PRELIMINARY REPORT ON THE SEVERE STORM OF APRIL 24-25, 1979

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

MAY 17, 1979

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FOREWORD

Over the past twenty-five years the District has established the procedure of reporting on, and analyzing unusual meteorological occurrences affecting the District area and District works. Several such reports have been prepared in the past, including the September 1960 report on Hurricane Donna and subsequent tropical storm Florence, and in 1964 the report on Hurricane Cleo. The purpose of these reports is to document and record pertinent facts regarding these occurrences which might not be otherwise available from any single source.

I. DESCRIPTION OF THE METEOROLOGICAL EVENT

On April 24 and 25, 1979 a spring storm with very high rainfall intensity deposited large amounts of precipitation on portions of the Lower East Coast of Florida. Available data suggest that during the early morning hours of April 25, 1979 rainfall intensities may have exceeded the highest rates previously recorded in portions of Dade, Broward and southern Palm Beach Counties. At the Miami International Airport Weather Bureau Station, a new maximum 24 hour rainfall record of 16.39 inches was established. This exceeded the previous maximum which was recorded on November 30, 1925 by 1.52 inches.

The storm of April 25 gave very little warning of its severity. The following synopsis of the teletype releases from the National Weather Service (NWS) gives an indication of the information the District had available from which to make operational decisions.

On the morning of Tuesday, April 24 a broad trough of low pressure over the eastern Gulf of Mexico and a large high pressure system over the western Atlantic were producing strong southeast winds and light rain over most of the state. Since these weather systems were nearly stationary on Tuesday morning, a "rainy and windy period" was forecast "through Wednesday."

By Tuesday at 5:00 P.M., radar showed all of the Florida peninsula south of a Ft. Myers to Vero Beach line covered with rain, light (less than 0.1 inches per hour) over the eastern half of the peninsula and moderate (from 0.1 to 0.3 inches per hour) over the western half. The National Weather Service (NWS) interpretation was that the intensity trend was unchanging and the movement was to the north at 25 knots.

By 4:00 A.M. on Wednesday NWS indicated that the intensity had increased during the night and that some stations had reported "more than 2 inches." Additional rain was forecast but in decreasing amounts. By 4:30 A.M. imbedded heavy thunderstorms were increasing in Florida Bay, the upper Keys, and the Everglades of western Dade County. A large rain area covered the area south and east of Lake Okeechobee, and east to the Bahamas. The storm area was moving north at 30 miles an hour.

By 5:00 A.M. rainfall in excess of 4 inches was reported to have occurred in many areas with the likelihood of further accumulation by daybreak. Radar indicated some very heavy thunderstorms over western Dade County moving towards the north. Street flooding was reported in the vicinity of Dadeland, and travelers were warned of flooding in low lying areas, but the rains were predicted to taper off by late morning or early afternoon.

By 5:30 A.M. imbedded heavy thunderstorms were reported to be continuing in south Broward and Dade Counties, and moving north at 30 miles an hour.

At 6:30 A.M. a radar summary was again issued by NWS noting heavy thunderstorms imbedded in a large rain area. The heaviest rainfall was noted as being east of Palm Beach to just west of Hollywood and south of Perrine.

At 7:00 A.M. it was reported that 16.39 inches of rain had fallen at the Miami NWS station in the preceding 24 hour period, but with over 14 inches between 1 and 7 A.M.

Heavy rainfall reports continued in the early morning, but by 10:00 A.M. NWS indicated that the low pressure area which had produced the record rainfall had moved northward and that the rain would gradually taper off.

Nevertheless, at 11:45 A.M. additional severe weather statements were issued indicating severe thunderstorms along the southeast coast but moving off the coast of Dade and Broward Counties. By 2:00 P.M. most of the rain activity had indeed moved offshore, though isolated thunderstorms were occurring into the evening along the Kissimmee River and between Lake Okeechobee and Ft. Myers.

The following paragraphs, supplied by the NWS, describe the meteorological events which gave rise to the storm conditions:

Upper Air Pattern The 500mb mean trough position was located in the Gulf of Mexico. A short wave trough moving out of Texas on April 23 caused the Gulf of Mexico trough to amplify during April 24 and April 25. The trough was moving eastward about 10 mph.

Surface Pressure Pattern Amplification of the 500mb trough caused a low pressure center to form over the Yucatan channel about 7 A.M. EST April 24. This low pressure center was not a tropical storm since it did not have a warm core and wind speed maxima were not concentrated near the center. Behaving like an extratropical low pressure system, the low moved northnortheast about 20 mph, reaching the Apalachicola area by 7 A.M. EST April 25.

Weather Relationships On April 23, satellite photographs showed a 300-mile wide area of clouds and possible rain in the western Gulf of Mexico that extended eastward from the 500mb troughline. This was a typical relationship in which clouds and precipitation are favored between the 500mb trough and downstream ridge line.

On April 24, the area of clouds and possible rain advanced into the eastern Gulf of Mexico and spread into Florida. The weather was located to the east of the 500mb trough and to the right of the path along which the surface low pressure center moved. Again, this weather pattern has been observed many times in conjunction with Florida rainfall.

Two of the strongest areas of convection (probably thunderstorms) were identified on the satellite photographs at 7 A.M. April 24. One was a line 250 miles long and 60 miles wide, and it was located about 300 miles west of Tampa. This area of convection was in response to upward vertical motions caused by the northnortheast movement of the low pressure center.

The second area of convection and possible thunderstorms at 7 A.M. EST was located about 250 miles southwest of Miami. Although irregular in shape, it had an average diameter of about 180 miles. By 7 A.M. EST April 24, this area of convection was in the Straits of Florida moving eastward 15 mph, but its size had shrunk by 50%. In the meantime new, small areas of convection had developed over portions of Collier County, to low level converging air flow over South Florida. By 7:30 A.M. EST April 25, the heaviest convection was moving off the southeast coast of Florida.

Between 5 P.M. EST and 11 P.M. EST April 24, NWS radar indicated light to moderate rain in Dade and Broward Counties. Hourly rainfall rates fell into the category of .2 inch to 1.1 inch per hour.

Rainfall rates increased after midnight. At 1:30 A.M. April 25, radar suggested a 45% probability that 5 inches of rain had fallen in the past 3 hours. At 04:30 A.M. EST, radar suggested a 50% probability that 5 inches had fallen in the past 3 hours. At 7:30 A.M. EST, radar suggested a 50% probability of 5 inch rains in the past 3 hours.

Locally heavy rainfall in Florida is related to the position and strength of the subtropical jetstream at about 40,000 ft and to low level converging air flow. At 7 P.M. EST April 24, low level winds were converging over Collier and Dade Counties. From 7 P.M. April 24 to 7 A.M. April 25 the subtropical jet with 70 knot winds moved eastward from the Yucatan channel - Apalachee Bay line to Naples - Orlando Line. These conditions enhanced upward vertical motions, condensation, and precipitation.

II. RAINFALL CHARACTERISTICS OF THE EVENT

The areas of highest rainfall intensity for April 24 and 25 occurred on the developed eastern areas of Dade, Broward and southern Palm Beach Counties. Rainfall in excess of 10 inches was reported in a strip from the western portions of Miami to Miami International Airport north through most of Broward County to southern Palm Beach County, and north to Lake Worth. A pocket in excess of 10 inches also occurred in the Homestead Area.

The highest rainfall quantity for this period, 18.83 inches, was reported several miles west of Delray Beach at a cooperative SFWMD gaging station.

Broward County received the heaviest, wide-spread rainfall with all but one station (currently available) reporting in excess of 9 inches. At the District's Broward County Field Station on April 24 and 25, 12.48 inches of rainfall was recorded, while nearby Sewell Locks received 12.66 inches. The highest rainfall in Broward County, 17.69 inches was recorded at the Deerfield Locks on the Hillsboro Canal. The S-9 Pump Station, adjacent to the Conservation Areas, received 9.10 inches. The least amount of rain recorded in the county was 5.11 inches at the Bahia Mar Marina near Port Everglades in Fort Lauderdale.

Although thunderstorms produced extremely high intensity rainfall in portions of Dade County, rainfall distribution was not uniform. Several stations within a few miles of Biscayne Bay reported between 4 and 5 inches. Miami Beach reported less than 2 inches for this period.

Most rainfall stations east of the Conservation Area levees and south of the West Palm Beach Canal reported in excess of 4 inches. Although portions of Conservation Areas I and II received over 6 inches of rainfall, rainfall in the Everglades Agricultural Area was relatively light.

To illustrate the areal distribution of rainfall, isohyetal maps were produced for the April 24-25, 1979 storm based on 84 rainfall stations within the Lower East Coast area. Figure 1 shows the isohyetal map of 1 day rainfall for April 25, 1979. The two day rainfall isohyetal map of April 24 and 25, 1979 is shown in Figure 2.

Tabulated rainfall values (Provisional Data) are presented in Table 1.

To evaluate the return frequency of rainfall associated with this storm event, a series of isohyetal maps were prepared for maximum 1-day and 2-day durations. These historical isohyetal frequency maps were based on rainfall values from climatological records of available rain gauges. Annual maximum 1-day and 2-day rainfall values in 26 rainfall stations within the Lower East Coast area were used in the analysis. All these selected stations have at least 20 years of daily rainfall records. The Log-pearson Type III Distribution was applied to estimate the depth-durations for 25, 50, 100, 200 and 1000 year return occurrences. The results are presented in Appendix I.

Since the distribution of rainfall for this storm event varied over the Lower East Coast area, the return-frequency occurrence also varied. The areas of particularly intense rainfall are identified as follows:

1. Rainfall in the area south of Boynton Beach through the southern limits of Delray Beach and east of the Florida Turnpike was of a 1 in 100 year frequency.

2. The area immediately west of the Florida Turnpike and within five miles north of Hillsboro Canal together with the area south of the canal including Coral Springs, Margate, and vicinity was subjected to a 1 in 50 to 1 in 100 year frequency storm. The rest of southern Palm Beach County east of Conservation Area I was subjected to an approximately 1 in 50 year frequency storm.

3. The area around Cooper City, Davie, Pembroke Pines, etc., experienced a 1 in 100 year frequency storm.

4. The area around Miami Springs, Miami International Airport, Coral Gables, etc., had a 1 in 100 to 1 in 200 year frequency storm. However, the area along the coast near Biscayne Bay had much less rainfall, on the order of a 1 in 10 year or greater frequency storm.

5. The area around Homestead had a 1 in 50 to 1 in 100 year frequency rainfall, although over a relatively limited area.

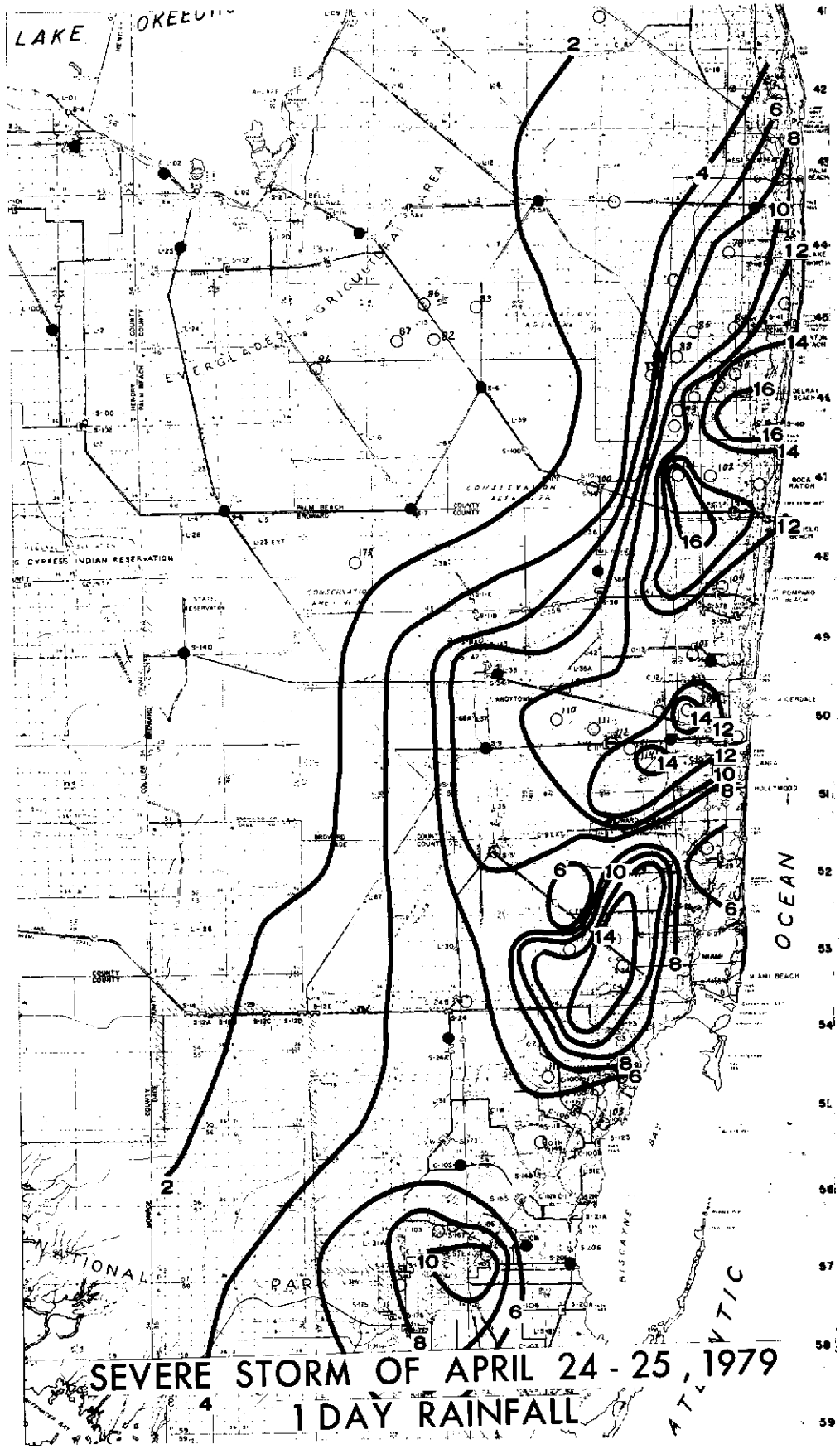

LAKE
EVERGLADES
AGRICULTURAL AREA
CONSERVATION AREA
OCEAN
ATLANTIC
NATIONAL PARK
2
4
6
8
10
12
14
16
SEVERE STORM OF APRIL 24 - 25, 1979
1 DAY RAINFALL

