SUMMARY OF 1983

HYDROLOGIC CONDITIONS

Prepared by the

Water Resources Division
Resource Planning Department
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SUMMARY

The rainfall pattern for January-May 1983 can be summarized as very wet overall, but dry in May. For the District as a whole, the January-May total rainfall was 21.37 inches or 156.7% of normal. With this pattern, major water storage areas rose and remained above their regulation schedules until the latter part of May. (Table 1)

The 1983 wet season rainfall (June-October) was below normal in the Kissimmee lakes area, Kissimmee River basin, Lake Okeechobee, and the Water Conservation Areas, and it was 10% above normal for the coastal areas such as the Upper East Coast, Lower East Coast, and the Lower West Coast. For the District as a whole, the wet season rainfall was 98.7% of normal. Stages in the upper Kissimmee lakes chain rose to its regulation schedule or exceeded it slightly during the latter part of the wet season. Lake Okeechobee was .25 to 1.50 feet below its regulation schedule. The Water Conservation Areas were slightly above their present regulation schedules.

The rainfall pattern for November-December can be summarized as wet. For the District as a whole, rainfall was about 173.7% of normal. The year end stage in Lake Okeechobee was approximately 0.5 feet below last year's level; however, it still was almost 2 feet and 800,000 acre-feet above normal. The year end stages at Water Conservation Areas 1 and 2A were 0.86 and 0.48 above last year's level. The year end stage for Water Conservation Area 3A was back to the same level as that of last year (10.18 feet msl).

The temporal and areal distributions, and their percent of normal of the 1983 rainfall, are shown in Figures 3 and 4. Detailed monthly rainfall and discharge statistics are presented in Figures 5 through 14.

Table 1

Period of Above Schedule Stages
in Major Storage Facilities
Winter and Spring 1983

Storage Facility	Rose Above Schedule	Dropped Below Schedule
Lake Okeechobee	January 25	May 15
Water Conservation Area 1	January 21	April 29
Water Conservation Area 2A	January 23	July 12
Water Conservation Area 3A	January 25	April 10
East Lake Tohopekaliga	February 2	April 25
Lake Tohopekaliga	February 1	May 31
Lake Kissimmee	February 3	May 1

Upper Kissimmee Lakes Basin

The total rainfall from January through May was 19.20 inches, or 128.6% of the 68-year historical average (normal). The total wet season rainfall was about 86.55% of normal, and the November through December rainfall was 195.5% of normal (Figure 5). Rainfall in February and March was very heavy. All lakes in the area rose above schedule, and maximum releases were instituted; however, all lakes followed their regulation schedule fairly close from the end of May for the balance of the year (Figures 15 and 16).

Lower Kissimmee River Basin

The total rainfall from January through May was 19.37 inches, or 139% of the 68-year historical average (normal). Total wet season rainfall was 83.33% of normal. The November and December rainfall was 157% of normal (Figure 5). The stream flow at S-65E and S-84 was 242% and 454.9% of normal for the period of January-May due to the heavy rainfall of that period. The stream flow dropped to about 41% of normal during the wet season due to the below normal rainfall condition (Figure 8). Lake Istokpoga rose above schedule in mid-February, when the lake schedule is at its annual maximum level. This situation was critical because non-project dikes at the south end of the lake are subject to overtopping at a level close to that actually reached. Consequently, maximum releases were required. Due to a design deficiency, the combined capacity of the control structures in the canal downstream from the lake is less than one-quarter of the design capacity of the lake control structure. Therefore, the discharge from the lake had to be limited to 1350 cfs in contrast to its alleged capacity of 5900 cfs. This situation has been well known for many years. The Corps of Engineers has been advised of this problem, but to date no substantive action has been taken.

The other operational problem in this area was the limitation on the Lake Kissimmee discharge imposed by the design deficiency of the S-65 structures, especially S-65B. As mentioned above, Lake Kissimmee rose above regulation schedule (0.5 feet) during the heavy rainfall in February and March. At that time, the discharge at S-65 was adjusted so that the gate opening at S-65B would not exceed the maximum allowable limitation criteria set by the Corps of Engineers. Under this criteria, the allowable gate opening was controlled by the levels of the headwater and tailwater elevations. The closer together these levels are, the greater the allowable gate opening. As a result, the tailwater at S-65B was raised 0.5 ft while holding the design headwater. This provided the greatest discharge possible from Lake Kissimmee through S-65.

Lake Okeechobee

Direct rainfall in the lake during January-May was 21.30 inches, or 162% of the 31-year historical average (normal), (Figure 5). The stage in the lake rose above its regulation schedule on January 21, 1983 and continued the rapid rise throughout February (Figure 16). Regulatory releases were increased steadily and reached maximum by the end of February into both the St. Lucie and Caloosahatchee Rivers. The stage began to decline at the end of March, and reached the bottom of the regulation schedule near the end of May. The 18.16 foot stage reached on March 1 was exceeded in the past 20 years only in 1947 when it reached 18.77 on November 2. The high stages in 1983, however, were the highest in the spring months since 1913. This rapid rise in stage in the first 18 days of February (from 17.2 to 18.0) an increase in storage of over 360,000 acre-feet, demonstrates how difficult it is to control the lake level, even when major releases are being made through both the Caloosahatchee and St. Lucie waterways. A similar drop in storage during the lake recession required 36 days, during which maximum releases were being made.

