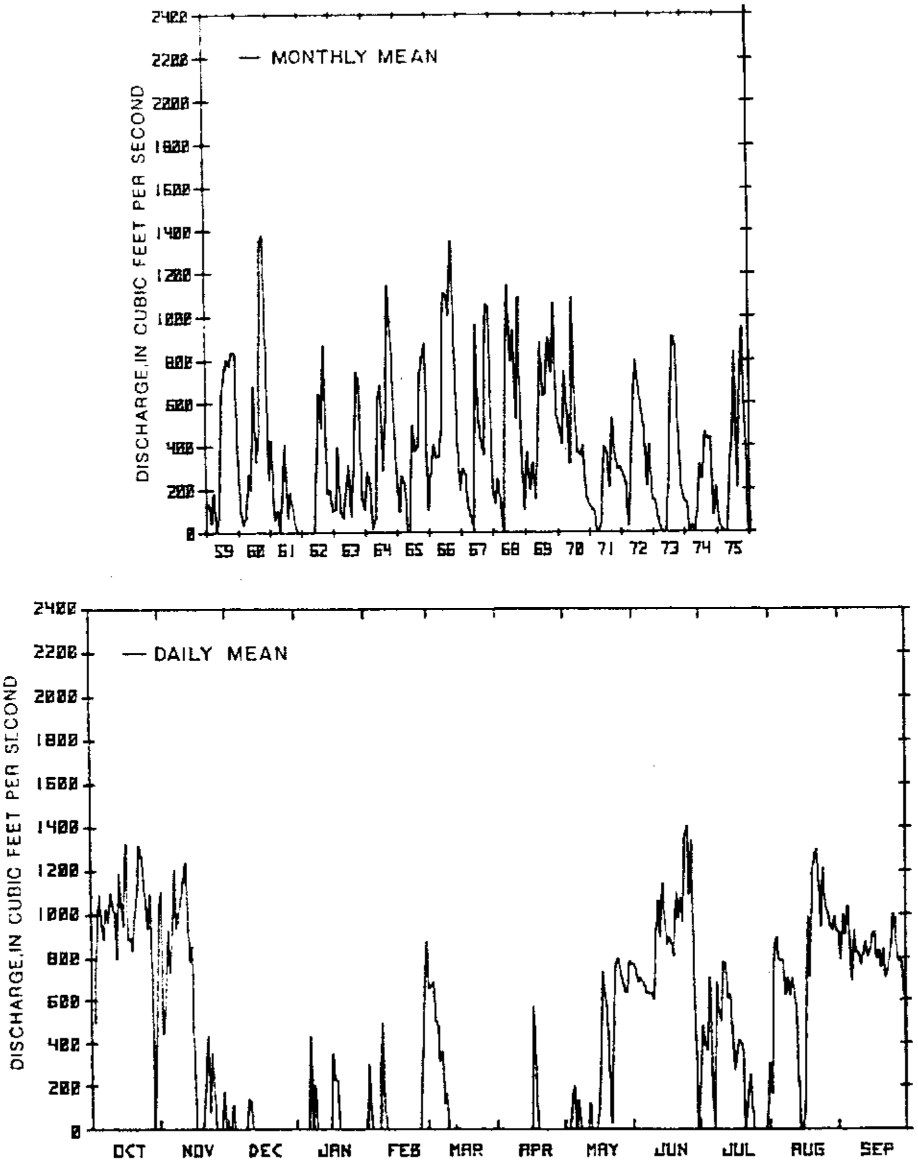



Figure 36.--Snake Creek Canal at S-29, at North Miami Beach for the 1976 water year and 1959-75 water years (Cont'd)

Water levels in the Intracoastal Waterway are affected by flow from the management system, chiefly when discharge is high. The daily high and low water levels in the waterway during the 1976 water year (figs. 37 and 38) were about the same as the monthly high and low water levels during the 1968-75 water years.

## WATER QUALITY

Water samples from 27 sites (fig. 39) in the primary canals of Broward County were collected quarterly and annually. Onsite measurements for dissolved oxygen (DO), pH, temperature, specific conductance, and alkalinity were made once every 4 hours for a 24-hour period to determine diurnal changes during the quarterly sampling periods. Water samples for nutrients (nitrogen and phosphorus species), bacteria, and biochemical oxygen demand (BOD) were collected once during the quarterly periods. Annual water samples included analyses for total metals and were collected once during a selected quarterly sampling period.

The principal source of public water supply in Broward County is ground water from the Biscayne aquifer. This water can be used for most purposes without treatment and can be easily treated to meet recommended standards of the U.S. Environmental Protection Agency (EPA) for public consumption and Florida Department of Environmental Regulation (FDER) criteria for surface waters (Table 2).

Untreated surface waters in Broward County generally meet criteria for most uses. During the 1976 water year, eight surface-water sampling stations were selected to monitor water quality in eastern Broward County canals (fig. 39, Table 3). These data (Tables 4 to 7) are presented in a format that readily refers to the data found in "Water-Quality Data for Canals in Eastern Broward County, Florida, 1969-74," by Waller, and others (1975). The 1975 data are included in this report for comparison with the 1976 data and for continuity of these stations when compared with the data report by Waller and others (1975).

The only constituent to exceed FDER criteria (Table 2) was iron in Snake Creek Canal at N.W. 67th Avenue (station 43). FDER and EPA criteria for iron establish a maximum concentration of 0.30 mg/L for domestic water supplies. Iron concentrations above 0.30 mg/L can produce objectionable tastes and stain laundry and plumbing fixtures (U.S. Environmental Protection Agency, 1976). Station 43 contained 0.44 mg/L (Table 4).

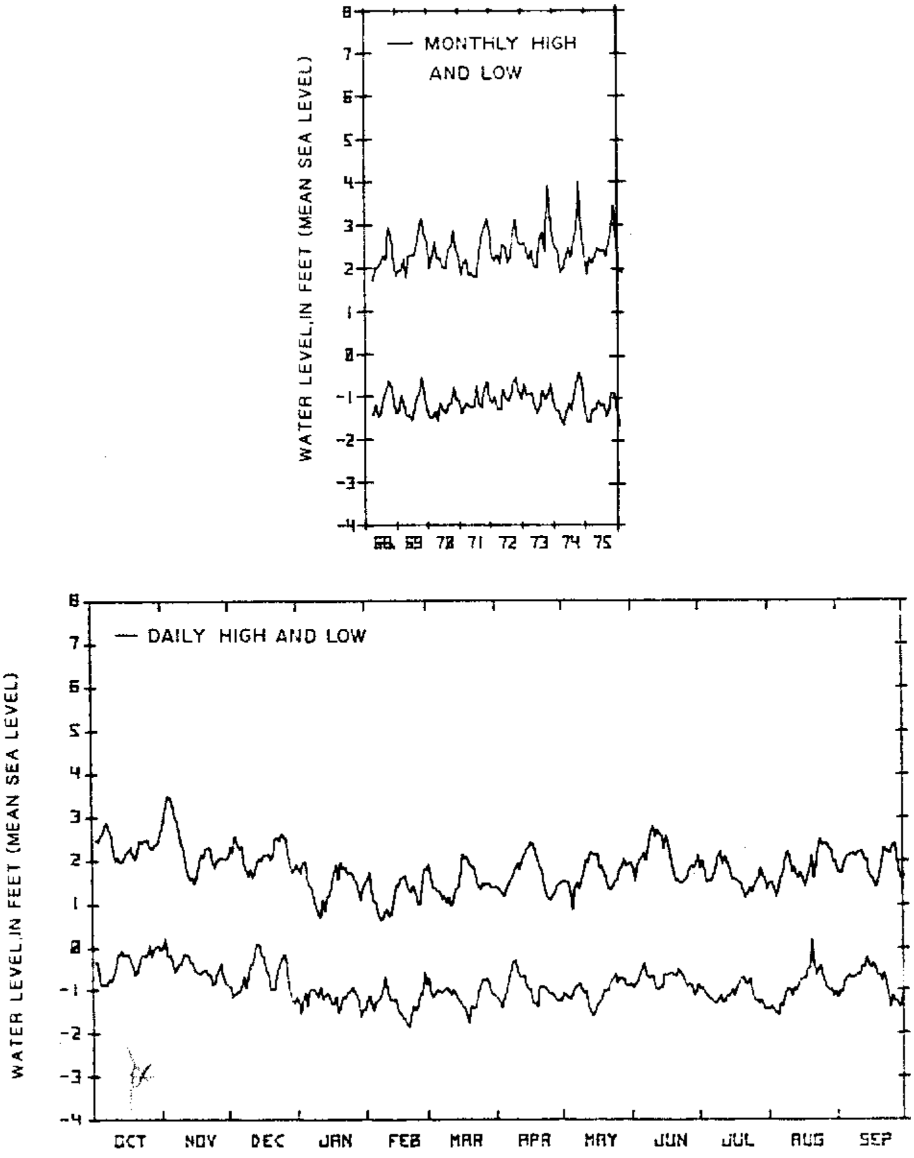



Figure 37.—Tidal fluctuations in Hillsboro River at Deerfield Beach and in the Intracoastal Waterway at Lauderdale-by-the-Sea, for the 1976 water year and 1968-75 water years