FIGURE 1

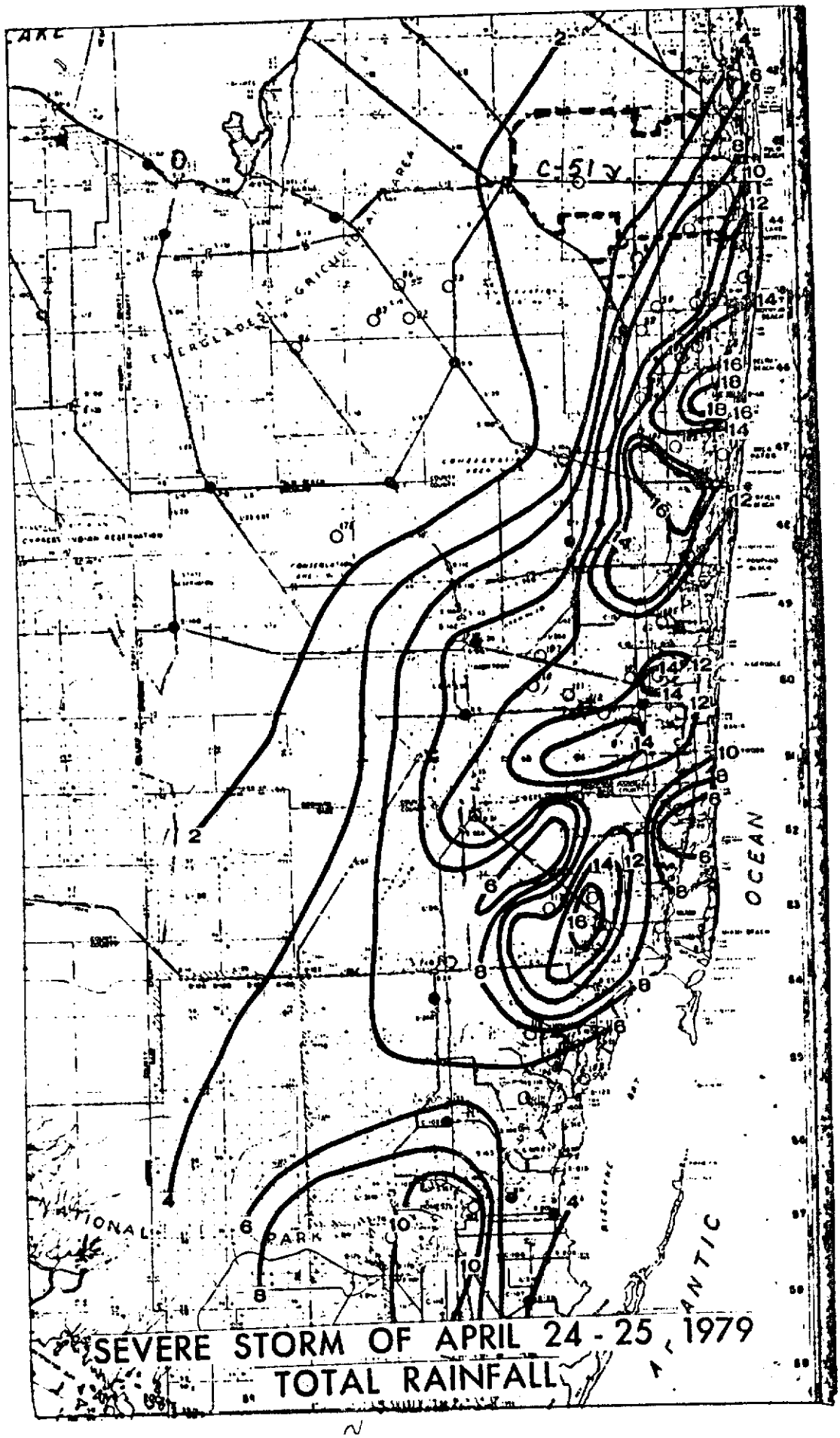

C-51
EVERGLADES AGRICULTURAL AREA
OCEAN
ATLANTIC
NATIONAL PARK
SEVERE STORM OF APRIL 24 - 25, 1979
TOTAL RAINFALL

FIGURE 4.

TABLE 1

RAINFALL ANALYSIS

Station	Station No.	Apr. 24	Apr. 25	Apr. 26	Apr. 27	Total 4 Days	Total Apr.'79
WPB F/S	WM077	0.74	3.52	0.00	0.00	4.26	4.26
Greenacres	WM078	0.04	8.30	0.00	0.00	8.34	n/r
Boynton Rd & Mil.	WM084	t'	9.32	0.00	0.00	9.32	n/r
Boynton Rd & E2	WM085	0.01	8.10	0.00	0.00	8.10	n/r
Lat 28 & Rangeline	WM088	0.08	8.40	0.00	0.00	8.48	n/r
1-8	WM089	0.96	5.21	0.00	0.00	6.17	6.90
S-6	WM095	0.06	1.61	0.00	0.00	1.67	2.20
Lat 30 & Office	WM090	0.05	14.09	0.00	0.00	14.14	n/r
Delray Rd & E2	WM092	0.06	12.86	0.00	0.00	12.92	n/r
S-8	WM098	t'	2.37	0.35	0.00	2.72	2.72
Lat 32 & Rangeline	WM093	0.08	10.06	0.00	0.00	10.14	n/r
S-7	WM099	0.00	1.75	0.75	0.75	3.25	3.33
S-39 Lox Recreation	WM100	0.00	2.01	0.00	0.00	2.01	2.22
Boca Rd & Rangeline	WM101	t'	17.50	0.00	0.00	17.50	n/r
Boca Rd & Powerline	WM102	0.00	12.50	0.00	0.00	12.50	n/r
S-36	WM105	0.72	10.43	0.00	0.00	11.15	11.15
3-26	WM106	1.15	8.43	0.00	0.00	9.58	12.30
Dixie Water Plant	WM108	1.20	14.59	0.00	0.00	15.79	19.47
Sewell Lock	WM109	0.00	10.42	2.24	n/r	12.66	14.78
Carroll Ranch	WM110	n/r	10.12	n/r	n/r	10.12	n/r

TABLE 1

RAINFALL ANALYSIS

Station	Station No.	Apr. 24	Apr. 25	Apr. 26	Apr. 27	Total 4 Days	Total Apr.'79
S-13	WM113	0.38	10.15	0.00	0.00	10.53	10.53
Gill Realty	WM114	n/r	14.00	0.01	0.00	14.01	16.28
S-9	WM115	1.00	8.19	0.00	0.00	9.19	9.19
Miami F/S	WM117	0.00	11.64	0.73	0.00	12.37	12.41
Homestead F/S	WM121	0.00	11.04	0.47	0.00	11.51	11.56
Deerfield Lock	WM141	0.02	15.00	2.10	n/r	17.12	17.12
S-140	WM145	0.96	1.14	0.00	0.00	2.10	2.15
Ft. Laud. F/S	WM151	0.00	12.33	0.42	n/r	12.75	15.12
CA-3 N/W	WM173	0.70	1.59	0.00	0.00	2.29	2.29
CA-3 N/E	WM174	0.78	1.90	0.00	0.00	2.68	3.70
CA-3 South	WM175	1.20	0.79	0.00	0.00	1.99	2.05
CA-3 S/W	WM202	1.97	3.95	0.00	0.00	5.92	7.67
Weyrahauser	WM204	0.02	4.95	0.00	0.00	4.97	n/r
Jupiter Fire Sta.	WM208	0.30	2.11	1.39	t'	3.80	n/r
Adams Property	WM209	0.01	9.69	0.41	0.00	10.11	11.46
Military Tr/& L-38	WM212	0.03	18.80	0.00	0.00	18.83	n/r
Rangeline Lat. 39	WM213	0.28	14.40	0.00	0.00	14.68	n/r
S-5A	WM220	0.07	2.40	0.10	0.00	2.57	2.65
E-1 & Lk. Worth Rd.	WM081	0.28	4.58	0.00	0.00	4.86	n/r

TABLE 1

RAINFALL ANALYSIS

Station	Station No.	Apr. 24	Apr. 25	Apr. 26	Apr. 27	Total 4 Days	Total Apr.'79
Greynold Park	DC3		6.40	Reflects 24 hour total April 24 & 25		6.40	n/r
Wheeler Frye	DC8		11.50	"	"	11.50	13.03
Clark	DC10		15.75	"	"	15.75	n/r
Hud No. 1 Plant	DC17		7.00	"	"	7.00	n/r
Stonebreaker	DC18		4.50	"	"	4.50	n/r
Skylake STP	DC28		7.00	"	"	7.00	n/r
Adventura STP	DC30		5.50	"	"	5.50	n/r
Miami 12SSW	DC42		4.40	"	"	4.40	n/r
Opa Locka Water Plant	DC69		13.00	"	"	13.00	n/r
58 Street Yard	DC73		12.00	"	"	12.00	n/r
Lorin Cope	DC83		8.00	"	"	8.00	9.16
Fla. Div. of Forestry	DC92		5.00	"	"	5.00	n/r
Goulds Pervine Water	DC94		5.50	"	"	5.50	n/r
Miami Fire Sta. #9	DC102		4.92	"	"	4.92	n/r
Miami Utilities	DC99		7.00	"	"	7.00	n/r
Coral Sprgs. Water Plant	A3	.04	8.84	2.80	0.00	11.68	12.80
Deerfield Water Plant	A1	1.65	12.32	0.00	0.00	13.97	14.62
Pompano Water Plant	A2	0.60	10.28	0.00	0.00	10.88	11.81
Five Ash Water Plant			8.10	n/r	n/r	8.10	n/r
Hollywood Water Plant	A4	1.20	11.36	0.00	0.00	12.56	17.67

TABLE 1
RAINFALL ANALYSIS

Station	Station No.	Apr. 24	Apr. 25	Apr. 26	Apr. 27	Total 4 Days	Total Apr.'79
Hollywood Waste Water Plant	A5	.18	6.30	0.00	0.00	6.48	10.62
Margate Water Plant			14.62	n/r	n/r	14.62	n/r
NW 2nd Ave. Glades Rd. Water Plant			12.50	n/r	n/r	12.50	n/r
Lantana Fire Station		0.03	13.16	0.02	0.00	13.21	16.64
Merimar Water Plant			12.10	n/r	n/r	12.10	n/r
Homestead Exp. Sta.	WB4091	2.91	8.09	1.10	0.75	12.85	12.88
Hialeah	WB3909	0.00	16.39	0.68	0.00	17.07	n/r
Miami WSO AP	WB5663	1.39	14.85	0.00	0.00	16.24	17.29
Miami 12SSW	WB5678	3.47	.88	0.00	0.00	4.35	6.40
WPB WSO AP	WB9525	1.04	6.49	0.00	0.00	7.53	8.71
CON-62		0.00	1.20	0.00	0.00	1.20	2.32
CON-63		1.08	4.20	0.00	0.00	5.28	5.28
CON-64		1.40	1.50	0.00	0.00	2.90	5.44
CON-65		n/r	2.80	0.00	0.00	2.80	5.88
CON-111		1.00	6.48	0.00	0.00	7.48	8.00
CON-159		n/r	n/r	n/r	n/r	n/r	n/r
CON-160		.96	1.52	0.00	0.00	2.48	4.48
Barwick		n/r	18.50	n/r	n/r	18.50	n/r
Swinton & 8th St.		n/r	10.20	n/r	n/r	10.20	n/r

TABLE 1
RAINFALL ANALYSIS

Station	Station No.	Apr. 24	Apr. 25	Apr. 26	Apr. 27	Total 4 Days	Total Apr.'79
S-194	WM120	1.50	5.33	0.00	0.00	6.83	n/r
S-20	WM123	1.85	1.83	0.00	0.00	3.68	n/r
S-18C	WM124	3.30	7.74	0.00	0.00	11.04	n/r
Krome Ave. Missle Site	WM201	0.85	4.55	1.92	0.05	7.37	n/r
Pennsuco	WB6988	2.10	8.50	0.00	0.00	10.60	n/r
Chekika		Only 4-day total reported				11.20	n/r

n/r - means not recorded

III. APPRAISAL OF CONDITIONS

A. Operations

Because of the drought condition, discharges were being made from Lake Okeechobee and the Conservation Areas prior to the storm. Since no indication of the severity of the impending storm was received, several water supply gate openings were retained through the night of April 24. Because of the light rain on the 24th, however, the discharge from the Lake through the hurricane gates was terminated on that date.

The heaviest rainfall occurred between midnight and 7:00 A.M. of April 25. This was especially true in the areas of maximum total rainfall. Nevertheless, before 7:00 A.M. the superintendents at the Homestead, Miami and Ft. Lauderdale Field Stations were aware that a severe event was occurring and were already taking appropriate action. District headquarters was notified and by 7:00 A.M. the newly installed Communications and Control System (C&CS) was proving its worth by scanning the water conditions throughout the entire area of the flood event. Early action included dispatching field crews to close the gates discharging from the Conservation Areas to the East Coast and all were closed by 9:00 A.M. The coastal control structures, which though partly open on automatic control, were opened fully either by dispatching crews to the sites, or by means of the C&CS.

Our pumping stations serving the C-11 basin at S-9 and S-13 were activated at about 8:00 A.M. on the 25th and continued pumping round-the-clock well into the month of May. When the overall discharge figures are tabulated, the continuous pumping at these stations will most probably establish a new record for removal of runoff from any one storm event in the C-11 basin. Such pumping was necessitated to relieve the persistent, though common, flooding in the western portion of the C-11 basin.

The other area of persistent flooding occurred in the western portion of the C-9 basin. Flooding in this area is, of course, inherent in the design of the primary system; that is, the eastern urbanized portion of the basin is essentially served first by the primary system. Consequently, until the eastern service area is brought under control, excess runoff is retained in the west end, which therefore results in the flooding. Such was the case during this storm event. However, it should be noted that this area also commonly floods with storms of much less intensity.

The coastal water control structure that serves the C-9 basin is S-29. This structure was operated by the Communications and Control System and four gates were fully opened until the salinity began to intrude above the structure. A tongue of dense salt water creeps up the C-9 channel bottom, even with the heavy discharges from the west, during high tide periods. When the salt tongue reached the structure the gates were lowered sufficiently to raise the headwater stage and force the salt back below the structure. This operation generally required

a gate closure to an opening of 1 to 2 feet. As soon as the tide reversed the gates were again opened fully. Fortunately, the salt content could be monitored by a sensor put above each coastal structure as a part of the Communications and Control System. Monitoring of salinity levels is important at this location (as well as others) due to the near upstream existence of deep lakes (borrow pits) and a well field.

Other coastal control structures were opened fully during the peak runoff period of the 25th. By the next day all were returned to normal automatic operation. The salt content at other structures was also monitored, but no intrusion was observed.