Operationally, greater attention needs to be given to winter storm events.

The wet season rainfall that fell directly in the lake was near normal (96.20%). The lake stage increased slightly and was about a foot below its schedule. The slightly above normal rainfall during November-December permitted the lake stage to hold steady.

Upper East Coast Area

The total rainfall from January through May was 22.70 inches, or 152.8% of the 69-year historical average (normal). The wet season rainfall was 110.8% of normal. The November and December rainfall was 152.2% of normal (Figure 5). The regulatory discharges from the Lake Okeechobee to the St. Lucie Canal increased from 700 cfs on February 1, to 8700 cfs on February 28. Releases remained at 7500 cfs in March, then were reduced to 2500 cfs after April 24, and ended May 12 when the lake stage dropped below its regulation schedule (Figure 10).

Everglades Agricultural Areas

The total rainfall from January through May was 19.18 inches, or 137.1% of the 54-year historical average (normal). The total wet season rainfall was 34.07 inches, or 96.0% of normal. November and December rainfall was about 110.3% of normal (Figure 7).

Although most of the pumping from the Everglades Agricultural Area in accordance with the Lake Okeechobee Operating Permit was into the Water Conservation Areas, the intensity of the rainfall did require some pumping into the lake (Figure 9). Table 1 presents monthly pumpage from the Everglades Agricultural Area.

Due to the above normal rainfall during the 1983 dry season, the required irrigation releases from Lake Okeechobee were very small, except for those during May. The irrigation releases from the lake are summarized in Table 3.

Table 2

Pumpage from the Everglades Agricultural Area

Month	Into Lake Okeechobee in 1000 Acre Feet (AF)	Into Water Conservation Areas In 1000-AF	Into Water Conservation Areas In Percent of Total - %
January	15.3	103.4	87
February	43.2	245.2	85
March	4.1	126.9	97
April	0.0	15.4	100
May	0.0	0.0	-
June	30.3	174.7	85
July	0.0	7.4	100
August	0.0	128.6	100
September	4.3	184.0	98
October	9.0	194.5	96
November	0.0	10.8	100
December	0.3	94.8	100
Total	106.6	1,285.7	92

Table 3

Irrigation Releases from Lake Okeechobee
(In Thousands of Acre-Feet)

	Miami Canal (HGS-3)	N. New River & Hillsboro Canal (HGS-4)	West Palm Beach Canal (HGS-5)	Total
January	10.9	0.4	0.0	11.3
February	0.0	0.0	0.0	0.0
March	0.0	0.0	0.0	0.0
April	5.0	6.5	6.3	17.8
May	37.0	52.3	20.2	109.5
June	0.0	0.0	0.0	0.0
July	6.0	6.6	4.6	17.2
August	0.0	0.0	0.0	0.0
September	0.0	0.0	1.8	1.8
October	0.0	0.5	0.6	1.1
November	1.4	4.7	5.2	11.3
December	3.9	4.9	5.5	14.3
Total	64.2	75.9	44.2	184.3

Problems in the Industrial Canal were encountered during 1983. Upon occasion, the stage in the Industrial Canal dropped so low as to ground boats in the Clewiston Marina at night. This was caused by the agricultural pumping from the canal while the lock structure, S-310, was closed. The canal stage was replenished by leaving the lock partially open, but during periods of heavy boat traffic the lock cannot be left open, and the canal stage drops unacceptably low. The capacity of the Industrial Canal is quite limited during flooding. As a stop gap measure, the District installed a Telemark water stage recorder in the canal. This instrument permits surveillance of the water level by telephone.

Water Conservation Areas

Direct rainfall to Water Conservation Areas 1, 2A, and 3A during January through May were 20.08, 20.93, and 20.89 inches, respectively, or 156%, 170%, and 181% of normal. The total wet season rainfall was near normal; November and December rainfall was 121 to 127% of normal (Figure 6).

Due to the heavy rainfall during the previous summer (1982), water levels in all major storage areas within the District (including Water Conservation Areas) were near their regulation schedules at the beginning of 1983. The water levels in all three Water Conservation Areas rose abruptly and exceeded their regulation schedule in January. Special measures were taken: first the special drawdown scheduled in Water Conservation Area 2A was temporarily abandoned; second, an attempt was made to share the adversity by establishing an objective of equalizing the amount by which each Water Conservation Area was above schedule.