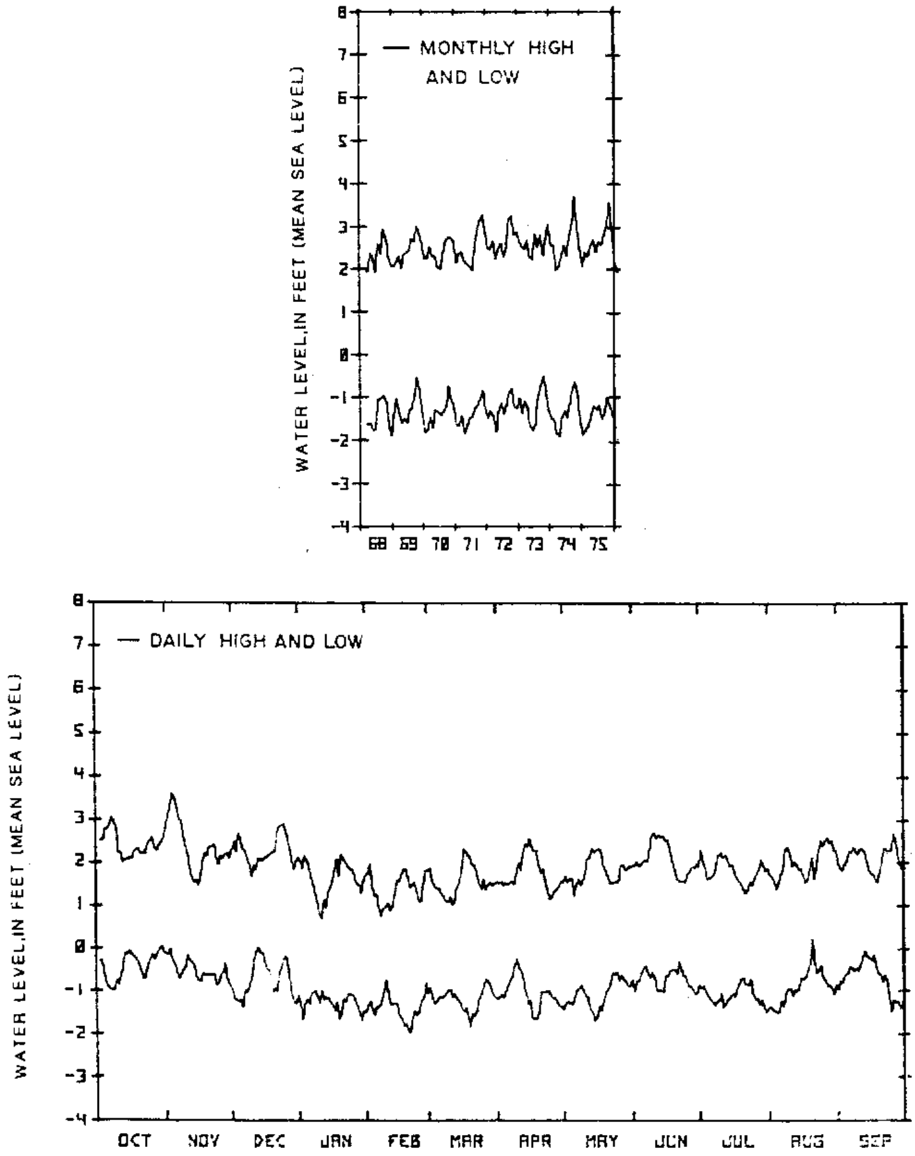
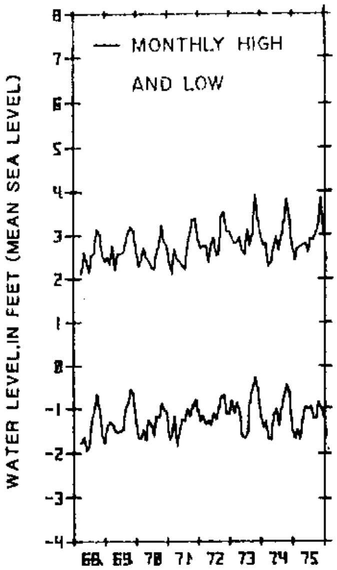



Figure 37.--Tidal fluctutions in Hillsboro River at Deerfield Beach and in the Intracoastal Waterway at Lauderdale-by-the-Sea, for the 1976 water year and 1968-75 water years



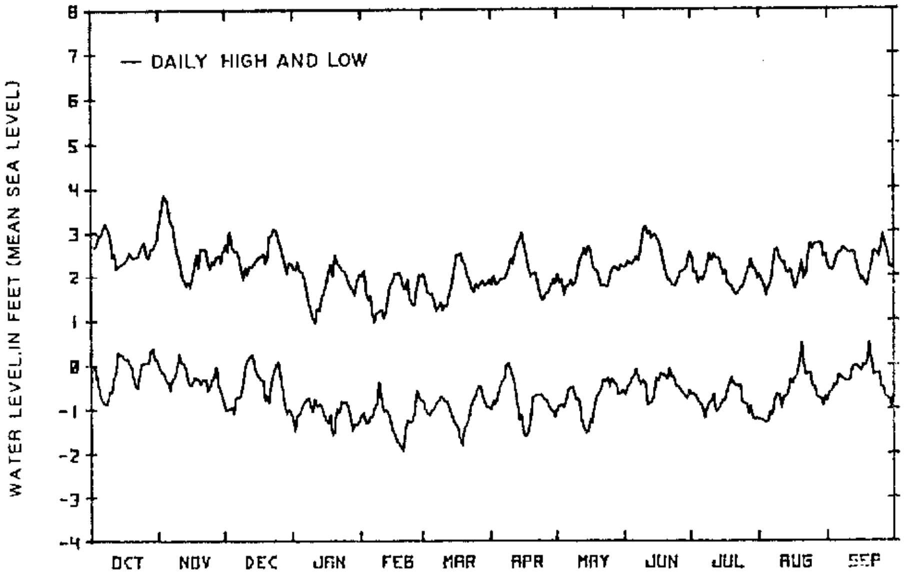




Figure 38.--Tidal fluctuations in the Intracoastal Waterway at Port Everglades, and at Hollywood, for the 1976 water year and 1968-75 water years

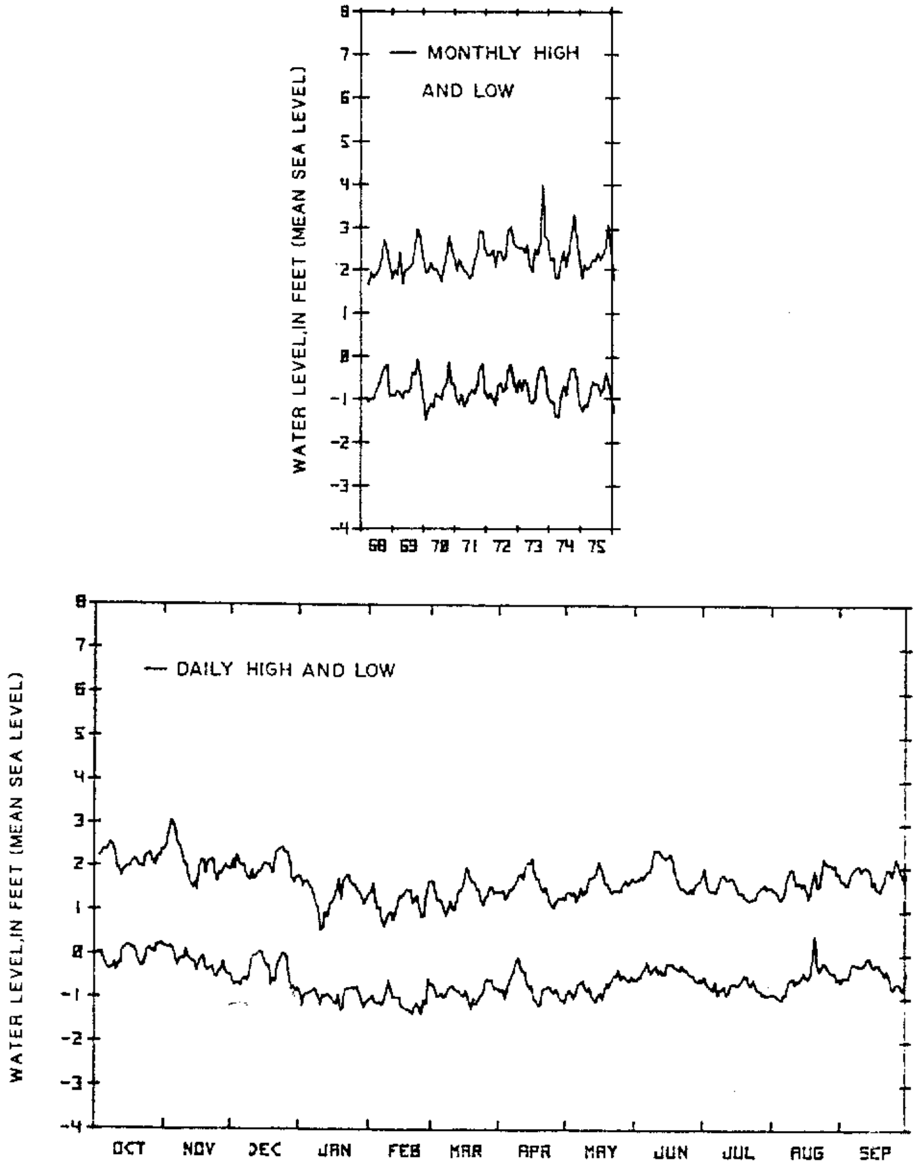



Figure 38.—Tidal fluctuations in the Intracoastal Waterway at Port Everglades, and at Hollywood for the 1976 water year and 1968-75 water years

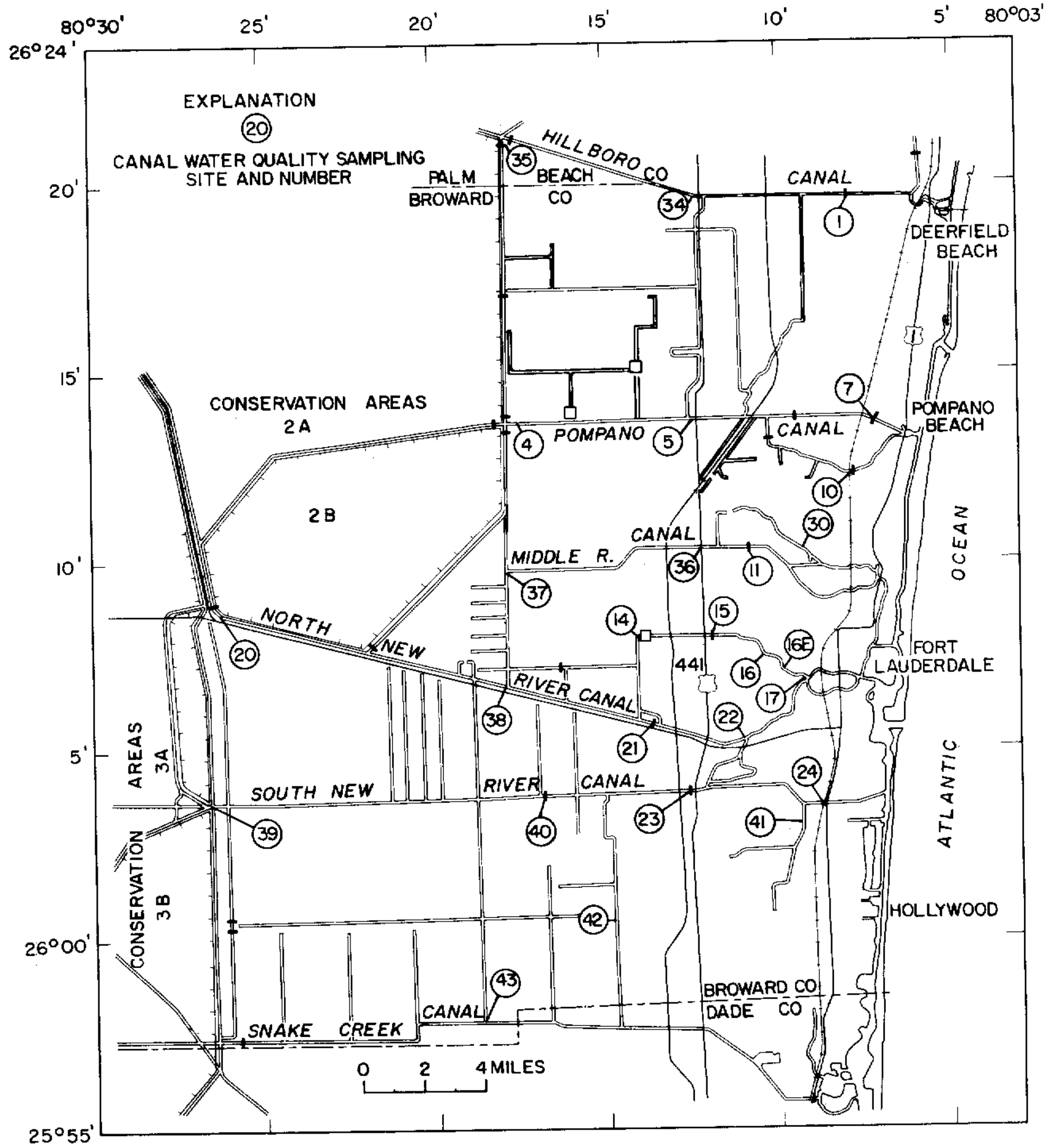



Figure 39.--Location of canal water-quality sampling sites

Table 2.--Florida Department of Environmental Regulation criteria for surface waters

[milligrams per liter except where noted]

The Florida Department of Environmental Regulation has established five 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 uses

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 (freshwater) | 250 |
| Chromium | .05 |
| Copper | .5 |
| Cyanide | .00 |
| Detergents | .5 |
| Dissolved solids 1/ | 500 |
| Fluoride | 10 |
| Iron | .30 |
| Lead | .05 |
| Oil and grease | 15 |
| Phenol | .001 |
| Zinc | 1 |

1/ Dissolved solids not to exceed 500 mg/L as a monthly average or 1,000 mg/L at any time.