In south Dade County coastal structures have two ranges for automatic operation. Following the storm, the lower range was used in order to lower the stages in the agricultural areas adjacent to District canals.

Every effort was made to remove theboards in the antiquated control structures on the North New River, the Hillsboro Canal and the Palm Beach Canal. Nevertheless because of the nature and age of these structures, some delay was experienced in fully opening them. In the case of the Deerfield Lock Structure (Hillsboro Canal), the water control gate in the old lock chamber was opened full by 8:00 A.M. and the flashboards were all removed from the water control spillway by 11:00 A.M. The flashboards in the Sewells Lock Structure (North New River Canal) were all removed by 7:25 A.M. At the Palm Beach Lock Structure, the water control gate in the old lock chamber was opened full by 8:40 A.M. and eight flashboards were removed for discharge through each of the eight box culverts by 1:20 P.M. on April 25th. The lack of automatic project-designed structures at these locations hindered our otherwise effective and efficient operations throughout the storm impact area.

Another operational problem occurred in the C-15 basin. The gates at the coastal control structure (S-40) were opened full by the C&CS in an effort to relieve the flooding in the secondary system to the west. During low tide at about 2:30 P.M. the gate openings had to be reduced because the head across the structure increased to an amount which was beginning to endanger the stability of the structure. This partial gate closure caused an increase in the headwater stage at a time when the stages at nearby structures were falling. However, in this case, no other alternatives existed except that of severely violating the gate opening criteria established by the U. S. Army, Corps of Engineers, who designed the structure. Such an alternative was not, in our judgment, justifiable in light of the possibility of losing the structure.

In general the system performed very well in view of the extreme stress created by very severe weather. The modern tools available to the District and the dedicated and prompt response of the employees all contributed to the confining of the damages to only those areas where it would have been virtually impossible to fully eliminate them. Moreover, the ability to monitor and control round-the-clock operations by means of the Communications and Control System proved most useful.

B. Problem Areas and Damages

During the storm event that occurred on April 25 there was no flooding damage which was caused as a result of design, operation, or malfunction of District facilities. None of the District's canals overflowed and our structures were operated as designed.

While it can be said that the record high water levels experienced in some District canals may have hindered some local drainage, our canals did operate as designed and in some cases exceeded their design discharges.

There were, however, some problem areas which surfaced as a result of deficient secondary or tertiary drainage system capacity, maintenance or operation. The problem areas covered in this report include areas which had either street flooding which lasted a minimum of three days or areas which had house flooding, or both. Short term street flooding is considered to be insignificant during a storm of this magnitude. Preliminary agricultural damage estimates are included herein.

Palm Beach County In Palm Beach County most of the problem areas and damages occurred in the southeastern part of the county south of Lake Worth Road and east of the Conservation Area. The Hillsboro Canal basin and the C-15 and C-16 basins were the hardest hit with little damage in the West Palm Beach Canal basin and none reported in other areas.

Although the level of the West Palm Beach Canal reached 10.08', and phone calls from areas such as Lake Clarke Shores were received, no known damage was caused by these levels. Elsewhere in the West Palm Beach Canal basin, some heavy street flooding and some house flooding occurred on Garden Avenue between Forest Hill Blvd., and Southern Blvd., in West Palm Beach. This is a recurring problem area whose problem is attributed to inadequate local drainage.

The major problems occurred in the area of heaviest rainfall drained by the Lake Worth Drainage District and our Hillsboro, C-15 and C-16 canals. Areas such as: Sandalfoot Cove and Boca Del Mar near the Hillsboro Canal, Via Verde and Timber Creek in Boca Raton, and Highlands Subdivision and Highpointe in Delray Beach suffered extensive street flooding and some house flooding. Investigations by our field personnel has revealed that the main identifiable problems lie in areas upstream of the primary system.

Agricultural damage incurred in Palm Beach County was also limited mainly to the area south of Lake Worth Road and east of the Conservation Area. This damage, mainly to vegetable crops and some commercial ornamentals, is estimated by the Agricultural Extension Service at $5.6 million.

Broward County Extensive areas of Broward County were flooded, because of inadequacy of the secondary and tertiary drainage systems. The Broward County Water Control Department is preparing a detailed report describing areas in which damage was sustained during the storm.

Most of the problems in urban areas consisted of street flooding. Very few houses were flooded, though the flooded streets came within an inch or two of entering houses in several areas. The Broward County Civil Defense office estimates losses of 1.4 million dollars to houses and roads in Broward County. Some of the areas of urban flooding are as follows:

Fort Lauderdale and Wilton Manors	-	Andrews Boulevard from Oakland Park Boulevard to downtown Fort Lauderdale. In many areas street flooding occurred in areas which drain directly tidewater because of the very high tides on April 25.
Oakland Park	-	West Oakland Park Boulevard from N.W. 21 Avenue to 31 Avenue.
Lauderhill	-	N. W. 55 Avenue from Oakland Park Boulevard to N. W. 19 Street.
Tamarac	-	Commercial Boulevard from SR 7 to NW 54 Avenue.
Sunrise	-	Sunset Strip from University Drive to 105th Lane.
Margate	-	Atlantic Boulevard east of University Drive.
North Lauderdale	-	The Broadview Country Club area north of Bailey Road and west of SR 7. Flooding in this area was increased when a secondary levee was overtopped.
Plantation Acres	-	This area was generally flooded.
Coral Springs	-	Most of the eastern portion, west of SR 7 and east of the Coral Springs Drainage District was still flooded three weeks after storm.
Sunshine Ranch Estates	-	Street and pasture flooding was extensive as is commonly the case in heavy rainfall periods.

Agricultural damages in Broward County were extensive both in flooded acreage and in dollar amounts. Most of the information and damage estimates in this section were supplied by the county agricultural agent. Preliminary estimates of agricultural losses have been placed at 20 million dollars.

Most of the 30,000 acres of livestock pasture in the county was flooded for a long period of time, consequently it is estimated that about 10% of this pasture will have to be reseeded. Most of the 2½ million dollars in damages to the livestock industry is for replacement feed during the period that the flooded pasture is recovering.

Most vegetable crops had been harvested at the time of the storm, consequently estimated damages to this industry were only one million dollars. Had the flood occurred earlier, these damages would have been much greater.

It is estimated that 25% or 750 acres of citrus were lost due to the storm. The estimated value of this loss is 2 million dollars. This estimate may be raised later.

Ornamental horticulture sustained the greatest loss in the agricultural sector. Since acreage values are so high, between $25,000 and $100,000 per acre, only a small acreage loss represents a large dollar loss. Preliminary estimates place the total loss in ornamental horticulture at 14.5 million dollars.

Northern Dade County Although northern Dade County (north of the Tamiami Canal) received some of the largest rainfall amounts recorded during the storm, there was relatively little damage here either to urban or rural areas.

Street flooding was suffered in some recurring problem areas such as C-5 near 32nd Avenue, and Biscayne Gardens in the C-8 basin, and some house flooding occurred in Lodgemont Gardens in the C-7 basin; but these and the other relatively minor flooding areas owe their difficulties to inadequate local drainage.

The preponderance of agricultural losses in northern Dade County were inflicted upon cattle grazing land. Monetary loss estimates are included in figures for southern Dade County.

Southern Dade County Developed areas of southern Dade County experienced only minor scattered street flooding in low areas or areas with poor street drainage. No specific problem areas can be identified in urbanized parts of south Dade. The major damage to this agriculturally intensive area was to vegetable crops. There were three major areas of agricultural flooding.

The entire East Glade agricultural area, the area east of U.S. 1 between Cutler Ridge and Florida City, was totally inundated for almost 48 hours due to:

1. The low elevation of the land.
2. The poor condition of the secondary drainage system.
3. The underlying marl layers, which prevented percolation to ground water.

The second agricultural area where flooding occurred was the area that is commonly referred to as the "Frog Pond." This area is bounded by C-111 on the east, L-31W on the north and west, and SR 27 on the south. The third area where agricultural flooding occurred was in the East Everglades, that area west of L-31N, including Chekika State Park. There are no primary flood control facilities in this area.

The Agricultural Stabilization and Conservation Service of the U.S. Department of Agriculture estimates that approximately 3000 acres of vegetable crops alone, estimated at 5.6 million dollars, were lost, while losses to fruit trees, ornamentals, Cuban Crops, and pastures (including northern Dade) total 5 million dollars.

C. Relationship of Rainfall and Discharges to Project Design Criteria

There were several primary canals for which rainfall associated with this storm was greater than the design criterion. Among the most severely tested was the C-15 basin where 18.8 inches were recorded, 0.8" above the standard project flood design and 5" above the actual design value. The C-14 basin received between 11 and 15 inches of rainfall. The design criterion for this facility is 10.2" for urban areas and 9.5" for agricultural areas. The C-12 and C-13 basins received between 10 and 12 inches. The design criterion here is 10.2"; therefore, the design was surpassed in certain areas.

The C-11 basin was designed for 3/4" protection which can accomodate roughly a maximum of 6" in 24 hours. It received between 10" and 14". Therefore, a great deal of flooding was expected in that area and did indeed occur. The North New River Canal eastern basin received between 10" and 14" also. Design criterion is around 10.5".

Stages in several of the District's Canals exceeded the design. The most severe occurrences were C-12 (± 0.5ft.), C-13 @ S-36 (± 0.5 ft.) @ University Drive (± 1.1 ft.) @ the west end (± 1.4 ft.), C-14 @ 37A (± 2.2 ft.) @ 37-B (± 1.8 ft.) @ S-38 (± 1.3 ft.), and C-15 @ S-40 (± 1.7 ft.).

Rainfall exceeded the design storm in these basins, as stated previously. Rainfall in excess of the design storm caused above design discharges in the C-13 and C-14 basins. On April 25, 2270 cfs was measured at U.S. 441, which was ± 870 cfs greater than the design of 1400 cfs. The calculated peak discharge of 2390 cfs @ S-36 was 790 cfs greater than the design discharge of 1600 cfs. C-13 was still discharging at 1590 cfs on the next day. Upstream of S-37A on C-14 a measurement estimated at ± 4800 cfs was made. This exceeded the design discharge by ± 900 cfs. At U. S. 441, 3100 cfs was measured. This exceeded the design of 2050 cfs by 1050 cfs.

Record project discharges were made at:

STRUCTURE	HISTORICAL RECORD	ESTIMATED APRIL 25 PEAK DISCHARGE
S-40 (C-15)	*1900 (1974)	± 4050
Deerfield Lock	3490 (1947)	3700
S-37A (C-14)	1910 (1976)	± 4800
S-36 (C-13)	1200 (1977)	∓ 2390
25-B (C-4)		1700*Calculated

*This is only 300 cfs less than SPF discharge of 2200 cfs.

On April 25, the approximate average daily discharge from the following canals to tidewater equalled:

WPB Canal	2620	cfs.
C-15	2000	"
Hillsboro Canal	3060	"
C-14	2900	"
NNRC	1300	"
C-9	2020	"
C-8	1290	"
C-7	770	"
Miami	1200	"
C-2	1040	"
C-100	890	
	21,080	cfs. = 41,800 AF
		= 13,600 MGD

The above canals represent about 75 percent of total primary system discharges to tidewater and about 1/3 of total storm discharges.

Discharges on April 26 were slightly less than the discharges of April 25.

IV. ANTECEDENT CONDITIONS

A. Rainfall Deficiency

Rainfall during the period preceding the April 24-25 storm was sufficiently deficient to be considered a drought condition. Even though the months of February, March and most of April experienced below normal rainfall conditions in the Lower East Coast of Florida (Palm Beach, Broward and Dade Counties), the severity of the drought was not as intense as in 1971. The main reason for this was the above normal rainfall conditions experienced during the beginning of this dry season (October, November and December 1978). From the meteorological point of view, the drought frequency for the 2½ months previous to the storm was estimated to be 1 in 11 years in Broward County, 1 in 4 years in Palm Beach County and 1 in 4 years in Dade County. A county average was computed and compared with historical data to estimate the magnitude of the drought.

For comparison purposes, Table 2 shows the average county rainfall monthly totals for Palm Beach, Broward and Dade Counties for 1 through 6 months period in 1970-71 and for 1978-79 Dry Season.

Figures 3, 4 and 5 show the results of the drought analysis performed for the 3 thru 6 month periods anteceding the storm. It can be seen in these Figures that for a period of more than 3 months the rainfall frequency is so high (1 in 2 years) that it can not be considered a drought.

B. Water Supply Conditions

Because of the dry period preceding the storm, relatively heavy releases were being made in order to supply consumptive use requirements both in the Everglades Agricultural Area and in the Lower East Coast, and to maintain stages at the coastal control structures. As is common at this time of year, lack of surface conveyance facilities prevented the maintenance of optimum levels at the coastal controls in south Dade County.

The following tabulation summarized the deliveries being made on the day before the storm:

TABLE 3
Water Delivery on April 24, 1979 in cfs

Releases from Lake Okeechobee

To WPB Canal	200
To CA-3A	1550
For use in Ag. Area	1615+X
Total	3365+X

TABLE 3 (con't.)

Into CA-1		0
Out of CA-1		135
Into CA-2A		0
Out of CA-2A		240+Y
Into CA-3A		1550
Out of CA-3A		
To CA-3B	414	
To -4	670	
Total		1084
Into CA-3B		414
Out of CA-3B		330

X is an unknown quantity discharged through the Corps operated 10A culverts at the north end of the L-8 Canal. No stages or discharge relationship is available (5 culverts open 10 feet.)

Y is an unknown quantity discharged through S-143 on the North New River. No discharge relationship available. (Two 6 feet culverts open 0.75 feet.)

The quantities delivered to the east coast were sufficient to meet the water supply needs on the east coast and maintain the optimum stages at the coastal structures in Palm Beach, Broward and northern Dade County, except for the non-project Arch Creek control. Since no conveyance facilities currently exist south of the Miami metropolitan area, water use, seepage and evapotranspiration had reduced stages in south Dade County to a point far below optimum. Table 4 following shows how low stages at the coastal control structures had fallen in that area.