This strategy resulted in fully opening the S-12 and S-10 structures, and closing S-11 (Figure 11). In response, Water Conservation Areas 1 and 3A fell gradually, and Water Conservation Area 2A rose very rapidly, about two feet in the last half of February (Figures 17 and 18). During this and subsequent periods when the water levels were above schedule, discharges were made into Water Conservation Areas 2B and 3B, and when capacity was available, into the coastal canals and to tidewater.

During March, the S-10 discharge was reduced, but S-11 remained closed and S-12 remained fully opened. During April, S-10 was closed, S-11 remained closed, and S-12 remained full open most of that month (Figure 12). Water releases through S-333 began on March 22 and continued until mid-June to aid in lowering the stage in Water Conservation Area 3A, and also to distribute the discharge from Water Conservation Area 3A through the 54 culverts beneath the Tamiami Trail, south of Water Conservation 3B, and into the natural drainage of northeast Shark River Slough.

The water levels in the Water Conservation Areas finally dropped below their regulation schedules. The unusually dry May resulted in heavy irrigation demands in the Everglades Agricultural Area from Water Conservation Area 1 which dropped about 2 feet below schedule to meet those demands. Water Conservation Areas 2A and 3A also dropped below their regulation schedules during May, but not as drastically as Water Conservation Area 1.

Heavy rainfall in June again brought water levels in all Water Conservation Areas up sharply. With near normal wet season rainfall and above normal rainfall in November and December, Water Conservation Areas 1 and 2A were above schedule for the rest of the year, while Water Conservation Area 3A was above schedule again during September and October.

An experiment was carried out by opening full the westernmost 18 of the 24 S-12 gates from June 9 to the end of the year, the easternmost six gates (S-12D) were left closed. The purpose of this experiment was mainly to draw down the abnormally high stage in Water Conservation Area 3A and minimize the probability of heavy discharge to Everglades National Park during the early months of 1984. In addition, flow through the westernmost gates more closely duplicates the natural sheet flow conditions.

Lower East Coast

The total rainfall from January through May was 26.99 inches, or 164.5% of the 68-year historical average (normal) (Figure 6). The heavy rain during January and June caused some flooding in the agricultural areas of the East Everglades and south Dade County.

The total wet season rainfall was 38.93 inches, or 102.9% of normal. Heavy rainfall in northern Palm Beach County on September 23-24 resulted in local flooding in the suburban areas of Jupiter and north of Royal Palm Beach.

The stage in the western reaches of C-51 rose to a record level of 16.21 early on October 24 when a storm of approximately a 5 to 10 year return period, limiting gravity discharge and overtopping the low levee on the south bank, flooded several thousand acres of agricultural land. Considerable street flooding occurred in the Wellington, Royal Palm Beach, and Loxahatchee Groves areas. The November and December rainfall was 128% of normal; however, no flooding was reported except in the Delray area due to a very intense, but short duration storm. The District has been maintaining S-40, the C-15 control structure, almost a foot below the normal operating range. When complaints were received about flooding, the control stage was dropped another foot to aid the secondary system which was greatly overtaxed. Figure 13 shows the typical stream flow in the Lower East Coast area.

The normal practice in coastal agricultural areas of south Dade County is to lower canal levels about one-half foot below normal high tide during the winter growing season. As a result, the groundwater levels throughout south Dade County were lower, especially during the spring months, thus permitting saline intrusion into the groundwater aquifer and coastal canals. Because of the heavy rainfall during most of the dry season during 1983, saltwater intrusion became less pronounced in 1983 than in normal years. Table 4 compares chloride levels in the C-103 basin for May 1983, October 1982, May 1981, and December 1980.

Table 4

Chloride Levels in South Dade County
(C-103 Basin) in PPM

	East Glades Experiment Site	Headwater Coastal Structure*
May 1983	2,500	2,200
October 1982	250	300
May 1981	3,000	13,000
December 1980	260	N/A

*Derived from specific electrical conductance.

Lower West Coast

The total rainfall from January through May was 21.71 inches, or 168.4% of the 56-year historical average (Figure 7). Lake Okeechobee regulatory releases began in late January, and discharges into the estuary area via the Caloosahatchee River ranged from 6,000 to 12,000 cfs during February, and 9,000 to 14,500 cfs during March, but decreased to about 6,500 cfs during April. The lake releases were terminated in mid May when the lake stage dropped below its regulation schedule (Figure 14).

The wet season rainfall was 114.8% of normal. Due to the heavy rainfall during September through November, moderate to heavy releases into the estuary through the Caloosahatchee River were required to prevent local flooding.

Everglades National Park

The water deliveries to Everglades National Park during 1983 was significantly above the minimum delivery schedule. As shown in Table 5, the delivery to Shark River Slough (S-12 structures) exceeded the minimum delivery schedule every month of the year. The heavy rainfall during January through April resulted in large regulatory releases from the Water Conservation Areas as explained previously. An experimental program which was worked out between the Park, the Corps of Engineers, and the District also contributed to the large releases throughout the rest of the year. As mentioned previously, the objective of this experiment was to minimize the probability of a repeat of 1983's heavy releases in the Spring of 1984, and to simulate the natural sheet flow pattern as closely as possible.