Table 2.--Florida Department of Environmental Regulation criteria for surface waters (Cont'd)

[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 | |
| Temperature (°C) 1/ | 34 |
| 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 34°C (93°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 concentration or combinations which are toxic and harmful to humans, animals, or aquatic life.

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

Table 3.--Surface-water sampling stations, identification numbers, and date record began

| Station number | Station name | Station identification number | Beginning of record |
|---|---|---|---|
| 1 | Hillsboro Canal above lock | 02281500 | 2-69 |
| 7 | Pompano Canal at Pompano Beach | 02282000 | 2-69 |
| 10 | Cypress Creek Canal above S-37A | 02282100 | 2-69 |
| 11 | Middle River Canal above S-36 | 02282700 | 2-69 |
| 15 | Plantation Canal above S-33 | 02283200 | 2-69 |
| 21 | North New River Canal above lock | 02285000 | 2-69 |
| 23 | South New River Canal above S-13 | 02286100 | 2-69 |
| 43 | Snake Creek Canal at N.W. 67th Avenue | 02286200 | 9-70 |

Table 4.--Concentrations of selected metals in surface water

[micrograms per liter]

| CANAL | Station Number | Date of Collection | Aluminum (Al) | Arsenic (As) | Boron (B) | Chromium (Cr+6) | Copper (Cu) | Iron (Fe) | Manganese (Mn) | Lead (Pb) | Zinc (Zn) | Mercury (Hg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hillsboro | 1 | 24 March 1975 | - | 0 | - | 0 | 5 | 130 | 10 | 6 | 40 | - |
| | | 23 March 1976 | 60 | 0 | - | 0 | 4 | 100 | 20 | 32 | 0 | - |
| Pompano | 7 | 24 March 1975 | - | 0 | - | 0 | 6 | 200 | 900 | 38 | 60 | - |
| | | 23 March 1976 | 50 | 1 | - | 0 | 10 | 180 | 10 | 18 | 10 | - |
| Cypress Creek | 10 | 24 March 1975 | - | 2 | - | 0 | 3 | 80 | 60 | 7 | 40 | - |
| | | 23 March 1976 | 50 | 0 | - | 0 | 4 | 90 | 10 | 22 | 20 | - |
| Middle River | 11 | 24 March 1975 | - | 2 | - | 0 | 8 | 120 | 70 | 0 | 30 | - |
| | | 23 March 1976 | 40 | 1 | - | 0 | 6 | 190 | 10 | 0 | 10 | - |
| Plantation | 15 | 24 March 1975 | - | 1 | - | 0 | 7 | 160 | 10 | 13 | 20 | - |
| | | 23 March 1976 | 30 | 1 | - | 0 | 10 | 90 | 10 | 4 | 20 | - |
| North New River | 21 | 24 March 1975 | - | 2 | - | 0 | 3 | 200 | 40 | 31 | 30 | - |
| | | 23 March 1976 | 10 | 0 | - | 0 | 4 | 110 | 10 | 5 | 10 | - |
| South New River | 23 | 24 March 1975 | - | 3 | - | 0 | 2 | 170 | 50 | 16 | 20 | - |
| | | 23 March 1976 | 0 | 1 | - | 0 | 4 | 250 | 10 | 20 | 20 | - |
| Snake Creek | 43 | 24 March 1975 | - | 0 | - | 0 | 3 | 370 | 40 | 0 | 20 | - |
| | | 23 March 1976 | 40 | 0 | - | 0 | 8 | 440 | 10 | 14 | 10 | - |

Table 5.-- Concentrations of major inorganic ions, hardness, and dissolved solids in surface water.

[milligrams per liter]

| CANAL | Station Number | Date of Collection | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Strontium (Sr) | Chloride (Cl) | Sulfate (SO4) | Fluoride (F) | Bicarbonate (HCO3) | Dissolved Solids | | Hardness (CaCO3) | | Silica ($SiO_2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Residue at 180°C | Calculated | Calcium, Magnesium | Non-carbonate | |
| Hillsboro | 1 | 24 March 1975 | 100 | 11 | 65 | 4.0 | 250 | 98 | 38 | 0.6 | 312 | 525 | 479 | 300 | 39 | 8.1 |
| | | 23 March 1976 | 98 | 9.5 | 62 | 3.8 | 130 | 95 | 33 | .5 | 308 | 516 | 461 | 280 | 31 | 7.3 |
| Pompano | 7 | 24 March 1975 | 82 | 3.6 | 21 | 2.2 | 740 | 32 | 18 | .3 | 240 | 311 | 283 | 220 | 24 | 5.2 |
| | | 23 March 1976 | 91 | 8.1 | 50 | 3.4 | 1100 | 74 | 30 | .5 | 280 | 408 | 400 | 260 | 32 | 4.2 |
| Cypress Creek | 10 | 24 March 1975 | 87 | .11 | 65 | 4.4 | 160 | 95 | 39 | .5 | 272 | 478 | 441 | 260 | 40 | 4.8 |
| | | 23 March 1976 | 88 | 8.8 | 54 | 3.8 | 1200 | 80 | 34 | .5 | 280 | 476 | 440 | 260 | 28 | 5.7 |
| Middle River | 11 | 24 March 1975 | 73 | 18 | 100 | 5.0 | 180 | 140 | 30 | .7 | 308 | 594 | 531 | 260 | 4 | 12 |
| | | 23 March 1976 | 83 | 9.0 | 52 | 2.4 | 960 | 81 | 13 | .5 | 280 | 404 | 385 | 250 | 16 | 5.4 |
| Plantation | 15 | 24 March 1975 | 68 | 8.2 | 80 | 6.0 | 860 | 120 | 30 | .5 | 188 | 495 | 410 | 200 | 50 | 3.4 |
| | | 23 March 1976 | 74 | 6.4 | 44 | 3.5 | 670 | 74 | 23 | .7 | 224 | 352 | 339 | 210 | 28 | 1.9 |
| North New River | 21 | 24 March 1975 | 75 | 25 | 120 | 5.2 | 220 | 170 | 28 | 1.0 | 321 | 548 | 593 | 280 | 20 | 13 |
| | | 23 March 1976 | 88 | 12 | 60 | 1.4 | 1000 | 110 | 5.4 | .5 | 308 | 456 | 436 | 270 | 18 | 5.9 |
| South New River | 23 | 24 March 1975 | 99 | 8.9 | 41 | 2.8 | 120 | 68 | 17 | .4 | 296 | 446 | 389 | 280 | 41 | 5.7 |
| | | 23 March 1976 | 95 | 8.9 | 38 | 2.0 | 840 | 67 | 13 | .3 | 300 | 410 | 379 | 270 | 29 | 6.0 |
| Snake Creek | 43 | 24 March 1975 | 92 | 11 | 55 | 1.5 | 120 | 85 | 4.6 | .5 | 284 | 465 | 398 | 280 | 42 | 8.0 |
| | | 23 March 1976 | 83 | 11 | 55 | 1.4 | 770 | 83 | 3.3 | .3 | 288 | 440 | 387 | 250 | 17 | 7.2 |

Table 6.--Concentrations of macronutrients and oxygen-related parameters in surface water

[milligrams per liter]

| CANAL | Station Number | Date of Collection | Specific Conductance 1/ | Temperature (°C) | Dissolved Oxygen | Biochemical Oxygen Demand | Color (PCS) 2/ | Turbidity (JTU) 3/ | pH | Alkalinity as $CaCO_3$ | Nitrogen species: Ammonia ($NH_3$-N) | Nitrite ($NO_2$-N) | Nitrate ($NO_3$-N) | Organic (N) | Total (N) | Phosphorus (P) as P: Ortho-Phosphate | Total Phosphorus | Carbon (C): Organic Carbon | Inorganic Carbon | Total Carbon |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hillsboro | 1 | 24 March 1975 | 420 | 24.0 | 6.1 | 1.9 | 70 | 4 | 7.9 | 256 | 0.06 | 0.01 | 0.02 | 1.1 | 1.1 | 0.02 | 0.05 | 21 | 61 | 82 |
| | | 23 March 1976 | - | 25.0 | 6.3 | 1.3 | 70 | 4 | 7.1 | 253 | .05 | .01 | .02 | 1.1 | 1.1 | .05 | .06 | 19 | 70 | 89 |
| Pompano | 7 | 24 March 1975 | 450 | 26.0 | 10 | 2.2 | 30 | 8 | 8.1 | 197 | .04 | .01 | .03 | .45 | .53 | .01 | .03 | 8 | 49 | 57 |
| | | 23 March 1976 | - | 25.0 | 5.1 | 1.1 | 40 | 6 | 7.2 | 230 | .08 | .00 | .03 | .89 | 1.0 | .08 | .08 | 14 | 63 | 77 |
| Cypress Creek | 10 | 24 March 1975 | 405 | 25.0 | 6.4 | .5 | 50 | 9 | 8.2 | 223 | .06 | .01 | .06 | 1.1 | 1.2 | .10 | .12 | 20 | 53 | 73 |
| | | 23 March 1976 | - | 25.0 | 6.8 | 1.6 | 40 | 3 | 7.5 | 230 | .06 | .01 | .11 | 1.0 | 1.1 | .10 | .10 | 15 | 59 | 74 |
| Middle River | 11 | 24 March 1975 | 580 | 25.0 | 7.7 | 1.4 | 70 | 6 | - | 253 | .05 | .01 | .00 | 1.8 | 1.8 | .02 | .03 | 32 | 54 | 86 |
| | | 23 March 1976 | - | 24.9 | 7.2 | 2.6 | 50 | 5 | 7.6 | 230 | .06 | .04 | .25 | 1.3 | 1.6 | .09 | .09 | 16 | 63 | 79 |
| Plantation | 15 | 24 March 1975 | 460 | 25.0 | 2.9 | 13 | 40 | 4 | 8.5 | 154 | .40 | .04 | 2.2 | 5.6 | 8.2 | 2.2 | 2.2 | 25 | 35 | 60 |
| | | 23 March 1976 | - | 24.0 | 3.0 | 2.6 | 40 | 6 | 7.2 | 184 | .09 | .02 | .79 | 1.3 | 2.2 | 1.2 | 1.2 | 20 | 47 | 67 |
| North New River | 21 | 24 March 1975 | 870 | 25.0 | 9.2 | 0.7 | 70 | 2 | 8.3 | 263 | .05 | .01 | .04 | 1.8 | 1.9 | .01 | .01 | 41 | 61 | 102 |
| | | 23 March 1976 | - | 25.0 | 7.8 | 1.4 | 50 | 2 | 7.9 | 253 | .03 | .01 | .27 | 1.2 | 1.5 | .00 | .01 | 26 | 64 | 90 |
| South New River | 23 | 24 March 1975 | 715 | 25.0 | 5.9 | 2.4 | 80 | 4 | 7.9 | 243 | .06 | .03 | .36 | 1.7 | 2.1 | .13 | .13 | 22 | 61 | 83 |
| | | 23 March 1976 | - | 25.0 | 4.8 | 1.8 | 40 | 4 | 7.6 | 246 | .11 | .04 | .31 | 1.5 | 1.9 | .10 | .12 | - | - | - |
| Snake Creek | 43 | 23 March 1975 | 730 | 25.0 | 5.6 | 1.7 | 60 | 3 | 7.5 | 233 | .02 | .01 | .39 | 1.4 | 1.8 | .01 | .01 | 20 | 70 | 90 |
| | | 23 March 1976 | - | 25.0 | 3.0 | 1.4 | 40 | 4 | 7.5 | 236 | .10 | .00 | .13 | 1.2 | 1.4 | .00 | .01 | 22 | 67 | 87 |