TABLE 4
Water Levels at Coastal Controls
in South Dade County

Structure	Headwater Stage on April 24, 1979	Optimum Headwater Stage
S-22	2.09	3.0
S-123	1.25	3.0
S-21	1.15	1.7
S-21A	0.63	1.2
S-20G	0.05	1.2
S-20F	-0.04	1.2
S-18C	-0.22	2.3

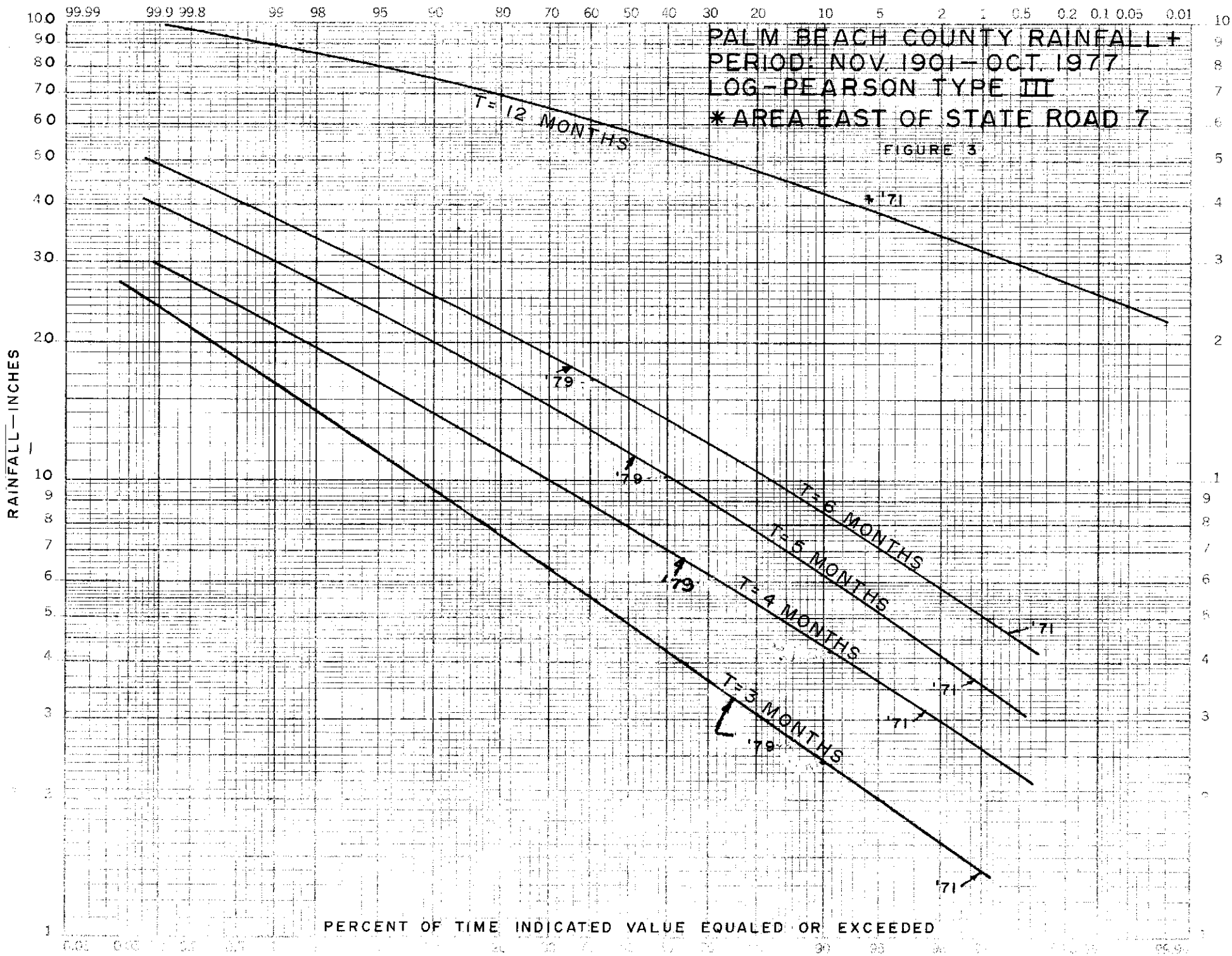
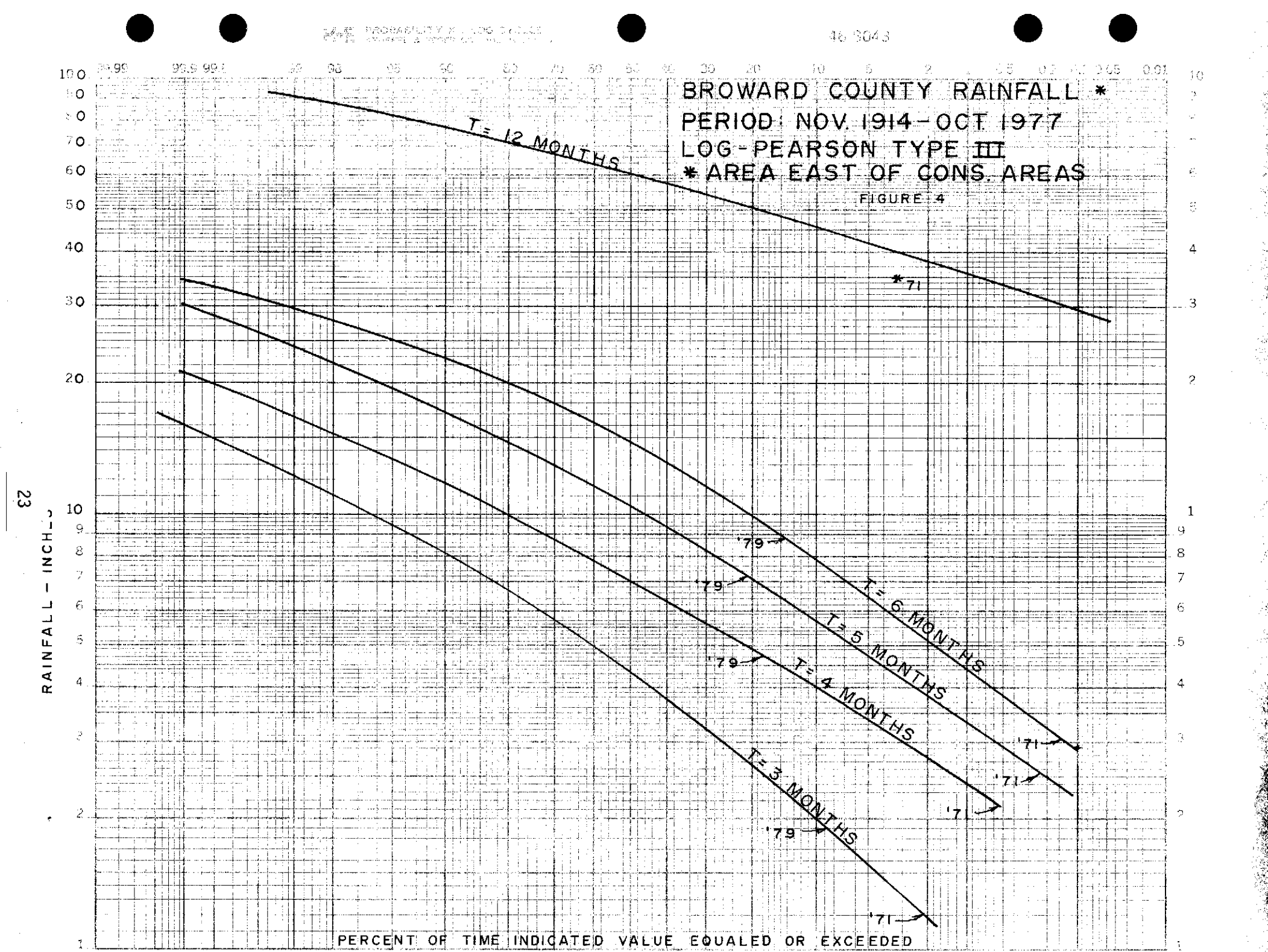


FIGURE 3


BROWARD COUNTY RAINFALL *
PERIOD: NOV. 1914 - OCT 1977
LOG-PEARSON TYPE III
* AREA EAST OF CONS. AREAS
FIGURE 4
T = 12 MONTHS
*71
T = 6 MONTHS
'79
'71
T = 5 MONTHS
'79
'71
T = 4 MONTHS
'79
'71
T = 3 MONTHS
'79
'71
RAINFALL - INCHES
PERCENT OF TIME INDICATED VALUE EQUALED OR EXCEEDED

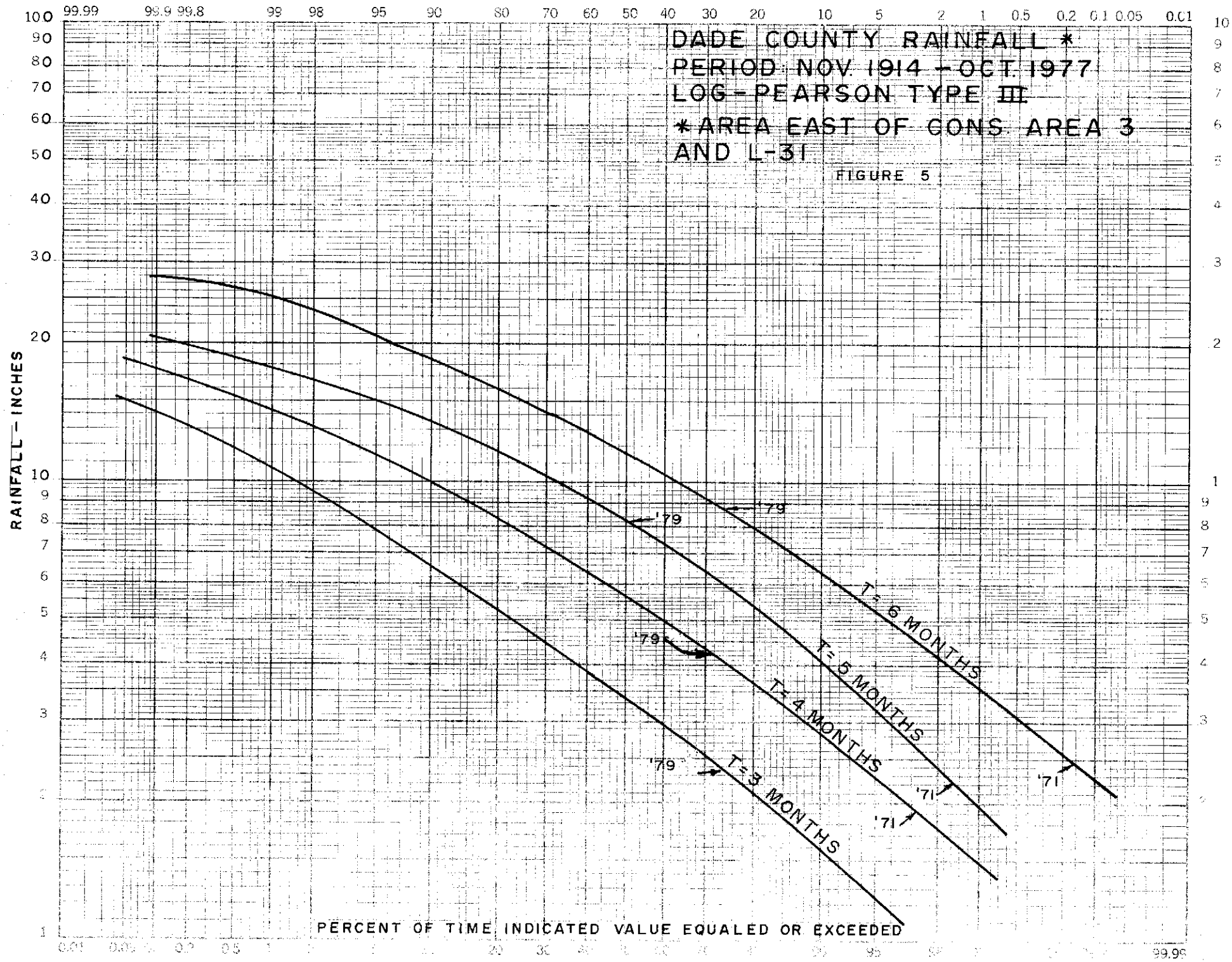

DADE COUNTY RAINFALL *
PERIOD NOV. 1914 - OCT. 1977
LOG-PEARSON TYPE III
*AREA EAST OF CONS. AREA 3 AND L-31
FIGURE 5
RAINFALL - INCHES
PERCENT OF TIME INDICATED VALUE EQUALED OR EXCEEDED
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
T = 6 MONTHS
T = 5 MONTHS
T = 4 MONTHS
T = 3 MONTHS
'79
'71

Table 2

Comparison of Dry Period Rainfall
Between Periods 1970-71 and 1978-79
Palm Beach, Broward, and Dade Counties

PALM BEACH COUNTY

Duration Month	1970-71 Period	Rainfall Inches	Rank	1978-79 Period	Rainfall Inches
1	Nov. 1970	0.14	8	Apr. 1979	0.69
2	Nov.-Dec. '70	0.40	1	Mar. '79-Apr. 23, '79	2.35
3	Nov. '70-Jan.'71	1.41	1	Feb. '79-Apr. 23, '79	3.39
4	Nov. '70-Feb.'71	3.17	2	Jan. '79-Apr. 23, '79	6.70
5	Nov. '70-Mar.'71	3.70	1	Dec. '78-Apr. 23, '79	10.79
6	Nov. '70-Apr.'71	4.78	1	Nov. '78-Apr. 23, '79	17.62

BROWARD COUNTY

Duration Month	1970-71 Period	Rainfall Inches	Rank	1978-79 Period	Rainfall Inches
1	Nov. 1970	0.21	15	April 1979	1.31
2	Nov. '70-Dec. '70	0.50	3	Mar. '79-Apr. 23, '79	1.90
3	Nov. '70-Jan. '71	1.21	2	Feb. '79-Apr. 23, '79	2.58
4	Nov. '70-Mar. '71	2.13	1	Jan. '79-Apr. 23, '79	4.69
5	Nov. '70-Mar. '71	2.55	1	Dec. '78-Apr. 23, '79	7.17
6	Nov. '70-Apr. '71	3.03	1	Nov. '78-Apr. 23, '79	8.73

DADE COUNTY

Duration Month	1970-71 Period	Rainfall Inches	Rank	1978-79 Period	Rainfall Inches
1	Nov. 1970q	0.11	1	Mar. 1979	.41
2	Nov. '70-Dec. '70	0.32	1	Feb. '79-Mar. '79	1.22
3	Nov. '70-Jan. '71	0.80	1	Feb. '79-Apr. 23, '79	2.45
4	Nov. '70-Feb. '71	1.92	3	Jan. '79-Apr. 23, '79	4.27
5	Nov. '70-Mar. '71	2.22	2	Dec. '78-Apr. 23, '79	6.00
6	Nov. '70-Apr. '71	2.43	1	Nov. '78-Apr. 23, '79	8.85

C. Water Shortages

In addition to problems in the south Dade area, localized municipal water shortages become significant during early April. The lack of adequate withdrawal storage, treatment and distribution capacity to meet the higher than normal demands was the main cause of most problems.