To simulate the natural sheet flow, releases were made through S-333 into the Tamiami Canal, through the culverts beneath the highway (U. S. 41), and into the natural headwater of Shark River Slough. A new culvert was constructed at the junction of L-28 and L-29 to discharge into the loop road area west of the Park.

The Corps of Engineers also obtained authorization and began construction of certain modifications as part of the Park's program to effectuate the sheet flow and spread the discharge to the east and west of the historic S-12 area of delivery.

Table 5

Monthly Discharge to Everglades National Park
to Shark River Slough (S-12 Structures)

Month	Schedule AF	Actual AF	Actual % of Schedule	Northeast Shark River Slough (S-333)-AF
January	22,000	26,400	120	0
February	9,000	89,800	1,000	0
March	4,000	134,400	3,360	16,000
April	1,700	63,400	3,730	50,000
May	1,700	28,000	1,660	34,400
June	5,000	31,000	620	7,900
July	7,400	37,300	500	0
August	12,200	45,500	370	300
September	39,000	69,800	180	400
October	67,000	90,300	140	0
November	59,000	84,900	140	0
December	32,000	86,500	270	0
Total	260,000	787,600	303	109,500

The delivery to Taylor Slough through pump station S-332 was heavy during January and February with the Park's agreement. No delivery was made during March through May due to requests from the Park. The normal releases were reinstated in late June and continued for the rest of the year except during November. Releases during November, as shown in Table 6, were a result of helping the farming interests in the adjacent area and as agreed to by the Park.

Table 6

Monthly Discharge to Everglades National Park to Taylor Slough (S-332)

Month	Schedule (AF)	Actual (AF)	Actual (% of Schedule)
January	740	4,000	540
February	370	4,400	1,190
March	185	0	0
April	185	0	0
May	370	0	0
June	6,600	1,900	30
July	7,400	7,400	100
August	2,960	3,000	100
September	5,920	6,000	100
October	7,770	7,700	100
November	3,700	8,000	220
December	740	930	120
Total	37,000	43,320	117

SIGNIFICANT IMPROVEMENTS

Several significant improvements were made in the District's operational area during 1983:

1. Five gated control structures were added to the communications and control (C and C) system; a microwave tower was added to complete the microwave backbone redundancy; sensors were added to the pump stations which automatically recorded pump speeds, enabling a continuous, complete record of the pump discharges. A sophisticated instrumentation was built into S-153 after the structure was vandalized before failure in 1979. This instrumentation is remotely monitored by the communications and control system.
2. Initiation of a contract with a consulting meteorologist. Daily reports were received of weather conditions directly related to District operations. On several occasions, this service has given the District early warnings which made possible operational moves in advance of severe weather events.
3. Four remote sensing devices were installed outside of the communications and control system. These devices operate a common carrier telephone. While not as reliable as the C and C system, they do provide a temporary input at critical sites before the C and C system can be expanded. The locations of these four sensing devices are:
   a. One installed at the Industrial Canal adjacent to the City of Clewiston. In the event of a major storm, the City of Clewiston could be in great danger of flooding due to the limited capacity of the Industrial Canal. This remote sensing device enables the

District to monitor the water level in the Industrial Canal and take appropriate action.

b. Two sensing devices were installed on the West Palm Beach Canal (C-51) during the vulnerable period of the construction of the coastal control structure S-155.

c. The fourth device was a replacement on an obsolete unit which had been in service for many years at the junction of C-2 and C-4.

CONCLUSIONS

1. Though the system, in general, is capable of handling unseasonable and heavy rainfall events and preventing flooding, in so doing it sometimes induces significant adverse environmental impacts.
2. During 1983, heavy winter rainfall events produced disproportionately greater runoff compared with those occurring in the summer due, primarily, to significantly lower evapotranspiration during the winter.
3. Even during a very dry spring, under conditions of a high stage in Lake Okeechobee, and severe gate opening restrictions on the hurricane gates, the system is able to provide most of the Everglades Agricultural Area with an adequate irrigation supply.
4. Due to structure limitations in Lake Okeechobee at high stages, the system cannot adequately supply the West Palm Beach canal portion of the Everglades Agricultural Area whenever Water Conservation Area 1 is at a low stage.
5. Except during very heavy rainfall events, the system is capable of following the new Lake Okeechobee operating permit and, thereby, minimize pumping and nitrogen loading from the Everglades Agricultural Area into Lake Okeechobee.
6. During wet periods, it is impossible to follow the special drawdown schedule in Water Conservation Area 2A.
7. Even during periods of very heavy winter rainfall, one dry spring month resulted in complete evacuation of usable water supplies from Water Conservation Area 1.

8. As a consequence of conclusion 7, Water Conservation Area 1 cannot always be relied on to supply the Everglades Agricultural Area or the East Coast during the spring.