1/ Micromhos at 25°C

2/ Platinum-Cobalt Standard

3/ Jackson Turbidity Units

Table 7.-- Coliform and fecal streptococci bacteria in surface water

[colonies per 100 milliliters]

| Canal | Station Number | Date of Collection | Total Coliform | Fecal Coliform | Fecal Streptococci | FC/FS 1/ Ratio |
|---|---|---|---|---|---|---|
| Hillsboro | 1 | 3-24-75 | 40 | 10 | 14 | 0.71 |
| | | 3-23-76 | 150 | 20 | 30 | .67 |
| Pompano | 7 | 3-24-75 | 160 | 4 | 36 | .11 |
| | | 3-23-76 | 108 | 0 | 16 | - |
| Cypress Creek | 10 | 3-24-75 | 160 | 20 | 28 | .71 |
| | | 3-23-76 | 52 | 2 | 8 | .25 |
| Middle River | 11 | 3-24-75 | 160 | 191 | 56 | - |
| | | 3-23-76 | 290 | 6 | 15 | .40 |
| Plantation | 15 | 3-24-75 | 5800 | 10 | 10 | - |
| | | 3-23-76 | 20000 | 40 | 4900 | .008 |
| North New River | 21 | 3-24-75 | 3600 | 2970 | 350 | 8.49 |
| | | 3-23-75 | 50 | 6 | 10 | .60 |
| South New Creek | 23 | 3-23-75 | 900 | 42 | 28 | 1.5 |
| | | 3-23-76 | 670 | 22 | 56 | .39 |
| Snake Creek | 43 | 3-24-75 | 2600 | 510 | 34 | 15 |
| | | 3-23-76 | 40 | 4 | 6 | .67 |

1/ Fecal coliform - fecal streptococci ratio

The concentration of calcium carbonate ($CaCO_3$) in water determines the degree of hardness. Hardness may range from soft, 0-60 mg/L of $CaCO_3$, to very hard, over 180 mg/L, (Hem, 1970). Limestone of the Biscayne aquifer and limestone exposed to surface water in the canals contribute to the hardness of water in Broward County. Hardness exceeded 180 mg/L at every station but was within normal ranges for surface waters in south Florida (Table 5).

## Nitrogen and Phosphorus

High levels of nitrogen (nitrite, nitrate, and ammonia) 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 is the waste water from sewage treatment plants.

Ammonia nitrogen in water generally originates from decomposition of nitrogenous organic matter. As the initial decomposition product in the complex nitrogen chain, it may eventually oxidize to nitrite and then to nitrate. In surface waters ammonia concentrations are normally 0.1 mg/L or less as nitrogen. Higher levels are usually indicative of sewage or industrial pollution (McKee and Wolf, 1963). The EPA (1973) recommends that ammonia nitrogen ($NH_3$-N) in water supply, not exceed 0.5 mg/L.

Nitrite in water is generally formed by bacterial action on ammonia and organic nitrogen. It is an unstable compound and oxidizes rapidly to nitrate; thus, it is not usually found in high concentrations in water. Like ammonia, the presence of substantial concentrations of nitrite is often an indicator of contamination by organic wastes. The EPA (1973) recommends that nitrite nitrogen ($NO_2$-N) in public water supply not exceed 1 mg/L. Concentrations in untreated water sources are usually less than 1 mg/L as nitrogen.

Nitrate normally does not occur in high concentrations in surface waters because it is readily available for consumption by plants. In canals where sewage effluent is being discharged, it may be present in high concentrations. The EPA (1973) recommends that the nitrate nitrogen ($NO_3$-N) in public water supply not exceed 10 mg/L.

The orthophosphate form of phosphorus is readily assimilated by aquatic plants and bacteria. For this reason orthophosphate concentrations are normally in the range of tenths or hundredths of a milligram per liter in surface waters. Higher concentrations are indicative of contamination by sources, such as sewage wastes or fertilizer runoff, and can result in nuisance blooms of algae as well as accelerated eutrophication rates of lentic waters. The EPA

(1976) does not set criteria for orthosphosphate in streams or flowing waters but suggests a goal of 0.10 mg/L phosphate, as total phosphorus (P), to prevent nuisance growths and control eutrophication.

Concentrations of the nitrogen species did not exceed established criteria and were within ranges normal for south Florida surface waters at all eight stations (Table 6). Orthophoshate levels (as P) were equal to or below 0.10 mg/L at all stations except Plantation Canal (Station 15) where the sample contained 1.2 mg/L orthophosphate.

## 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.

Fecal streptococci are also intestinal bacteria that are more prevalent in warm-blooded animal feces than in human wastes. The ratio of fecal coliform to fecal streptococci (FC/FS) gives an indication of the source of fecal contamination. A ratio greater than 4.0 indicates human contamination. A ratio of less than 0.7 indicates the coliform bacteria are primarily from livestock, poultry, or wildlife wastes. A ratio between 0.7 and 4.0 usually indicates mixed sources of contamination.

The concentrations of coliforms allowed by FDER and EPA depend on the classification and use of the water. The FDER requires that in Class III water (water for recreation and the propagation and management of fish and wildlife), total coliforms are not to exceed 1,000 per 100 milliliters in more than 20 percent of the samples examined during the month. The FDER requirements for surface water to be used for public supply, Class I water, are the same as for Class III water. In surface water to be used as public supply the EPA lists 20,000 total coliforms per 100 milliliters and 2,000 fecal coliforms per 100 milliliters as permissible limits, and 100 total coliforms and less than 20 fecal coliforms per 100 milliliters as desirable limits. The criteria are of value in comparing one water with another insofar as potability is concerned. Fecal streptococci have no established criteria and are used only as an indicator of contamination.

Plantation Canal (station 15) had the highest total coliform count in March 1976 (Table 7). The concentration of 20,000 colonies per 100 milliliters of water at station 15 is the maximum value under EPA criteria. The FC/FS ratio of 0.008 at station 15 indicates contamination from animal wastes other than human.

Total coliforms at the other stations were well below permissible limits. Three of the stations (10, 21, 43) had counts within desirable limits. Fecal coliforms were all within recommended limits, and six stations had counts that were within desirable limits (20 colonies per 100 milliliters or less). FC/FS ratios at all of the stations were less than 0.7.

BOD is a measure of the amount of oxygen consumed by living organisms (mainly bacteria) while utilizing the organic matter present in the water. 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 lowers the DO concentration to levels that are detrimental to plant and animal life. Where reaeration, dilution, or photosynthesis offset or minimize this depletion, BOD does not interfere with reasonable use of the water. The FDER criterion says that BOD should not be altered to exceed values which would cause DO to be depressed below 4.0 mg/L (or 70 percent saturation), unless background data indicate lower values under unpolluted conditions. BOD ranged from 1.1 to 2.6 mg/L at the eight stations in March 1976.

## Dissolved Oxygen

Dissolved oxygen 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 material affect the production and utilization of oxygen. As a result of these physical, chemical, and biological activities, the DO content changes daily and seasonally.

The FDER and EPA established criteria for DO concentration in Class III water. The FDER 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 concentration 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 concentrations in Broward County canals are generally low when water levels and flow in canals are high. During high-flow periods, storm runoff from the Everglades, conservation, agricultural, and urban areas is high in oxygen-consuming materials. DO concentrations are generally highest when canal flow is low. During low-flow periods, submersed plant communities establish themselves and increase the DO concentration. The DO values for March 1976 ranged from 3.0 mg/L to 7.8 mg/L (Table 6) which is a normal range for these canals.

## Pesticides

Pesticides are introduced into the aquatic system by aerial drift of sprays, runoff, or direct application. Pesticide concentrations in water are short lived and reflect antecedent applications. Analysis of pesticides during the 1976 water year was limited to insecticides and polychlorinated biphenyls (PCB) in bottom sediment.

Insecticides used extensively in Broward County are primarily chlorinated hydrocarbons and organophosphates. The most commonly used chlorinated hydrocarbons include the dichloro-diphenyl family (DDT, DDE, and DDD), dieldrin, endrin, chlordane, and toxaphene, while the organophosphates include parathion and malathion. These substances are relatively insoluble in water and are bound to the organic fraction of bottom sediments by ionic attraction, covalent bonding, absorption, and entrapment. Insecticides may enter the food chain and undergo biological magnification and bioconcentration.

During the 1975 water year, 28.7 percent of the insecticide analyses in bottom sediment was positive (Table 8). The range was 0.5 to 370 micrograms per kilogram (ug/kg) with a median value of 5.0 ug/kg. Insecticides were detected at all eight stations. Of the insecticides detected, 92.6 percent, by weight, were chlorinated hydrocarbons and 7.4 percent were organophosphates.

Although the number of positive analyses decreased to 16.2 percent and the median value to 4.0 ug/kg during the 1976 water year, the total concentration of insecticides increased from 494.6 ug/kg in 1975 to 537.1 ug/kg in 1976, an increase of 8.5 percent. Insecticides were not detected at two stations, 15 and 43, but the range increased from 0.5 to 370 ug/kg. Chlorinated hydrocarbons made up 99 percent of the total concentration, by weight, and organophosphates 1 percent.