The following synopses of water shortages (from press reports) illustrate the conditions prior to the storm event:

During the first week in April, the Deerfield Beach City Commission instituted an emergency ordinance which prohibited residents from watering lawns, washing cars, etc., more than once a week. Although a voluntary program, citizens complied by cutting their consumption almost five million gallons per day.

On April 10, officials of Fort Lauderdale, which supplies water to Oakland Park, Wilton Manors, Lauderdale-By-The-Sea, Hacienda Village, Sea Ranch Lakes, and parts of Dania and Tamarac, asked residents of those areas and their own city to curtail use of water. Sprinkling in city parks was reduced by 50 percent. If voluntary cutbacks failed, officials indicated they would seek stronger restrictions such as mandating when lawns could be watered. Because of the drought, there was a heavier demand on the water system which was being operated at full capacity but was maintaining only 30 pounds of water pressure during peak periods compared to the usual 60 to 70 pounds. On April 20, restrictions were ordered for the next 3 years (the length of time expected to build additional water treatment facilities) with enforcement to begin by the middle of the following week. Restrictions were announced by the City Manager and the extent of those restrictions took many officials by surprise. Residents were told that if water consumption did not drop by 15 to 20 percent violators of the lawn sprinkling and car washing restrictions could face added charges on their water bills and even fines and jail terms.

During the week of April 16, the Juno Beach Town Commission asked for voluntary cutbacks in outside water use. Jupiter, only a few miles to the north, had plenty of water for its citizens and for the Tequesta water system as well. The difference is the location of their wellfields - Juno Beach has its wells near the coast while Jupiter's are located farther inland. Saltwater intrusion is the main worry of the Juno Beach system.

In Boynton Beach, two new wells started pumping water on April 19th to ease the shortage that had left the city without water for three hours on the 18th. The huge demand for water left the storage tanks dry and a television and radio appeal was made by the City Manager asking residents to use as little water as possible. The two new wells were pushed into production ahead of schedule because of the lack of rain and the fact that people were watering their lawns very heavily.

During the first two weeks of April, Boca Raton, although running close to using its daily production, had not started to ration water and they didn't expect to have rationing as they have a system that is large enough to handle their needs. However, by the 20th of April, officials were asking residents to water their lawns only at night, as water pressure is very low during peak usage hours during the day.

The City of Riviera Beach enacted a moratorium on water use to take effect on April 23rd that would allow residents to use water for non-essential purposes on certain days during set hours. The ordinance, as enacted into law, calls for police enforcement and fines for violators.

Delray Beach residents were to start rationing plans for lawn sprinkling on April 23rd. Because of the drought that had the area's rainfall level 5 inches below normal, the city's water plant was running near capacity. Boynton Beach was asking Delray Beach if they could help with their water situation, but Delray had to say no - they were in trouble themselves and could stand to lose their operating license for the water plant if they surpassed the capacity level set by the County Health Department.

D. Groundwater Conditions

Groundwater table elevations in the Lower East Coast area are of interest not only from the viewpoint of water supply conditions during the drought which preceded the April storm event, but also because of the available groundwater storage capacity of the aquifer.

To display the relationship between the storm and groundwater levels, contour maps of month-end water levels were prepared from data published by the U. S. Geological Survey.

Figure 6 shows the groundwater table contours which existed at the end of March 1979, the month preceding the storm. Similarily, groundwater table contours at the end of April 1979, immediately following the storm event, are shown in Figure 7. Contours representing the difference between the March and April water levels are presented in Figure 8. These contours show the net change of the water table in feet.

Groundwater levels prior to the storm were low, reflecting the effects of wellfield pumping and the low rainfall associated with the moderate drought that was underway. The pre-storm groundwater contour map clearly shows the areal extent of the cones of depression of regional wellfields particularly in the Miami and Fort Lauderdale areas.

The post-storm contour map indicates a substantial use in water levels which can be dramatically seen by comparing this map with the pre-storm areal extent of the Miami and Fort Lauderdale cones of depression. As can be seen, the highly permeable Biscayne Aquifer accepted very large quantities of rainfall as recharge.

The relatively low groundwater elevations prior to the storm had several obvious water resources benefits. First, as can be observed on the net difference map, water levels over most of the Lower East Coast east of the Conservation Areas rose 3-4 feet. It has long been recognized that the storage coefficient for the Lower East Coast Biscayne aquifer is 0.2. This means that the porosity of the formation is 20%, which translates into 1" of rainfall will "fill up" 5 inches of aquifer. Thus the 36-48" of aquifer storage potentially accommodated 7-9 inches of the rainfall event; which could account for 50-60% of the rain that fell during this severe storm. Secondly, at least half of the water that fell as rain was not lost to the sea by canal discharge, but rather was retained in groundwater storage for future beneficial use. Third, runoff and areal stages and consequently the severity of potential flooding was dramatically reduced, particularly in Dade and Broward Counties.

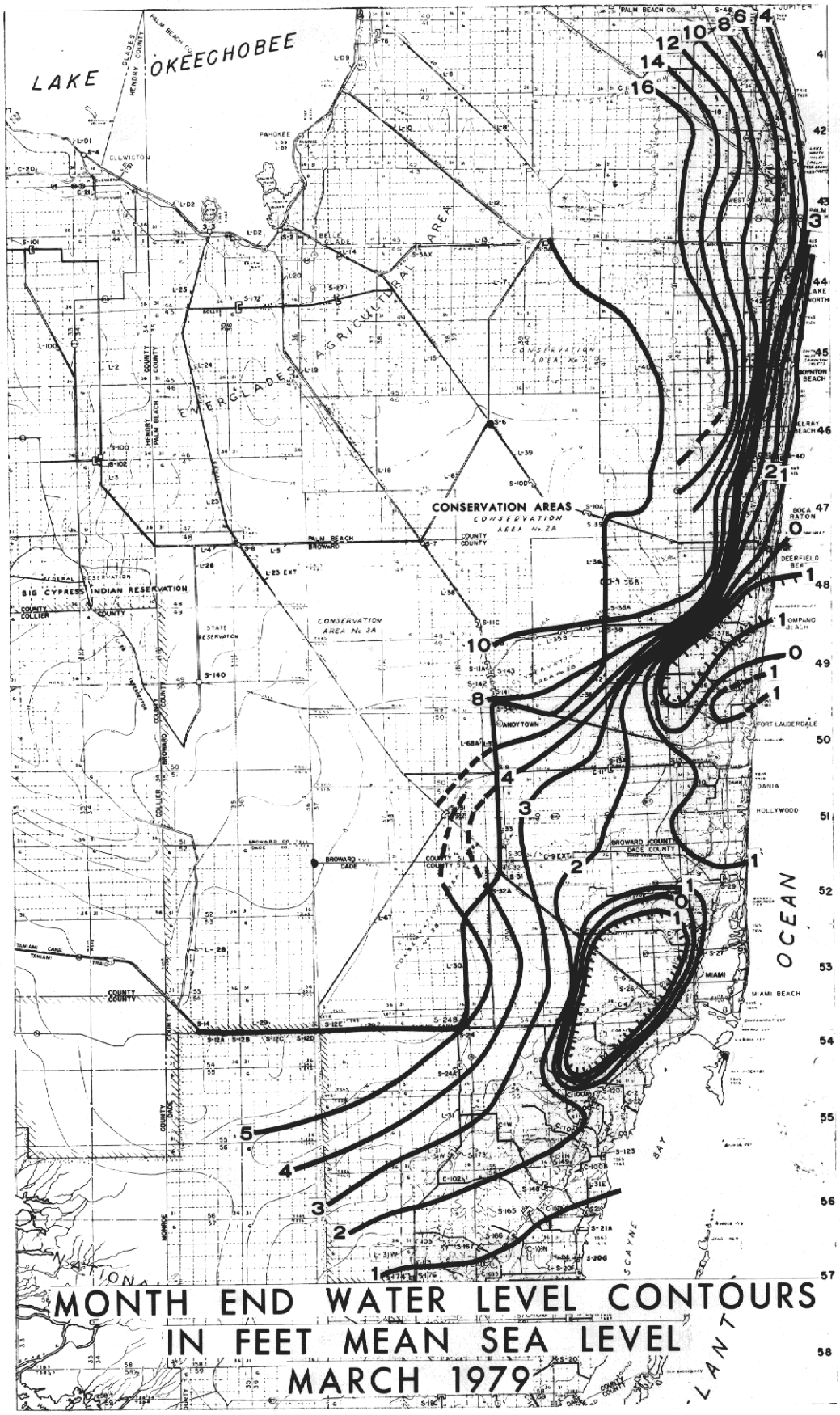

LAKE OKEECHOBEE
EVERGLADES AGRICULTURAL AREA
CONSERVATION AREAS
CONSERVATION AREA No. 2A
CONSERVATION AREA No. 3A
BIG CYPRESS INDIAN RESERVATION
OCEAN
BISCAYNE BAY
MONTH END WATER LEVEL CONTOURS
IN FEET MEAN SEA LEVEL
MARCH 1979

FIGURE 6

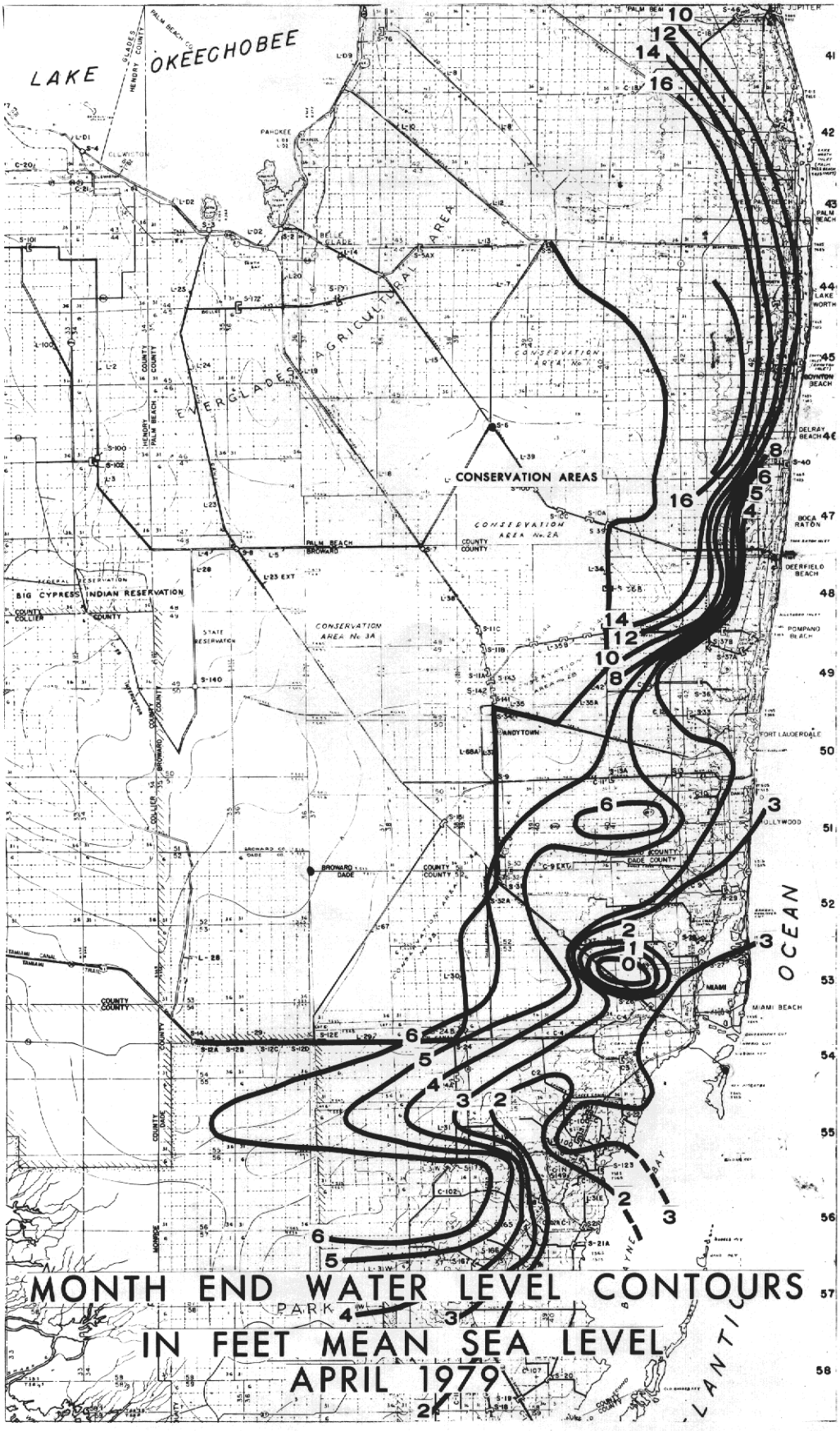

LAKE OKEECHOBEE
EVERGLADES AGRICULTURAL AREA
CONSERVATION AREAS
CONSERVATION AREA No. 2A
CONSERVATION AREA No. 3A
BIG CYPRESS INDIAN RESERVATION
OCEAN
MONTH END WATER LEVEL CONTOURS
IN FEET MEAN SEA LEVEL
APRIL 1979