9. Agricultural flooding cannot be prevented in the C-111, L-31N drainage basin during heavy (but less than design) rainfall events, even when the primary system is lowered well below the design levels.

10. The western C-51 basin is subject to flooding with a relatively high return frequency storm (on the order of one in five years). Backflow through S-5A system may also be utilized under certain circumstances to assist in reducing flood impacts.

11. Quick response in areas of local urban flooding, such as was done in the C-15 basin during the winter of 1983, can mitigate flood damages.

12. The District's practice of lowering the water table during the winter and spring months in coastal south Dade County may influence saline intrusion into canals and the groundwater in that area.

13. Heavy boat lockages at the Franklin Lock (S-79) during dry periods permit saltwater accumulation in the lower Caloosahatchee River, which, at times, threatens the municipal water supply of Lee County.

14. The capacity of S-333 and the culverts beneath the Tamiami Trail is equal or greater to the total flow through S-12A, B, and C during periods of low stage at the south end of Water Conservation Area 3A.

15. The District response to storms has been greatly improved by several factors:

    a. Expansion of the communications and control system.

    b. Addition of temporary portable water level sensors at critical locations which report over common carrier.

c. Real time services of a meteorological consultant.

16. The special "interim" schedules of the Upper Kissimmee Lakes, holding the maximum stage through the spring months, have increased reports of flood damages from lake front property owners.

17. Serious design deficiencies remain in the maximum discharge capacity of several structures, compared with their design capacities:

    a. The capacity from Lake Istokpoga is limited to about 25% of design by the downstream capacity of C-41 and C-41A.

    b. The discharge of all but one structure on the Kissimmee River, but especially S-65B and 65D, limits the discharge from Lake Kissimmee because of the error in omitting the energy dissipating baffle blocks at each structure (S-65, S-65A, S-65B, S-65C, and S-65D).

18. The permitted inflows to the Industrial Canal far exceed the outlet capacity at S-169.

19. Agricultural users sometimes pump the Industrial Canal so low as to cause damages to recreational facilities.

RECOMMENDATIONS

1. Means should be pursued to increase the irrigation supply to the L-10/L-12, basin by replacing HGS-5 as promptly as possible.
2. Recognize drainage limitations in the developed portions of the C-111 and L-31N drainage basins and actively cooperate with the Corps of Engineers in developing a feasible solution to both the drainage and the environmental problems of these basins.
3. Analyze storm runoff in south Dade County in order to develop an operational strategy during storm events. This strategy should determine when it is necessary to open gates and discharge to tidewater as a function of rainfall and depth to water table.
4. An investigation should be made to determine if saltwater intrusion into the system, regardless of its cause, has significant detrimental effects.
5. Every effort, consistent with previously established District policy, should be pursued to speed the implementation of the C-51 backpumping plan into Water Conservation Area 1.
6. The Communications and Control System should be expanded as quickly as possible.
7. Consulting meteorological services should be continued.
8. Efforts should be pursued to minimize the entry of salt into the Franklin Lock during boat passage.
9. The usefulness of the high winter and spring stages in the Upper Kissimmee Lake "interim" schedules should be evaluated in light of the potential damages in that vicinity.

10. The Corps of Engineers should be urged to correct the lowered discharge capacity from:

    a. Lake Istokpoga caused by the design deficiency in the downstream canal system (C-41/C-41A).

    b. Lake Kissimmee (S-65) caused by the design deficiency in the downstream S-65 structures.

11. Either the capacity of S-169 should be increased in line with the permitted inflows, the latter be reduced in line with the capacity of the structure, or the levees on the Industrial Canal be strengthened to accommodate higher stages.