Table 8.--Concentrations of pesticides in bottom sediment

[micrograms per kilogram]

| CANAL | Station Number | Date of Collection | Aldrin | Chlordane | DDD | DDE | DDT | Dieldrin | Endrin | Heptachlor | Lindane | Toxaphene | Diazinon | Ethion | Malathion | Methyl parathion | Methyl trithion | Parathion | Trithion | PCB 1/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hillsboro | 1 | 04 April 1975 | 0.0 | 1 | 0.5 | 0.5 | 0.3 | 0.4 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| | | 16 April 1976 | .0 | 2 | 1.6 | 1.3 | .0 | .0 | .0 | .0 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 0 |
| Pompano | 7 | 03 April 1975 | 2.0 | 58 | 9.1 | 6.1 | 2.4 | 7.8 | .0 | .0 | .0 | 0 | .7 | 1.4 | .0 | .0 | .0 | .0 | .0 | 17 |
| | | 16 April 1976 | .0 | 370 | 28 | 26 | .0 | 7.3 | .0 | .0 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 180 |
| Cypress Creek | 10 | 03 April 1975 | .4 | 20 | 10 | 10 | 1.6 | 3.5 | .0 | .0 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 0 |
| | | 16 April 1976 | .0 | 17 | 7.6 | 15 | 1.9 | .5 | .0 | .0 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 38 |
| Middle River | 11 | 04 April 1975 | .0 | 34 | 8.8 | 2.9 | 2.0 | 9.6 | .0 | .0 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 52 |
| | | 16 April 1976 | .0 | 21 | .0 | 6.9 | .0 | 1.7 | .0 | .0 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 47 |
| Plantation | 15 | 04 April 1975 | .0 | 130 | 4.2 | 6.2 | .0 | 5.5 | .0 | .0 | .0 | 0 | .0 | 5.7 | .0 | .0 | .0 | .0 | 29 | 46 |
| | | 16 April 1976 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 0 |
| North New River | 21 | 07 April 1975 | 0.0 | 5 | 12 | 11 | .4 | .0 | .0 | .0 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 0 |
| | | 15 April 1976 | .0 | 0 | 2.4 | 1.6 | .0 | .0 | .0 | .0 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 26 |
| South New River | 23 | 03 April 1975 | .0 | 35 | .0 | .0 | .0 | 1.8 | .0 | .0 | .0 | 0 | .0 | 55 | .0 | .0 | .0 | .0 | .0 | 0 |
| | | 15 April 1976 | .0 | 16 | 1.4 | 1.7 | .0 | .6 | .0 | .0 | .0 | 0 | .0 | 5.6 | .0 | .0 | .0 | .0 | .0 | 71 |
| Snake Creek | 43 | 03 April 1975 | .0 | 0 | .5 | .3 | .0 | .0 | .0 | .0 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1 |
| | | 15 April 1976 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 0 |

1/ Polychlorinated biphenyls

PCB are chlorinated hydrocarbon compounds with a variety of industrial uses. Their resistance to decomposition makes them ideal for use in plastic products and as insulator fluid in transformers. They are also used as pesticide extenders to increase the toxicity and effective life of the pesticide. The basic chemical structure of PCB is similar to that of the DDT family.

PCB were detected at five of the eight stations (7, 10, 11, 21 and 23) in 1976, as compared to four stations (7, 11, 15, and 43) in 1975. Total concentration, by weight of PCB in all eight canals, increased from 116 ug/kg in 1975 to 362 ug/kg in 1976 for a net increase of 246 ug/kg or 212 percent. The net percentage value seems significant until compared with the range of detected concentrations for period of record (1969), which is 85 to 631 ug/kg for the eight stations (Waller, and others, 1975), indicating no trend in the data. These values reflect increases or decreases of contaminant inflow into the canal system. Another factor to be considered is flow rate. Low or no flow enhances sedimentation, while rapid flow produces scour carrying the sediment and contaminants downstream.

## SEAWATER INTRUSION

The position and movement of the salt front in the Biscayne aquifer was determined from chloride analysis of water from wells shown in figure 4. Water samples for the chloride analyses were collected monthly during the middle and latter part of the dry season (February-May) and once during the wet season (October).

Chloride analyses were also determined from monthly water samples collected at the salinity control structures and selected sites in the tidal canals (fig. 40). Specific conductance was measured by continuous recorders in three canals near the centers of ground-water withdrawal.

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

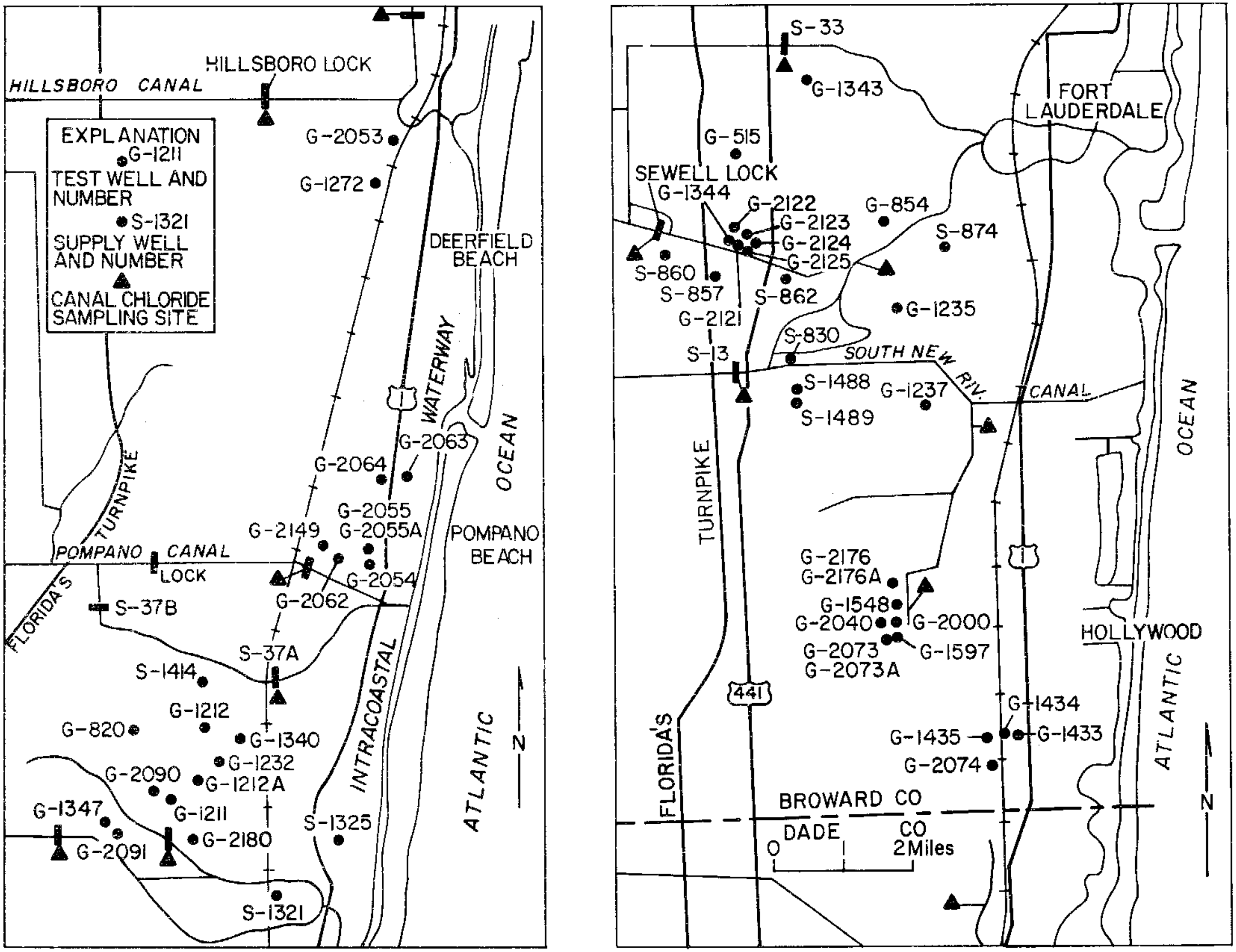



Figure 40.--Locations of wells and canal sites sampled for chloride analysis

Controls have been built on all major canals near the coast to halt upstream movement of seawater and to maintain high freshwater heads to prevent intrusion in the aquifer. However, the controls are 2 to 5 miles from the Intracoastal Waterway. Seawater can move inland that far when water levels and discharge in the canals are low. The chloride concentration of water downstream from the controls in Broward County varies from 45 mg/L to 13,680 mg/L, depending on whether low-water or high-water conditions prevail (fig. 41).

When seawater moves into the uncontrolled reaches of the canal during periods when freshwater levels are low, it also infiltrates the aquifer. The approximate position of the saltwater front is shown on figure 42 for the coastal area of Broward County. The position of the saltwater front is determined by sampling water from test wells for chloride content (fig. 40) near the saltwater-freshwater interface along the coastal areas. The chloride concentration in water from many of the wells varies greatly from low to high-water periods (Table 9). Water from some of the wells increased in chloride and decreased from other wells over the period of record (figs. 43 and 44). The wells with decreasing chloride concentration reflect the effects of better water management resulting from the canal modifications that allow sufficient freshwater levels to be maintained for recharge to the aquifer during the dry season. In the wells yielding water where chloride concentrations have been increasing, water levels have declined.

## WATER USE

All public water supplies in Broward County use ground water. In the vicinity of many of the wells, the aquifer is replenished in part by infiltration from nearby canals. Most domestic suppplies 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, 1973).

In Broward County 32 municipal and privately owned utilities supply a resident population of over 832,000 and a peak tourist season population of over 1,000,000. During 1976 the 13 largest suppliers (Table 10) pumped 49.544 billion gallons or 135.4 million gallons daily for public supply. The average annual pumpage of seven of the major suppliers (fig. 45) has increased by over 140 percent since 1961. Pumpage in 1976 from the seven suppliers shown in figure 45 was 34.530 billion gallons (fig. 46).