FIGURE 7

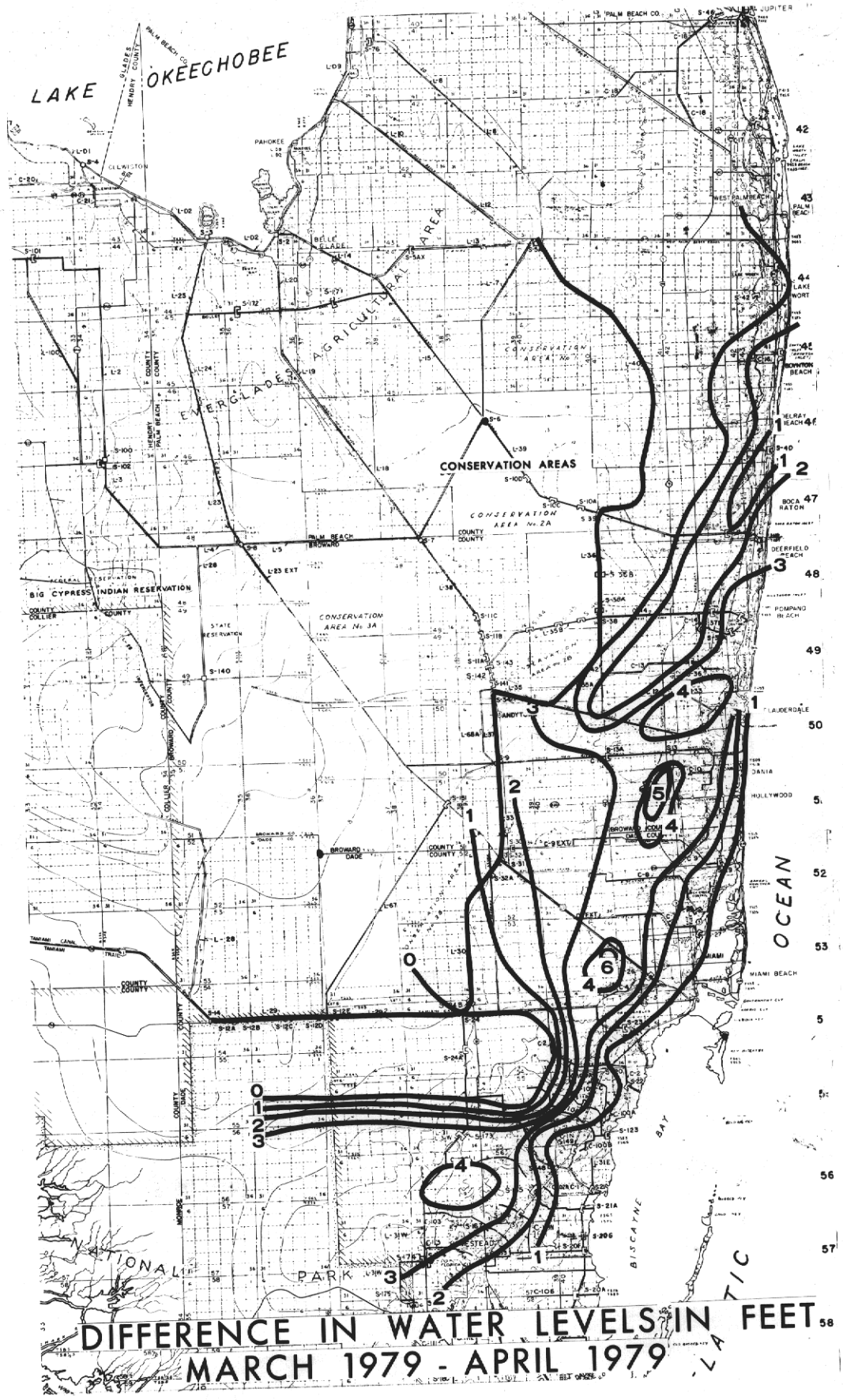

LAKE OKEECHOBEE
EVERGLADES AGRICULTURAL AREA
CONSERVATION AREAS
CONSERVATION AREA No. 2A
CONSERVATION AREA No. 3A
BIG CYPRESS INDIAN RESERVATION
STATE RESERVATION
BROWARD COUNTY
COLLIER COUNTY
HENDRY COUNTY
PALM BEACH COUNTY
DADE COUNTY
BELLE GLADE
PAHOKEE
CLEWISTON
WEST PALM BEACH
BOCA RATON
DEERFIELD BEACH
POMPANO BEACH
FT. LAUDERDALE
HOLLYWOOD
MIAMI
MIAMI BEACH
OCEAN
BISCAYNE BAY
NATIONAL PARK
DIFFERENCE IN WATER LEVELS IN FEET
MARCH 1979 - APRIL 1979

FIGURE 8

V. HISTORICAL COMPARISON

A. Rainfall

It is apparent from comparison of the April 24-25 spring storm with other historical storms, that this event was equivalent to and in certain areas greater than storms originated from past hurricanes. For example, Hurricane Donna, September 9-11, 1960 resulted in 10 to 12 inches of rainfall on south Dade County and on most of the central portions of the Everglades National Park. In certain areas of South Miami and Coral Gables there were about 14 inches of rainfall. A subsequent storm, September 17-19, 1960 produced 8-10 inches of rainfall in eastern Palm Beach County. Comparing the April 1979 storm with Hurricane Donna, it can be seen that the April storm was of a much higher magnitude in Broward and south Palm Beach County and slightly higher in eastern Dade County. It produced less rainfall than Donna in western Dade and Monroe Counties and in northern Palm Beach County. If we compare the April storm with Hurricane Betsy, September 6-8, 1965, it can be easily seen that the 1979 storm produced on the order of 3 to 8 inches more rainfall in both Dade and Broward Counties. On October 14-15, 1965, rainfall intensities of 14 to 19 inches in 24 hours was reported in south Palm Beach County and eastern Broward County and in October 30-31, 1965 rainfall intensities of 10 to 14 inches were also reported in the same general area.

The maximum 24 hour rainfall on record at Miami International Airport Weather Bureau Station was 14.87 inches (November 30, 1925). On April 25 it was reported as 16.39 inches, 1.52 inches above the maximum on record. Undoubtedly, shorter period intensities were higher than the highest on record in Dade and Broward and south Palm Beach Counties.

B. Population and Land Use Changes

The intensity and areal extent of rainfall associated with the April 1979 storm has not been approached, since September, 1960 when Hurricane Donna and Tropical Storm Florence occurred within a week of each other. The Lower East Coast area of the District has experienced much development since that time.

To provide some insight into these changes, Table 5 presents the population increase that has occurred in Dade, Broward, and Palm Beach Counties from 1960 to 1978.

As a graphic illustration of these changes, Figure 9 compares the approximate extent of urban development in 1960 and 1979.

TABLE 5

POPULATION COMPARISON

	1960	1970	1978 U/F Est.	1960 - 1978
Dade	935,047	1,267,792	1,494,276	60 percent increase
Broward	333,946	620,100	929,584	178 percent increase
Palm Beach	228,106	348,993	534,551	134 percent increase
TOTAL	1,497,099	2,236,885	2,958,411	98 percent increase

(1960, 1970 - Census Data; 1978 - U. of F. Estimates)

It is clear that with the extent and intensity of the April 1979 storm and the current extent of development in the Lower East Coast area, this storm event placed a greater stress on District facilities and posed a greater threat of potential flood damages than has any storm since establishment of the District.

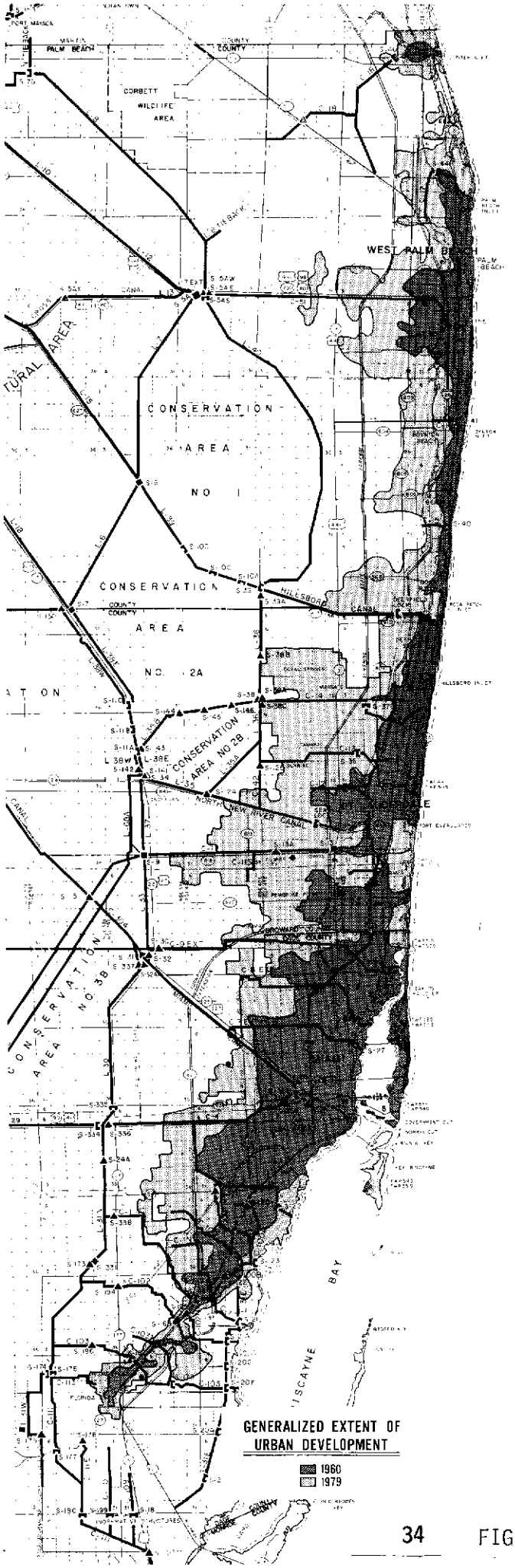

CORBETT WILDLIFE AREA
CONSERVATION AREA NO 1
CONSERVATION AREA NO 2A
CONSERVATION AREA NO 2B
CONSERVATION AREA NO 3B
NORTH NEW RIVER CANAL
HILLSBORO CANAL
BISCAYNE BAY
GENERALIZED EXTENT OF URBAN DEVELOPMENT
1960
1979

FIGURE 9

VI. SUMMARY AND CONCLUSIONS

1. The spring storm of April 24 and 25, 1979 in the Lower East Coast area of the District was for the most part the most intense storm in this area since initiation of the Central and Southern Florida Flood Control Project. Rainfall from this storm was not uniformly distributed and was most intense over the developed eastern portions of Dade, Broward and Palm Beach Counties. Rainfall amounts in excess of 16.0 inches were recorded at locations in each of these counties. The maximum rainfall recorded was 18.83 inches west of Delray Beach.

2. Unlike hurricanes, which can often be predicted to some degree, there was very little warning possible of the intensity of this spring storm event. At 5:00 P.M., April 24, high intensity rainfall was not predicted. During the next 14-18 hours, however, record rainfall amounts were recorded. The return frequency of these rainfall events was variable depending on location, but approximated a 1 in 200 year occurrence in the heaviest area near Miami International Airport. Rainfall occurrences approximating the 1 in 100 year storm were recorded in substantial areas of all three counties.

3. In view of the extreme stress that was placed on District facilities, the C and SF system performed very well. Design rainfall amounts, discharge rates and stages were exceeded in several areas without significant system failure. The new District Communications and Control System performed exceptionally well, although minor problems were encountered. Low tidal stages were encountered during peak discharge periods at some locations, necessitating reduction of discharge to prevent structure failure.

4. This storm event brought to an end the moderate drought that was underway throughout the area. The existence of low groundwater elevations was fortunate since groundwater storage absorbed roughly half of the rainfall in many areas. This reduced flooding stages, and the extent and duration of flooding.

5. Significant localized flooding occurred in many areas, resulting in substantial flood damages. Inadequate secondary and third order drainage systems, and inadequate fill elevations were the primary factors in these losses. In most areas, however, the primary District facilities together with adequate local systems and fill criteria prevented enormous potential losses. Although these damages which were prevented can not currently be calculated, the total flood damages prevented exceeded many million dollars.

6. This storm event emphasized the critical need for improvements and specific actions in several areas:

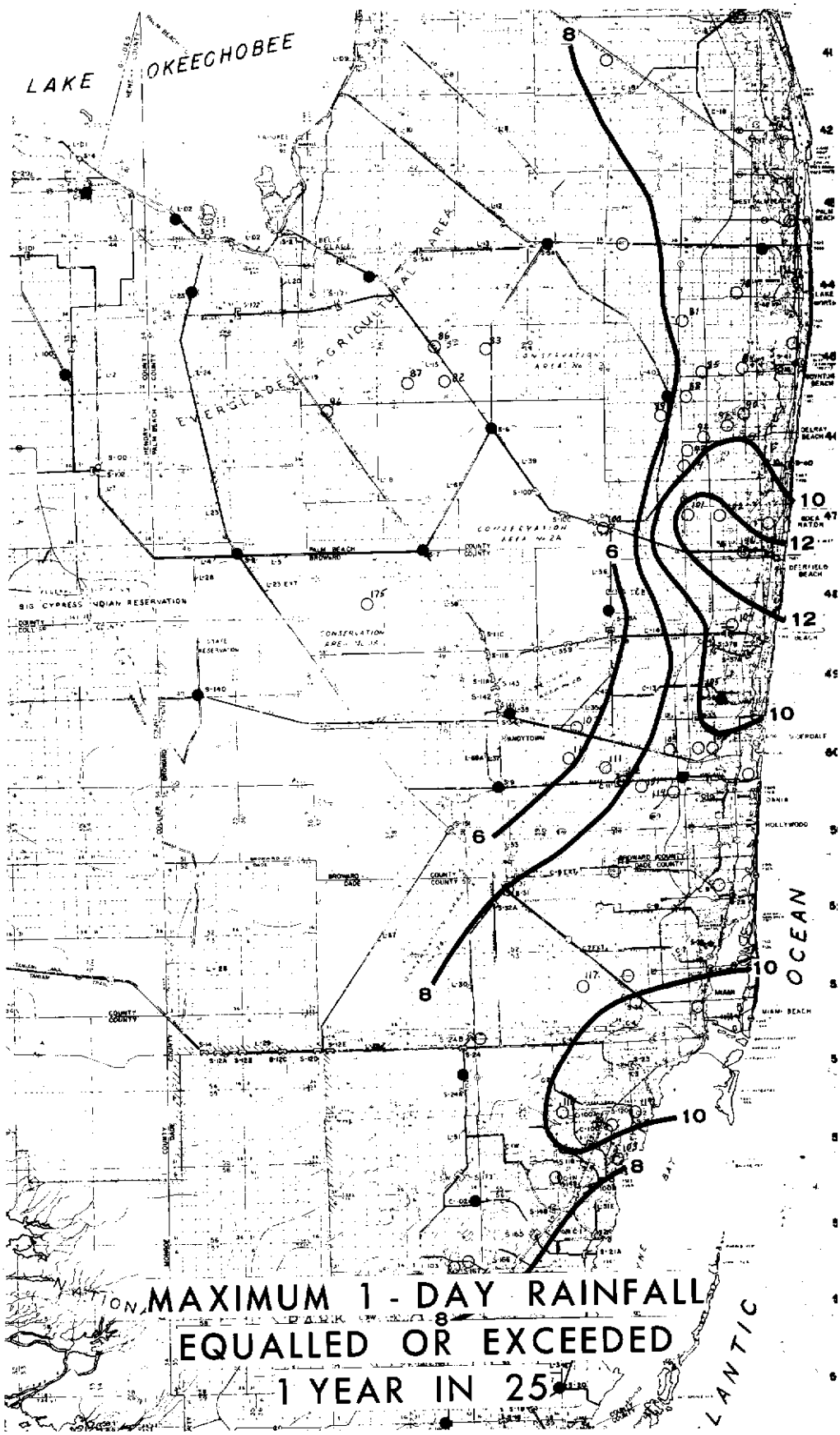
   a. Improvement of the canal section in the western C-11 basin.