12. Provide inflows into the Industrial Canal by either structural means (preferable) or by restricting lockages.

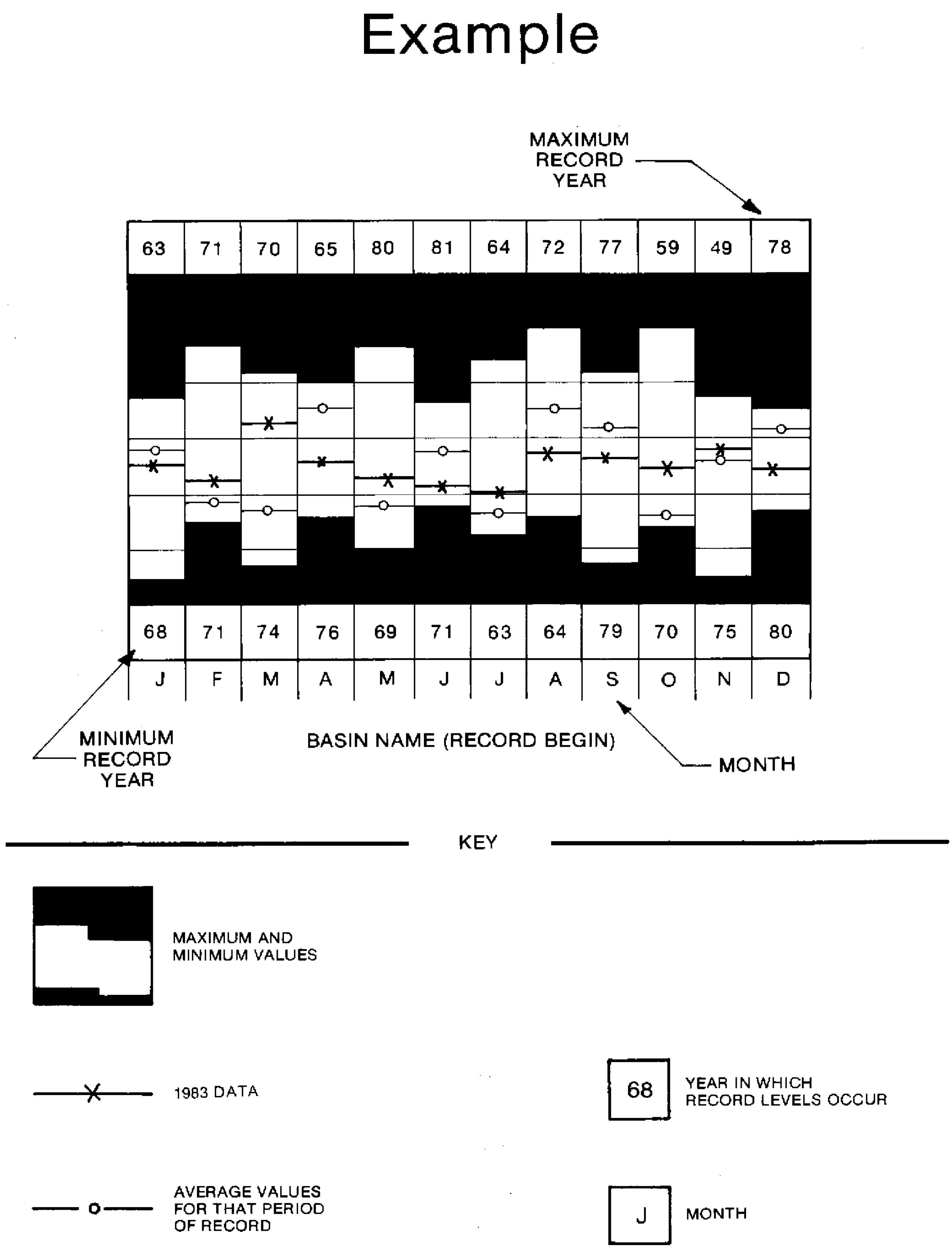