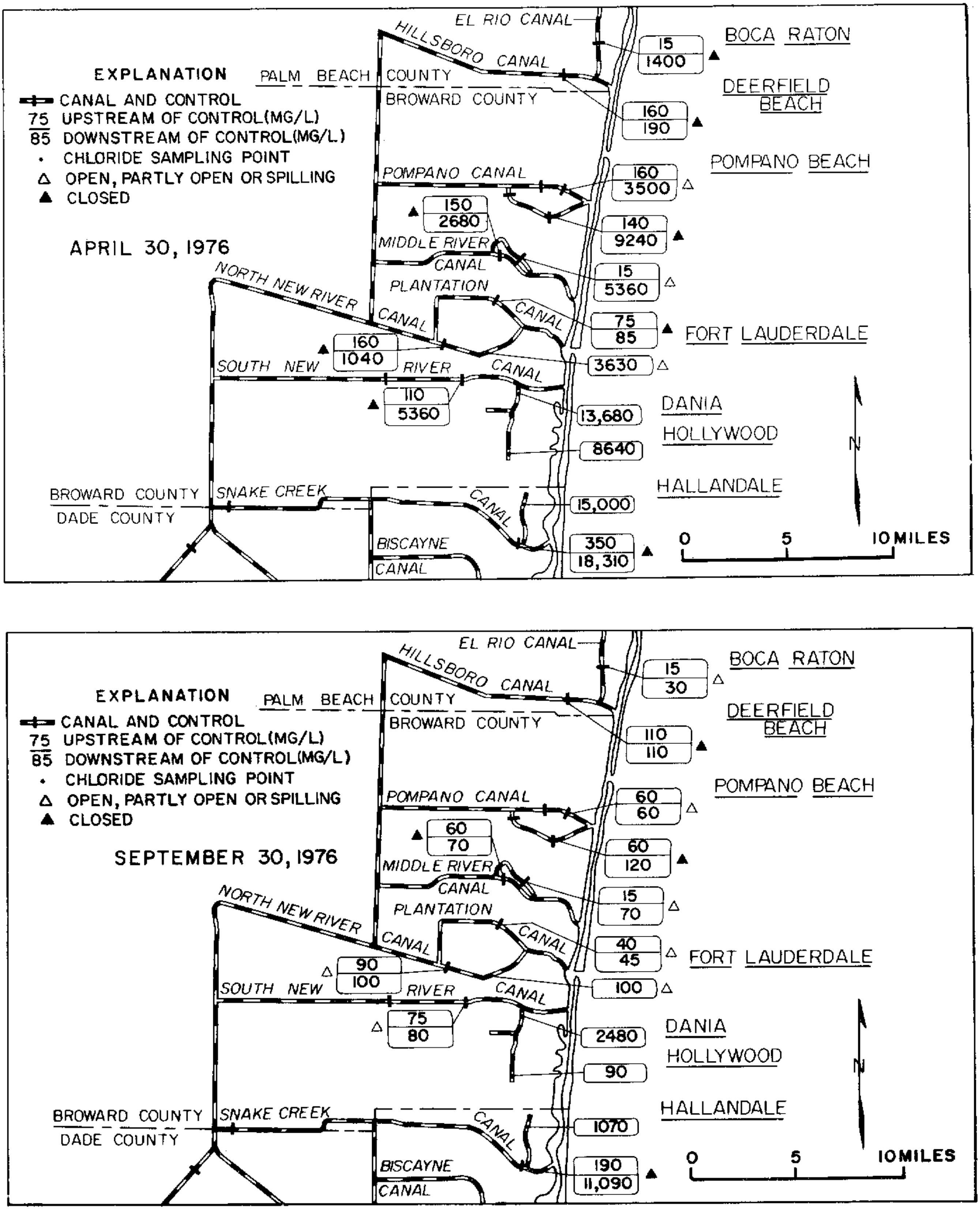



Figure 41.--Chloride concentration in canals at selected sites during low-water conditions, April 30, 1976, and high-water conditions, September 30, 1976

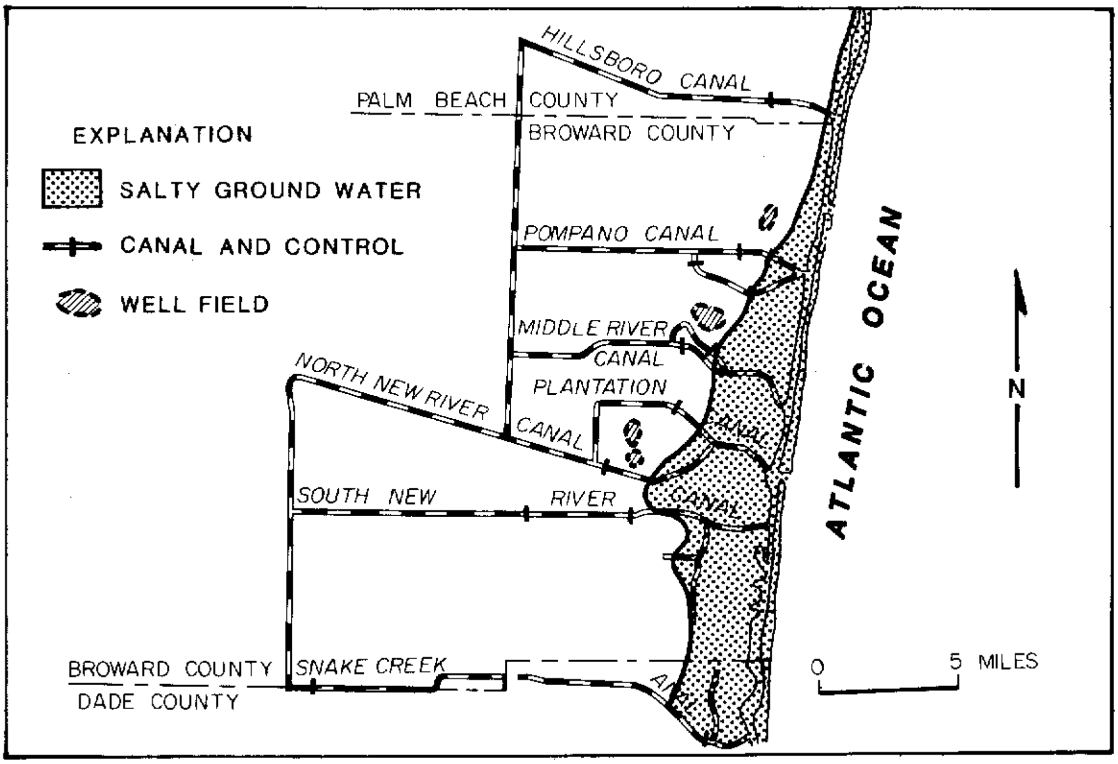



Figure 42.—Extent of seawater intrusion, 1976

Table 9.--Chloride concentrations of water from wells in Broward County

[milligrams per liter]

| Well number 1/ | Chloride concentrations: Low-water conditions 5/5/76 | Chloride concentrations: High-water conditions 10/14/76 | Date record began | Chloride concentrations period of record through 1975: maximum (year) | Chloride concentrations period of record through 1975: minimum (year) |
|---|---|---|---|---|---|
| S-830 | 2750 | 2750 | 10/46 | 3600(46) | 240(58) |
| S-857 | 210 | 73 | 10/46 | 212(75) | 26(49) |
| S-860 | 84 | 85 | 10/46 | 124(51) | 16(48) |
| S-862 | 486 | 484 | 10/46 | 550(75) | 14(53) |
| S-874 | 62 | 54 | 10/46 | 458(46) | 52(63) |
| S-1321 | 66 | 76 | 12/56 | 120(63) | 21(66) |
| S-1325 | 550 | 430 | 12/56 | 600(75) | 18(61) |
| S-1414 | 52 | 62 | 03/59 | 143(62) | 20(61) |
| S-1488 | 25 | 23 | 06/65 | 54(69) | 15(66) |
| G-515 | 700 | 700 | 01/47 | 750(75) | 520(47) |
| G-820 | 20 | 19 | 06/56 | 41(56) | 14(60) |
| G-854 | 1050 | — | 09/59 | 100(75) | 160(59) |
| G-1211 | 18 | 18 | 08/62 | 69(67) | 16(70) |
| G-1212 | 64 | 66 | *03/72 | 110(72) | 56(75) |
| G-1212A | 30 | 31 | 08/62 | 38(69) | 12(62) |
| G-1232 | 16 | 14 | 11/67 | 26(68) | 11(71) |
| G-1235 | 800 | 625 | 11/67 | 880(69) | 432(72) |
| G-1237 | 226 | 254 | 10/67 | 260(69) | 56(72) |
| G-1240 | 226 | 232 | 09/67 | 300(75) | 82(72) |
| G-1272 | 22 | 26 | 11/67 | | |
| G-1340 | 62 | 62 | 02/68 | 177(68) | 60(75) |
| G-1343 | 62 | 55 | 03/68 | 130(70) | 14(72) |
| G-1344 | 310 | 310 | 04/68 | 404(70) | 280(72) |
| G-1347 | 34 | 36 | 04/68 | 37(68) | 22(73) |
| G-1433 | 350 | 322 | 08/69 | 302(75) | 62(72) |
| G-1434 | 4650 | 4750 | 09/69 | 4700(75) | 660(72) |
| G-1435 | 24 | 30 | 09/69 | 60(69) | 24(70) |
| G-1548 | 510 | 488 | 05/71 | 640(73) | 500(75) |
| G-1597 | 418 | 316 | 05/71 | 600(72) | 320(72) |
| G-2000 | 750 | 700 | 05/71 | 750(75) | 210(72) |
| G-2040 | 90 | 83 | 03/72 | 92(73) | 62(72) |
| G-2053 2/ | 1675 | 1150 | 05/72 | | |
| G-2054 2/ | 6250 | 6550 | 05/72 | 5800(75) | 525(74) |
| G-2055 | 10 | 16 | 03/74 | 24(75) | 12(75) |
| G-2055A | 5050 | 5500 | 10/74 | 3900(75) | 580(74) |
| G-2062 | 5900 | 3550 | 10/73 | | |
| G-2063 | 15,250 | 14,550 | 10/73 | 15,800(75) | 8950(74) |
| G-2073 | 184 | 150 | 04/73 | 168(75) | 28(73) |

Table 9.--Chloride concentrations of water from wells in Broward County (Cont'd)

| Well number1/ | Chloride concentrations Low-water conditions 5/5/76 | Chloride concentrations High-water conditions 10/14/76 | Date record began | Chloride concentrations period of record through 1975 maximum (year) | Chloride concentrations period of record through 1975 minimum (year) |
|---|---|---|---|---|---|
| G-2073A | 144 | 50 | 11/74 | 166(75) | 36(74) |
| G-2074 | 3350 | 2650 | 05/73 | 2800(75) | 12(75) |
| G-2090 | 40 | 70 | 10/74 | 76(75) | 62(75) |
| G-2091 | 54 | 52 | 10/74 | 62(74) | 52(75) |
| G-2121 | 316 | 328 | 05/74 | | |
| G-2122 | 33 | 36 | 05/74 | | |
| G-2123 | 82 | 74 | 05/74 | | |
| G-2124 | 18 | 17 | 05/74 | | |
| G-2125 | 34 | 36 | 05/74 | | 16(75) |
| G-2149 | 54 | 44 | 10/74 | 47(75) | 24(75) |
| G-2176 | 214 | 188 | 11/74 | 300(75) | 196(74) |
| G-2176A | 32 | 30 | 11/74 | 32(75) | 22(75) |
| G-2180 | 102 | 54 | 11/74 | 306(74) | 10(75) |