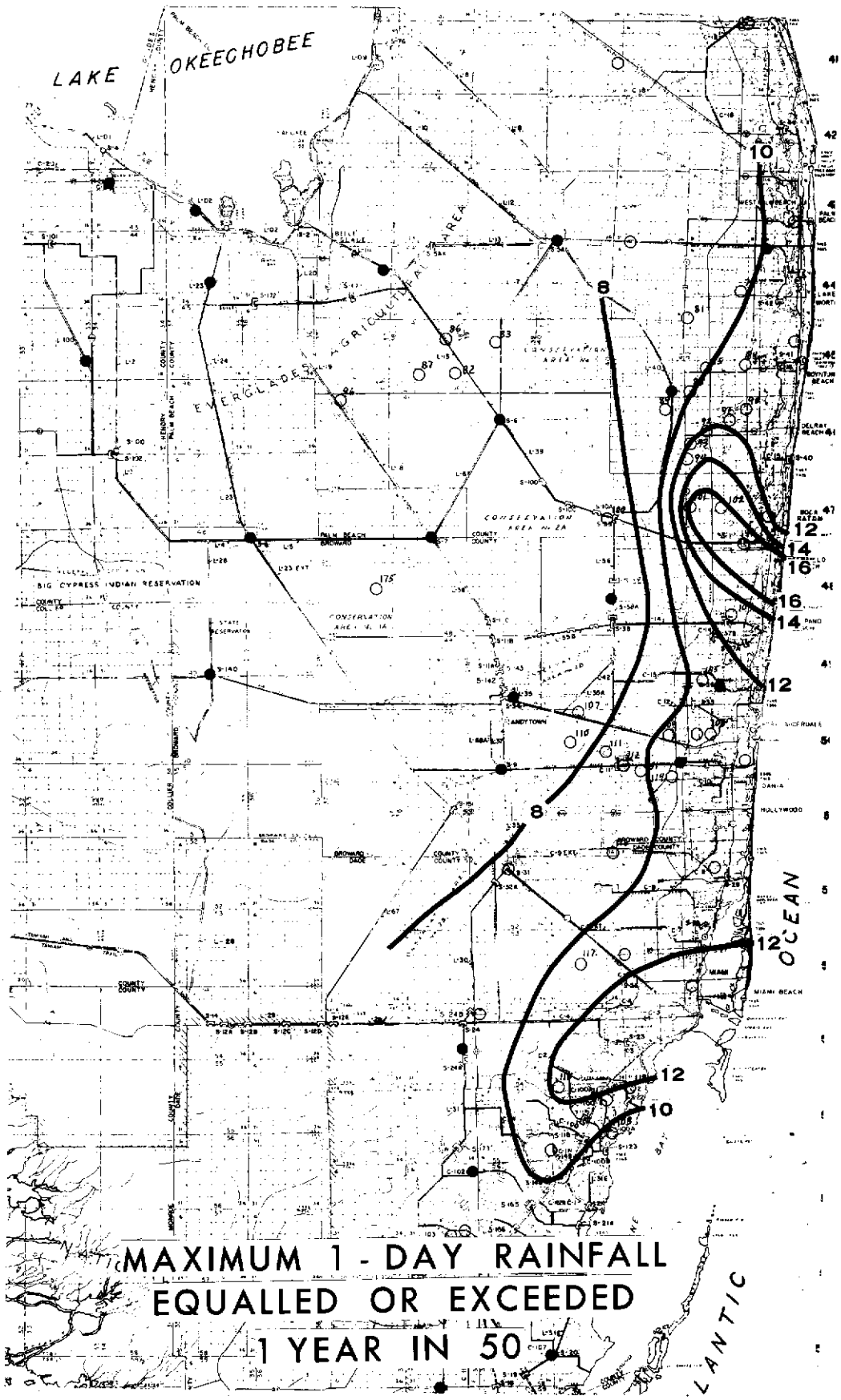
   b. Replacement of antiquated structures at Sewell Locks, Deerfield Locks and Palm Beach Locks.

c. Reexamination of operational criteria at coastal structures at which design discharges could not be attained due to low tidal stages.

APPENDIX

RAINFALL ISOHYETAL MAPS FOR GIVEN RETURN FREQUENCIES AND DURATIONS


LAKE OKEECHOBEE
EVERGLADES AGRICULTURAL AREA
BIG CYPRESS INDIAN RESERVATION
OCEAN
ATLANTIC
8
6
10
12
MAXIMUM 1-DAY RAINFALL
EQUALLED OR EXCEEDED
1 YEAR IN 25


LAKE OKEECHOBEE
EVERGLADES AGRICULTURAL AREA
BIG CYPRESS INDIAN RESERVATION
CONSERVATION AREA NO. 2A
CONSERVATION AREA NO. 3A
OCEAN
10
8
12
14
16
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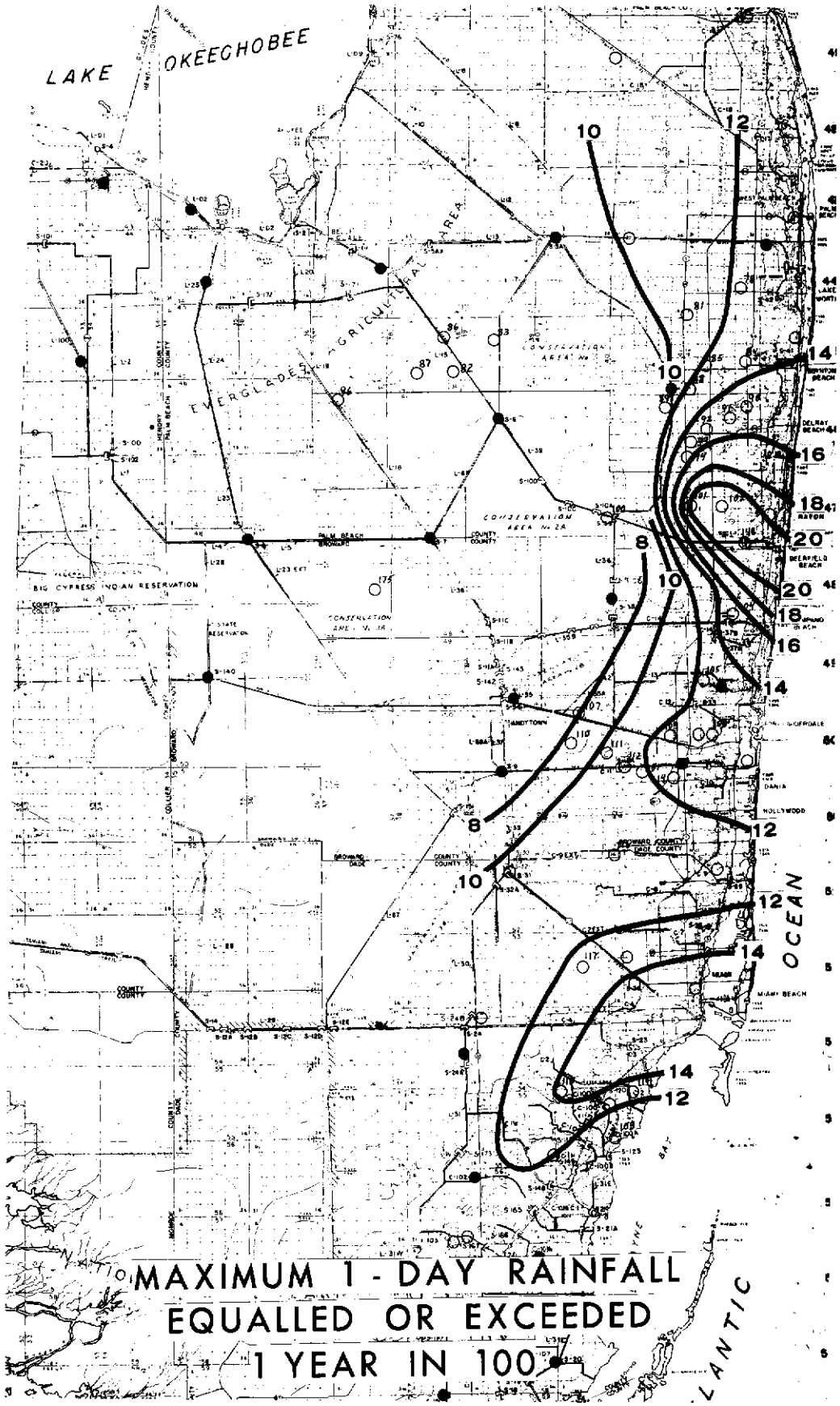
12
8
12
10
12
MAXIMUM 1-DAY RAINFALL
EQUALLED OR EXCEEDED
1 YEAR IN 50