Figure 1 KEY MAP FOR RAINFALL AND DISCHARGE FIGURES

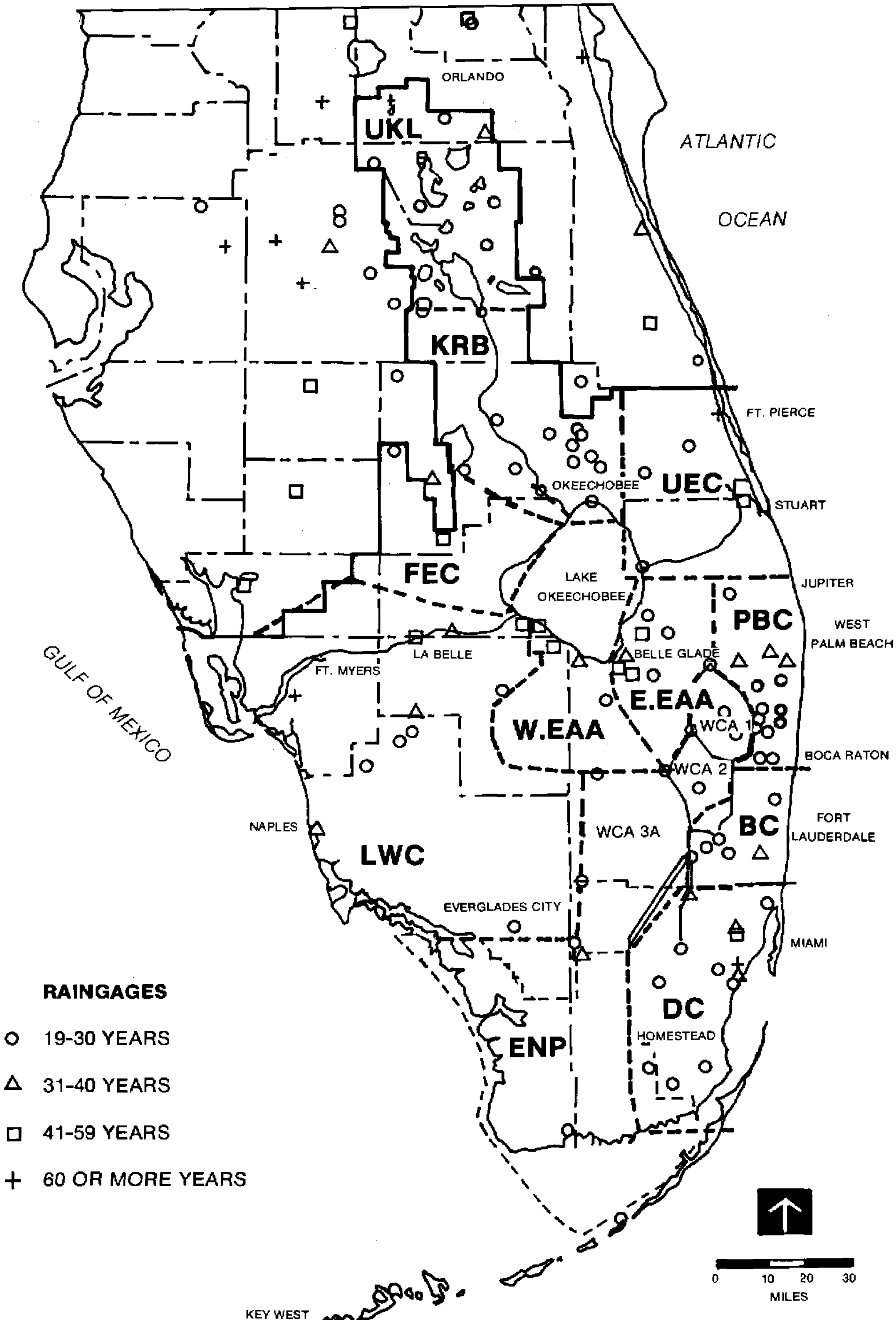


Figure 2 RAINGAGES AND BASIN BOUNDARY