*deepened from 181 to 230 feet in 1972

1/ for location of wells see figure 4

2/ wells lost but recovered in 1974

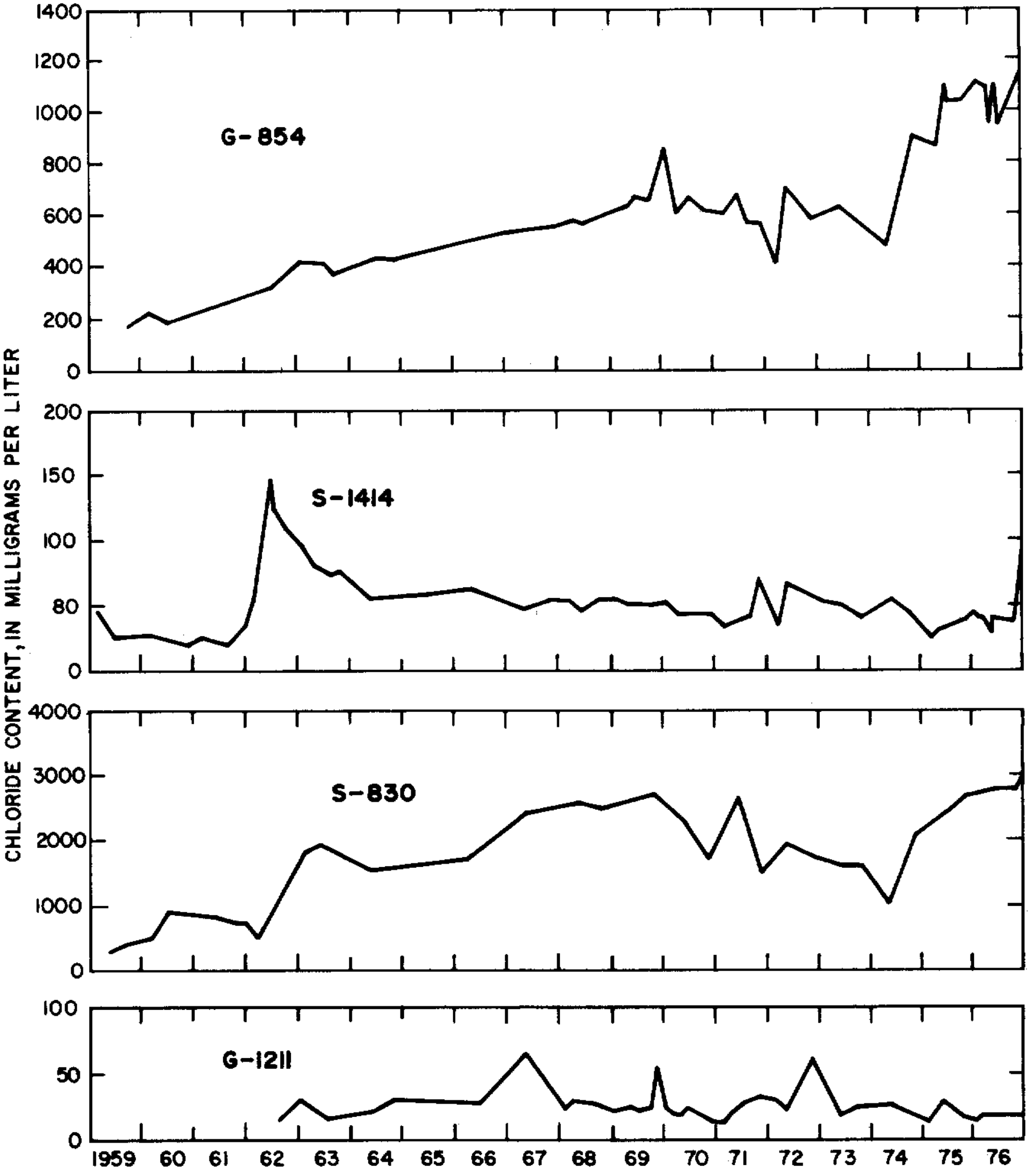



Figure 43.--Chloride concentrations of water in wells G-854, S-830, and G-1211 in Broward County

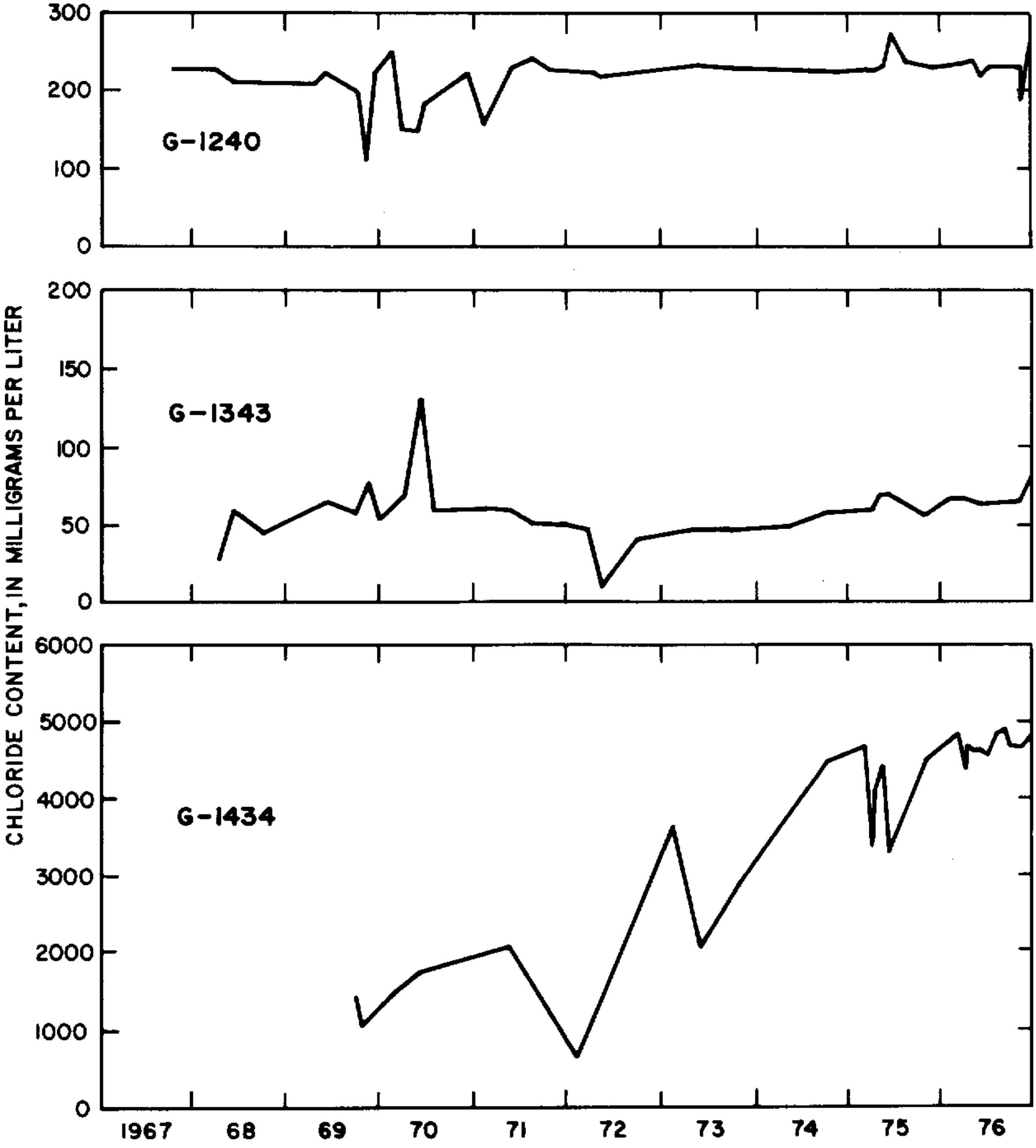



Figure 44.--Chloride concentrations of water in wells G-1240, G-1343, and G-1434 in Broward County

Table 10.—Treatment capacity, number of supply wells, and pumpage for the major water suppliers in Broward County during 1976

| City | No. wells | Treatment capacity (mgd) | Pumpage - 1976 total (mg)* | Pumpage - 1976 Daily average (mg)** |
|---|---|---|---|---|
| Fort Lauderdale | 59 | 60 | 17,551 | 48.0 |
| Broward County (Systems 1-5)1/ | 37 | 33.2 | 6673 | 18.2 |
| Coral Springs1/ | 8 | 5.3 | 649 | 1.8 |
| Dania | 2 | 3.02 | 500 | 1.4 |
| Deerfield | 15 | 12 | 2357 | 6.4 |
| Hallandale | 8 | 7.7 | 1903 | 5.2 |
| Hollywood | 20 | 20 | 5100 | 14.0 |
| Lauderhill | 7 | 11 | 1617 | 4.4 |
| Margate1/ | 8 | 10 | 2215 | 6.0 |
| Miramar | 9 | 6.3 | 890 | 2.4 |
| Plantation1/ | 8 | 7 | 2042 | 5.6 |
| Pompano Beach | 16 | 30 | 6230 | 17.0 |
| Sunrise1/ | 22 | 13.5 | 1817 | 5.0 |
| | | TOTAL | 49,544 | 135.4 |