LAKE OKEECHOBEE
EVERGLADES AGRICULTURAL AREA
CONSERVATION AREA NO. 3A
CONSERVATION AREA NO. 3B
CONSERVATION AREA NO. 2A
BIG CYPRESS INDIAN RESERVATION
OCEAN
ATLANTIC
10
12
10
14
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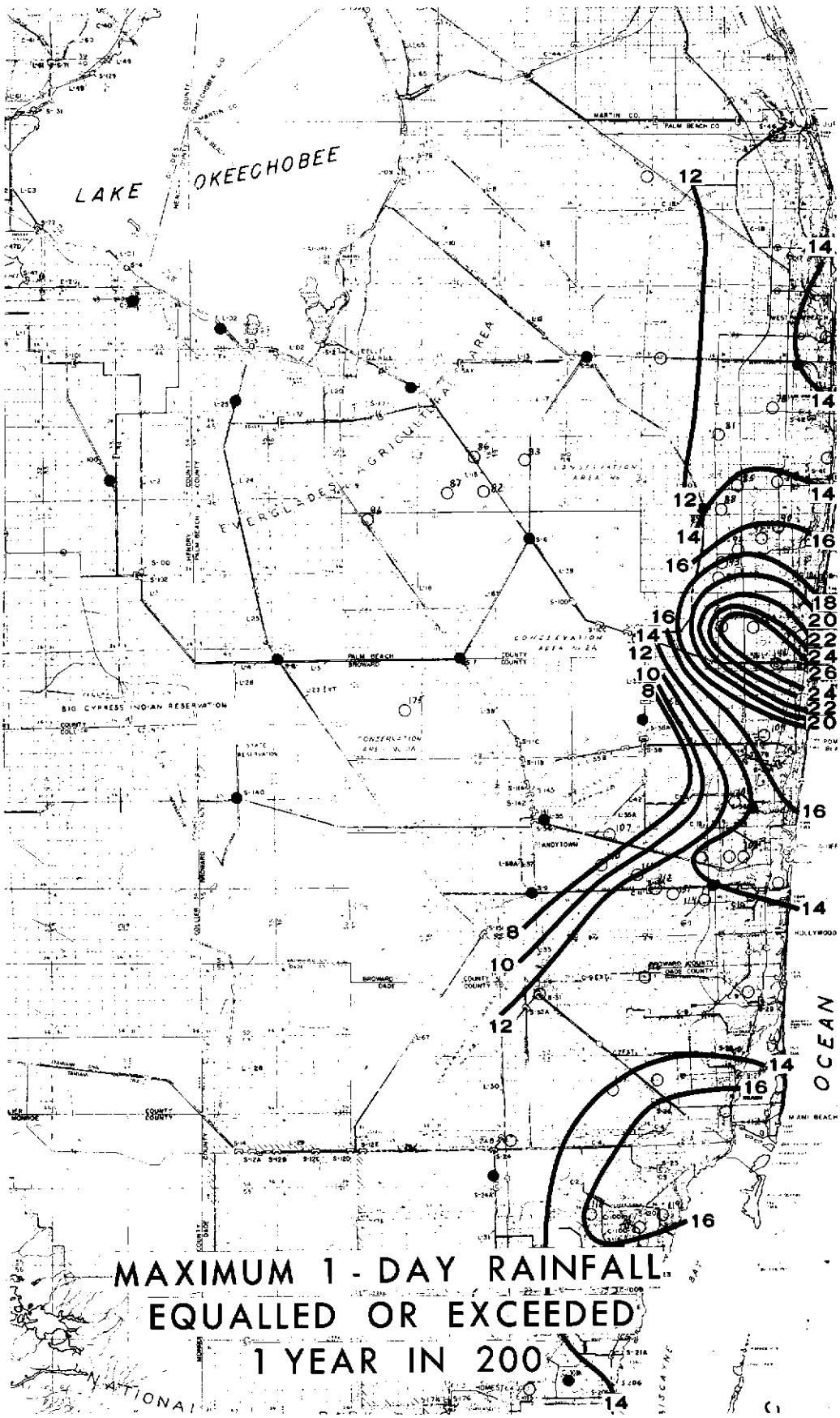
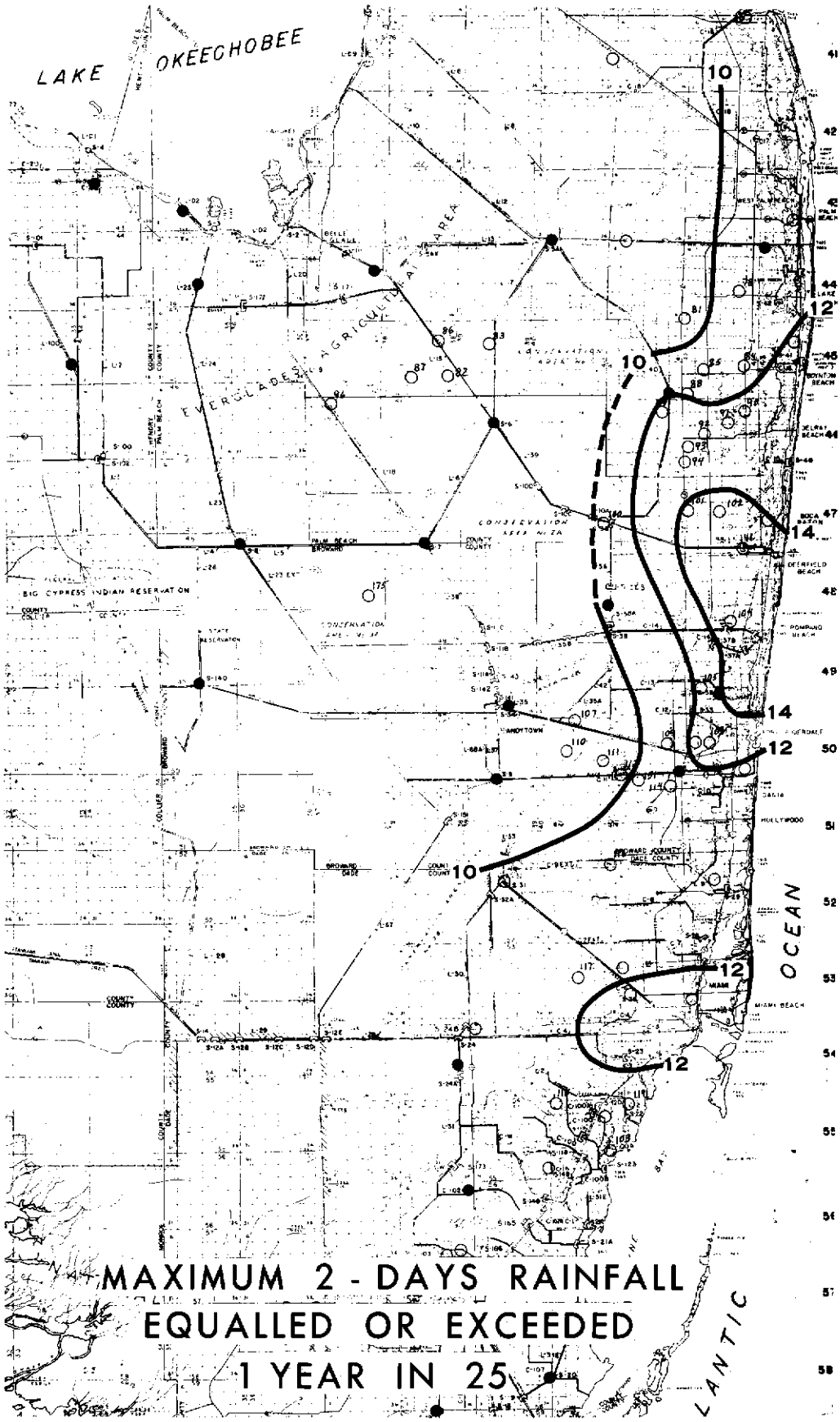
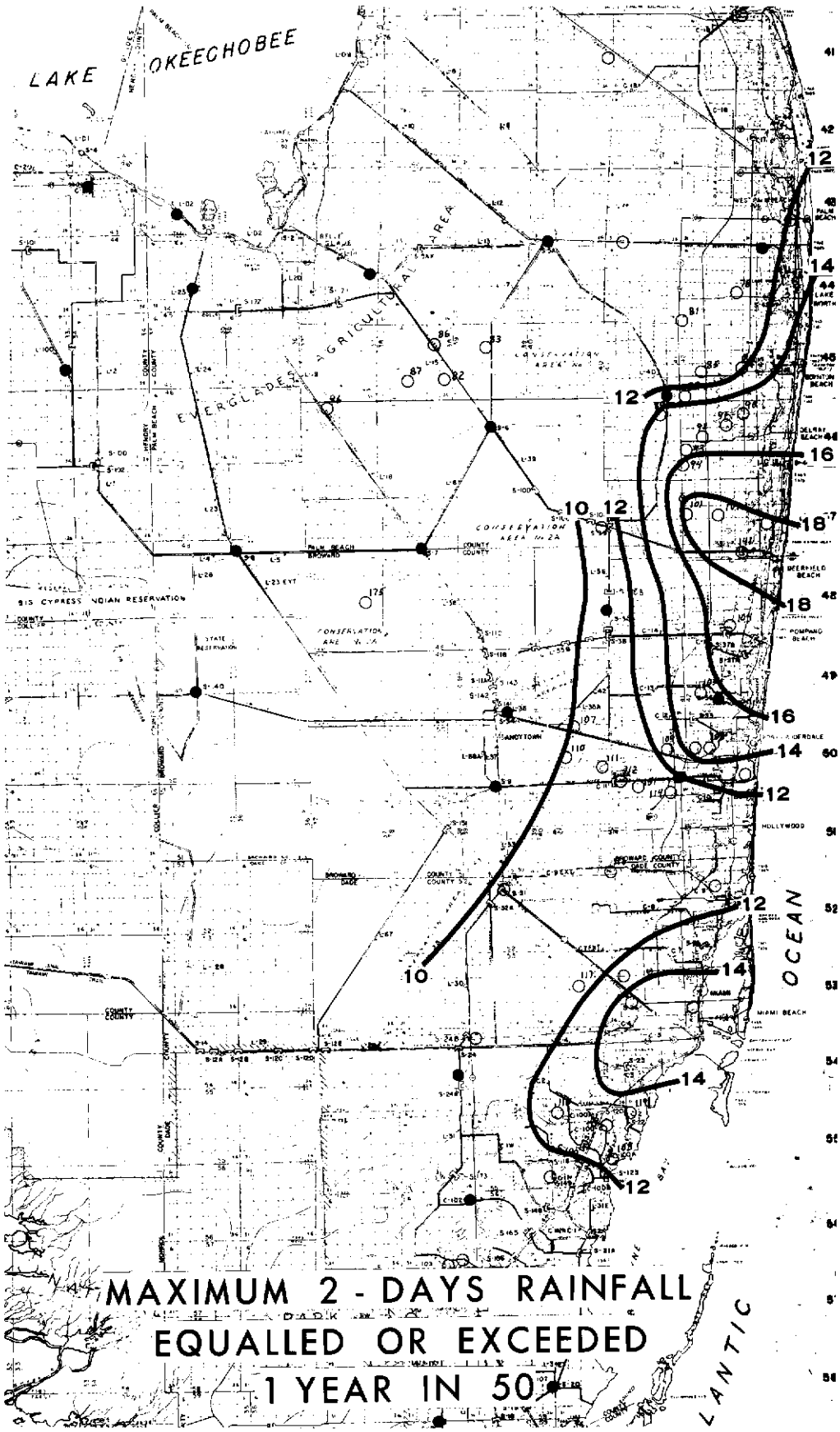
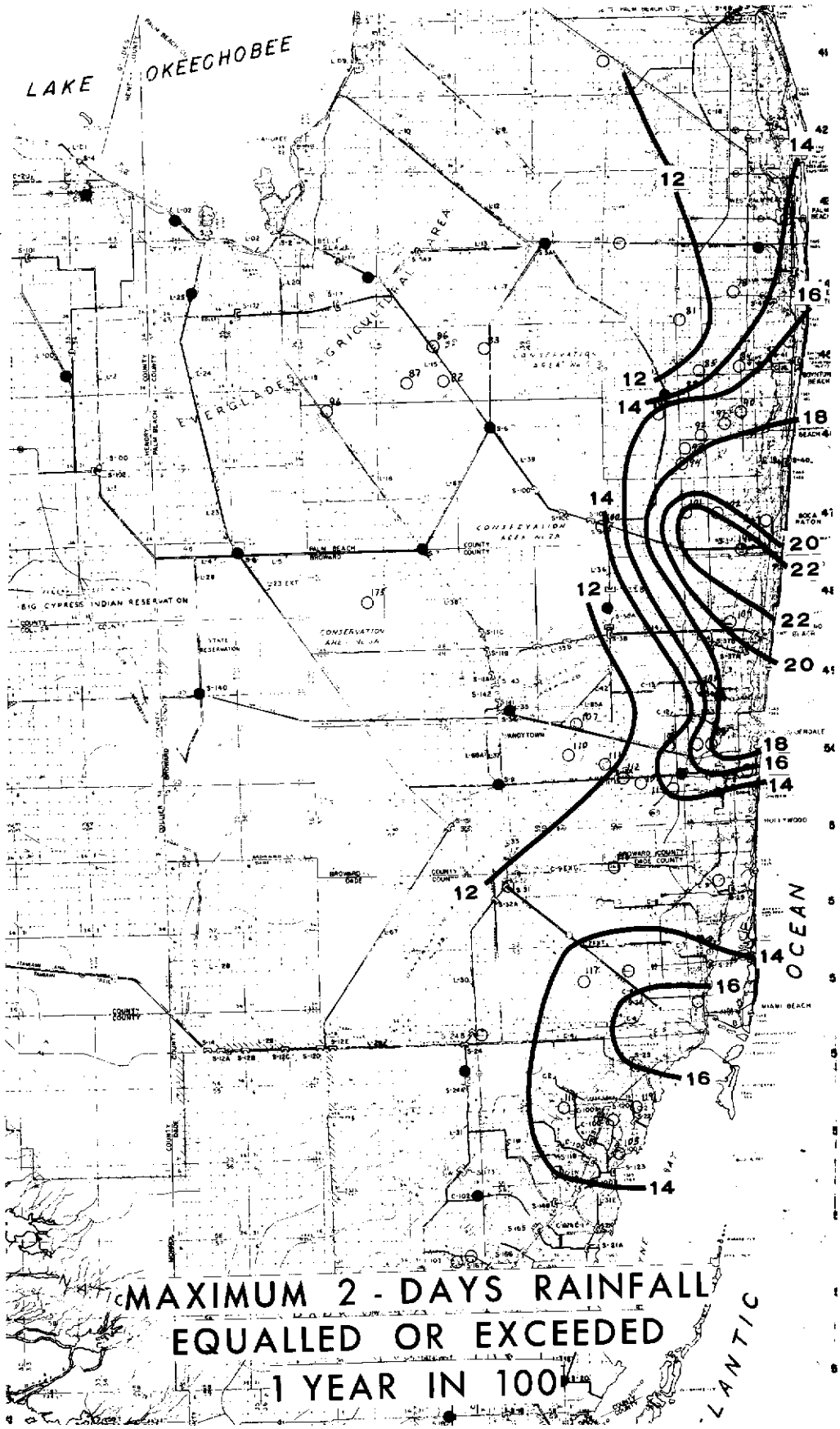
12
MAXIMUM 1-DAY RAINFALL
EQUALLED OR EXCEEDED
1 YEAR IN 100

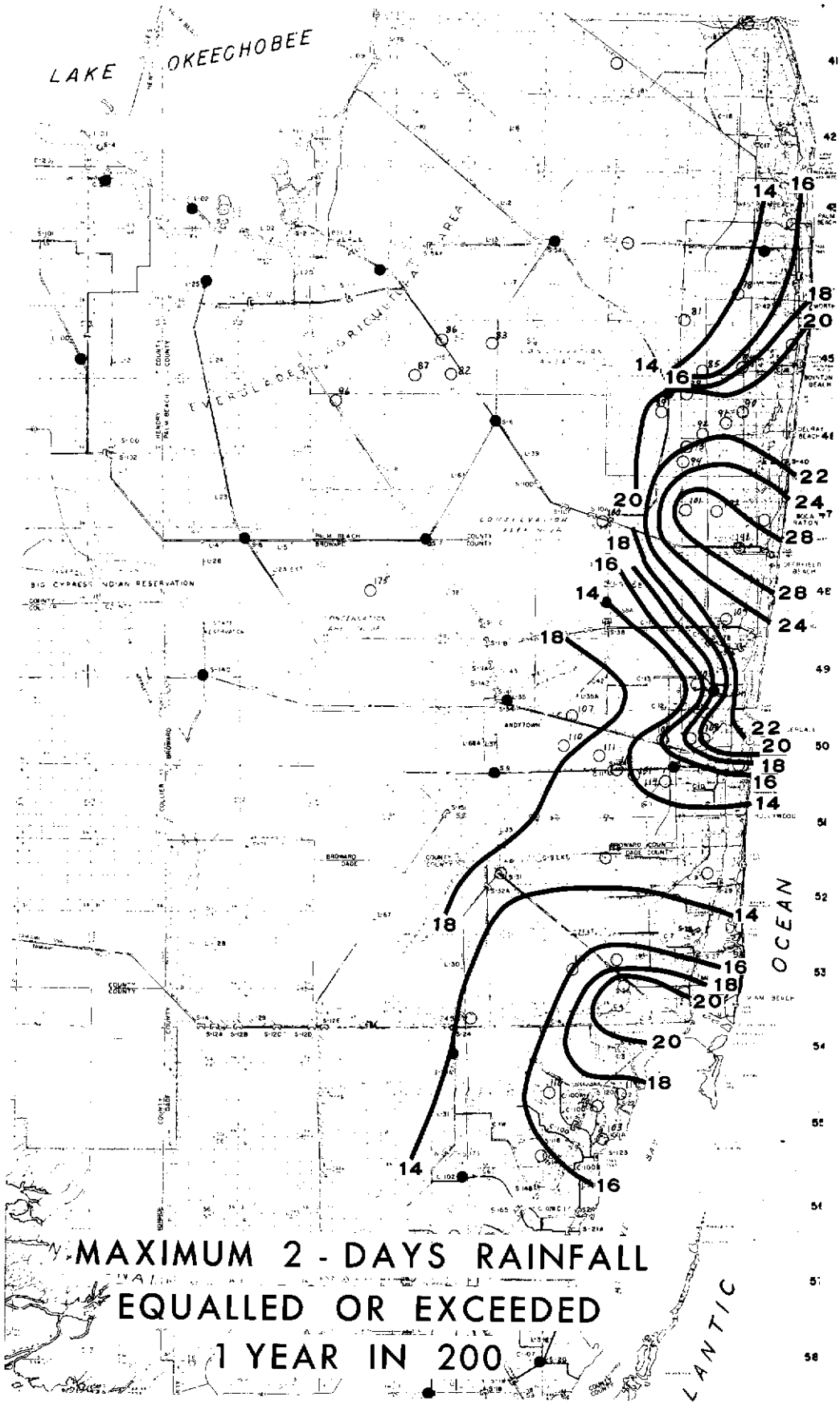


MAXIMUM 1-DAY RAINFALL EQUALLED OR EXCEEDED 1 YEAR IN 200


LAKE OKEECHOBEE
EVERGLADES AGRICULTURAL AREA
BIG CYPRESS INDIAN RESERVATION
OCEAN
10
12
14
MAXIMUM 2 - DAYS RAINFALL
EQUALLED OR EXCEEDED
1 YEAR IN 25


LAKE OKEECHOBEE
EVERGLADES AGRICULTURAL AREA
CONSERVATION AREA NO. 2A
CONSERVATION AREA NO. 3A
BIG CYPRESS INDIAN RESERVATION
OCEAN
10
12
14
16
18
MAXIMUM 2 - DAYS RAINFALL
EQUALLED OR EXCEEDED
1 YEAR IN 50


LAKE OKEECHOBEE
EVERGLADES AGRICULTURAL AREA
CONSERVATION AREA NO. 2A
CONSERVATION AREA NO. 3A
BIG CYPRESS INDIAN RESERVATION
OCEAN
ATLANTIC
12
14
16
18
20
22
MAXIMUM 2 - DAYS RAINFALL
EQUALLED OR EXCEEDED
1 YEAR IN 100


LAKE OKEECHOBEE
EVERGLADES AGRICULTURAL AREA
BIG CYPRESS INDIAN RESERVATION
OCEAN
14
16
18
20
22
24
28
MAXIMUM 2 - DAYS RAINFALL
EQUALLED OR EXCEEDED
1 YEAR IN 200