1/ not included in figure 48 due to short period of record

*million gallons

**million gallons daily

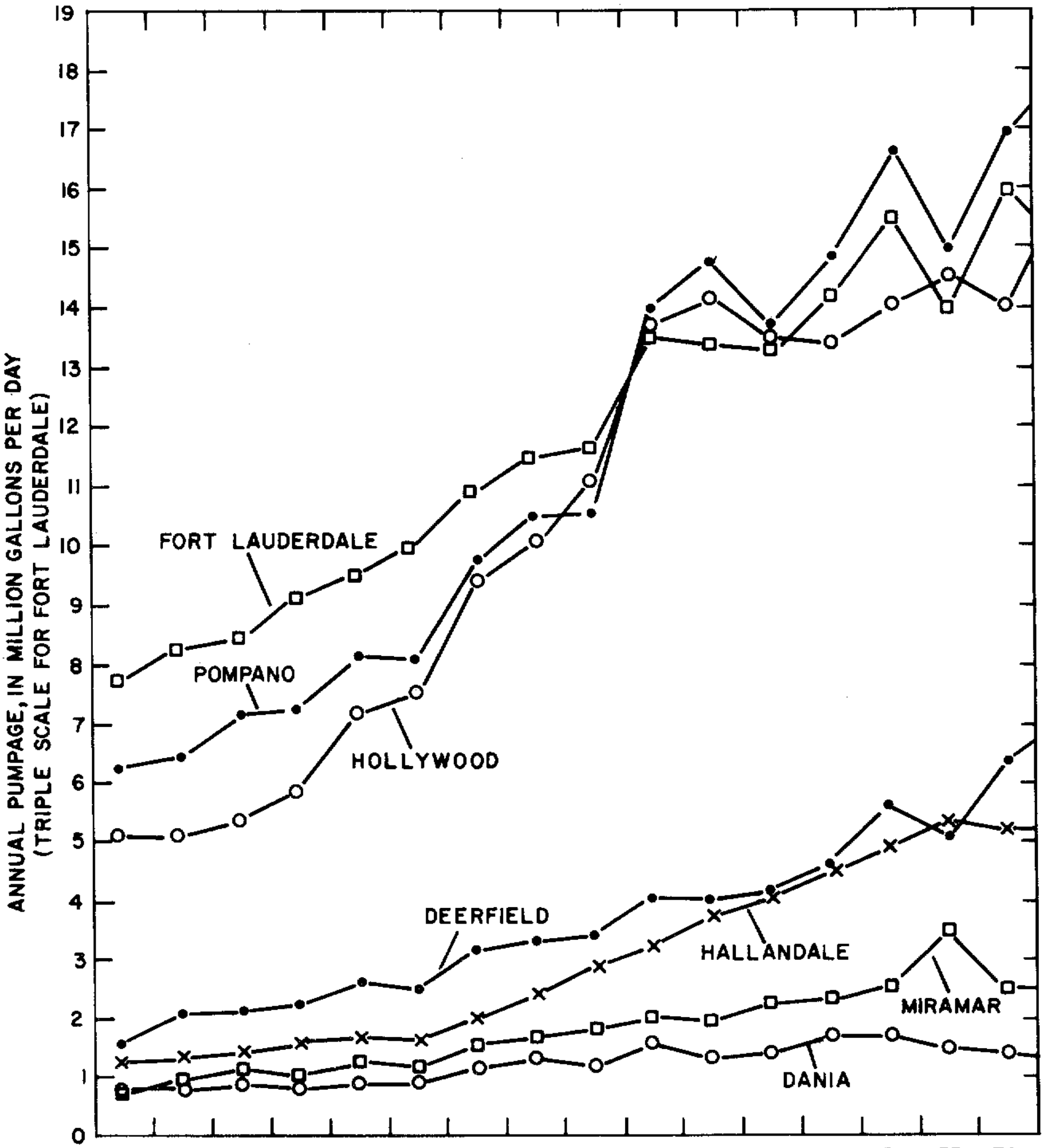



Figure 45.--Annual pumpage from selected city supply wells, 1961-76

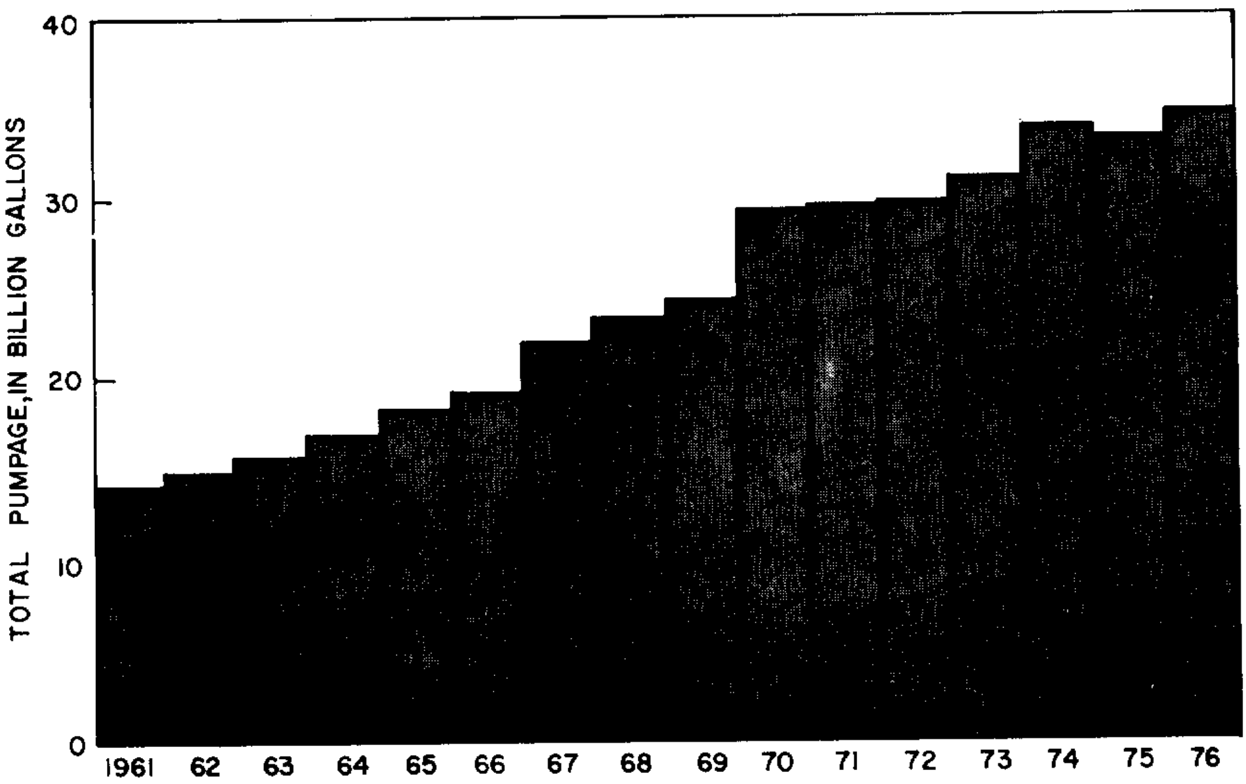



Figure 46.—Annual pumpage from the Fort Lauderdale, Hollywood, Pompano, Hallandale, Deerfield Beach, Dania, and Miramar municipal wells, 1961-76

The water system of Fort Lauderdale, the largest in Broward County, has a treatment capacity of 60 Mgal/d. The average demand in 1976 was 48.2 Mgal/d, but the demand exceeded 60 Mgal/d in March and April, a period during which rainfall was deficient (fig. 47). Monthly pumpages at Fort Lauderdale are generally highest during the dry season (December-May) because of heavy water use for lawn irrigation and increased demands caused by the influx of tourists.

## SUMMARY

Flows in the primary canals of Broward County are regulated by the SFWMD to obtain optimum seasonal ground-water levels and storage and to provide flood protection. A series of secondary canals in the county are regulated by the Broward County Water Resources Department. The agencies work together to effectively manage the county water resources.

Rainfall is the major source of recharge to the Biscayne aquifer and surface-flow system in Broward County. The average water-year rainfall in Broward County, based on 33 years of record at two coastal and an inland station, is 57.35 inches. There was 55.28 inches of rainfall for the 1976 water year.

Infiltration of rainfall through surface materials and seepage from controlled canals and the conservation areas constitute the recharge to the aquifer. 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, areawide water levels fluctuate chiefly in response to variations in rainfall. Rainfall during the 1976 water year was 3.6 percent below average. Consequently, water levels were slightly below average during most of the year. Water levels in the Pompano Beach and Dixie well fields were lower during the peak of the 1976 dry season than the peak of the record dry season in 1971.

Water management in Broward County depends on the SFWMD 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 to maintain high freshwater heads to prevent saltwater intrusion. During droughts, Broward County's freshwater supply chiefly depends on releases into the major canal network. Flow was variable in the major canals during the 1976 water year when compared to the 1962-75 averages. Cypress Creek, Middle River, and Snake Creek Canal at S-29 had greater flow than the 1962-75 averages. Flows in Plantation Canal and South New River Canal were equal to the 1962-75 average, while Hillsboro, North New River Canal, and Snake Creek Canal at N.W. 67th Avenue had flow below the long-term averages.

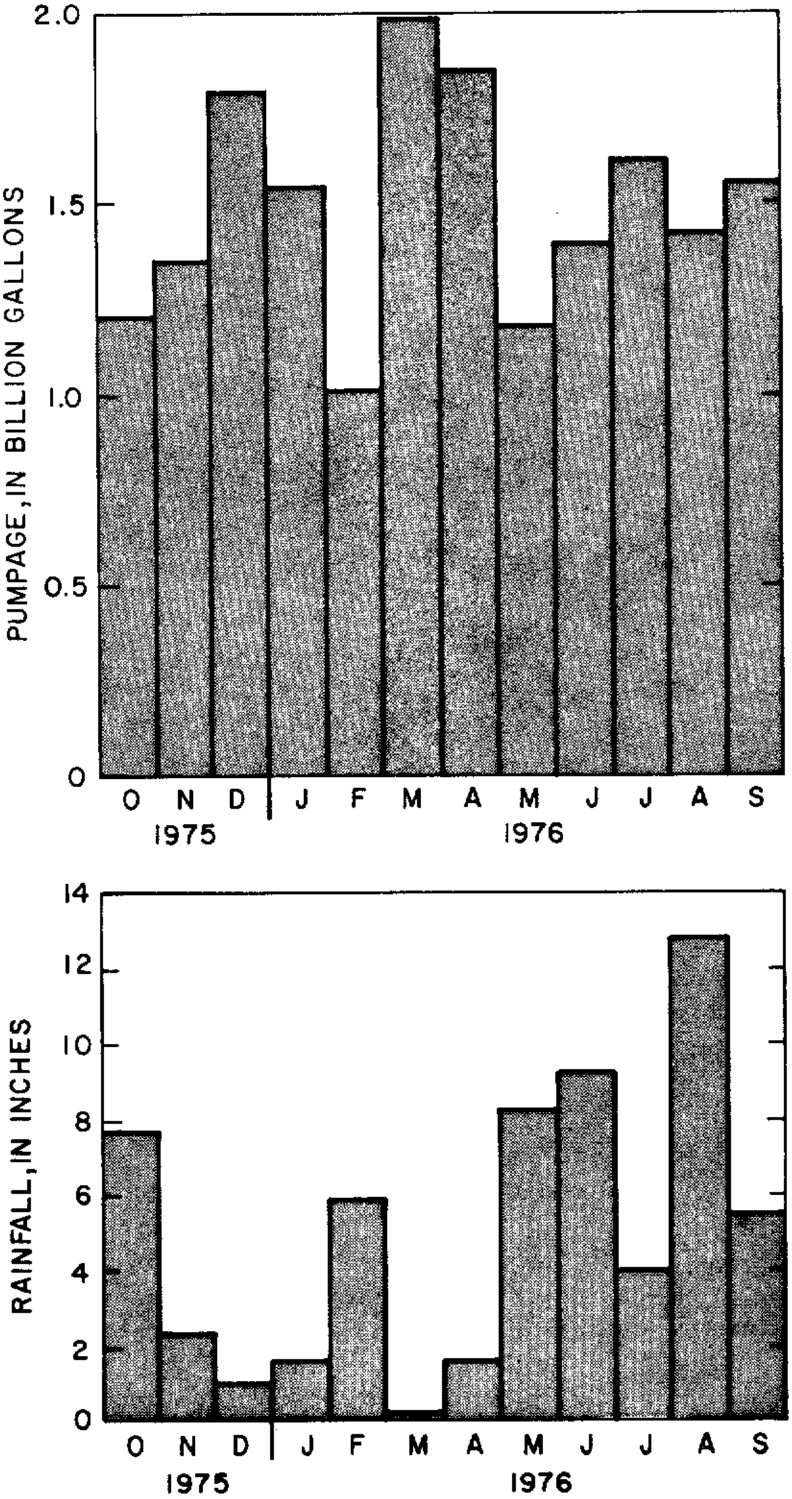



Figure 47.—Monthly pumpage from the Fort Lauderdale Dixie and Prospect municipal wells, and monthly rainfall at Fort Lauderdale, 1976 water year

The concentrations of principal mineral constituents in surface water in Broward County were within limits established by Florida State Water Standards (with the exception of iron at one station). The chief threat to surface-water quality in urban areas is man-made contamination. Typical indicators of man-made contaminants are nitrogen and phosphorus, bacteria, and pesticides. Bacteriological parameters included BOD and total and fecal coliforms and are probably the best indicators of contamination. Total coliforms were equal to or within permissible limits for Class III water and water for public supply in Broward County canals at all sites during the 1976 water year. Fecal coliform did not exceed the permissible limit for public water supply at any of the sites during the 1976 water year.

All public water supplies in Broward County are pumped from wells in the Biscayne aquifer. There are 32 municipal and privately-owned utilities in Broward County supplying a resident population of over 832,000 and a peak tourist season population of over 1,000,000. During 1976 the 13 largest suppliers pumped 49.544 billion gallons (135.4 million gallons daily).

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