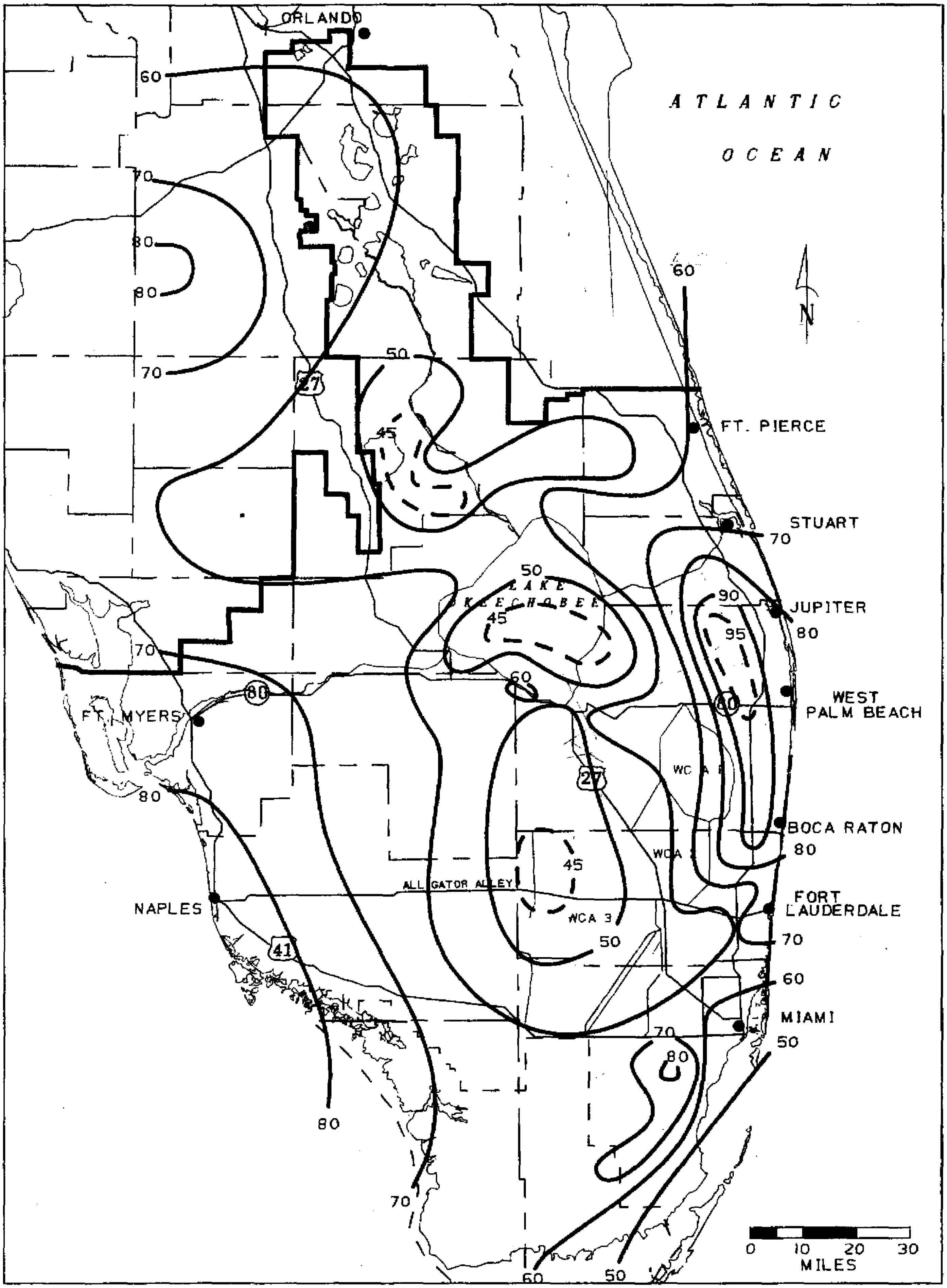
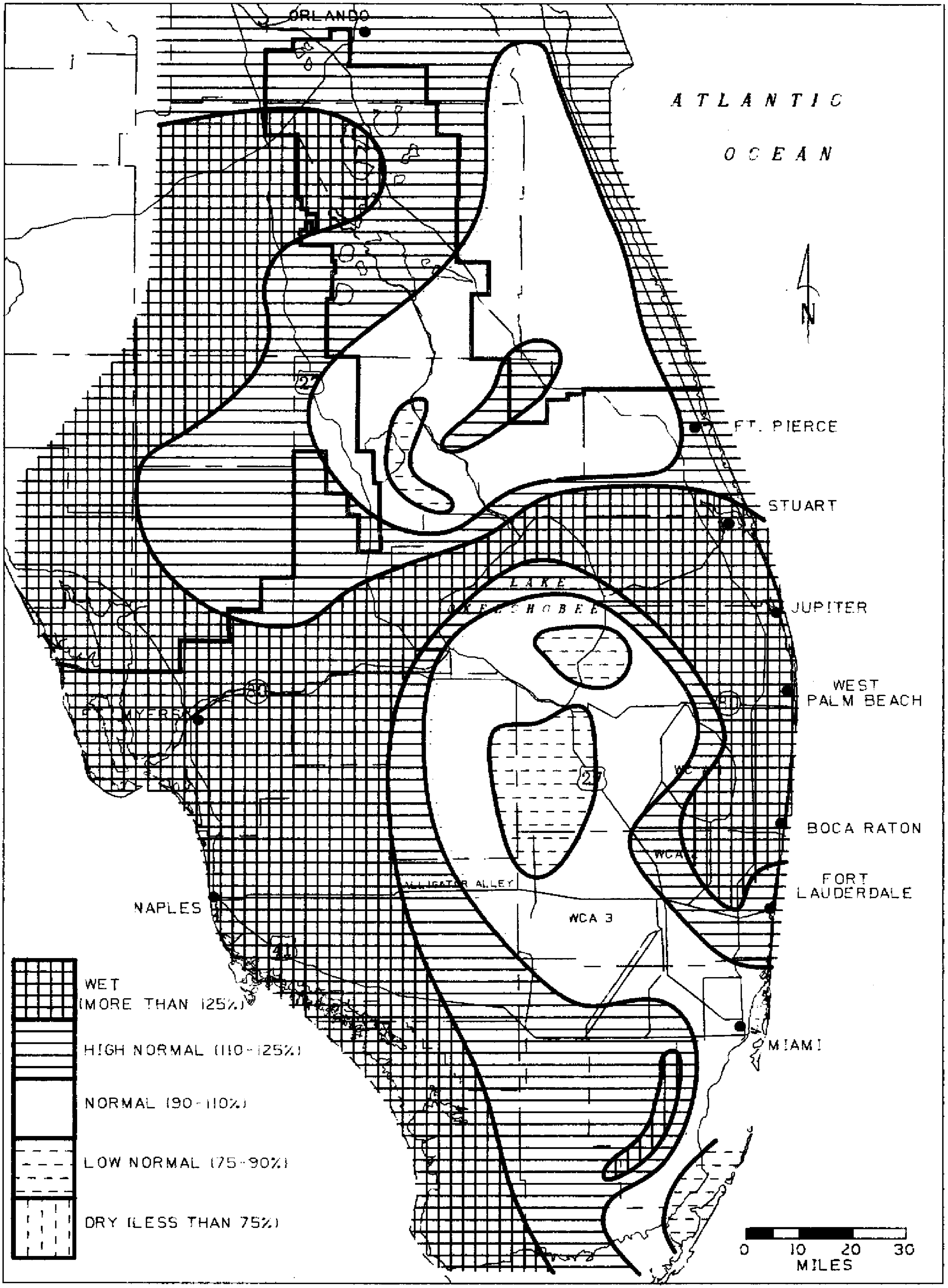


Figure 3 ANNUAL RAINFALL - 1983 (INCHES)



RAINFALL - PERCENT OF NORMAL - 1983

Figure 4

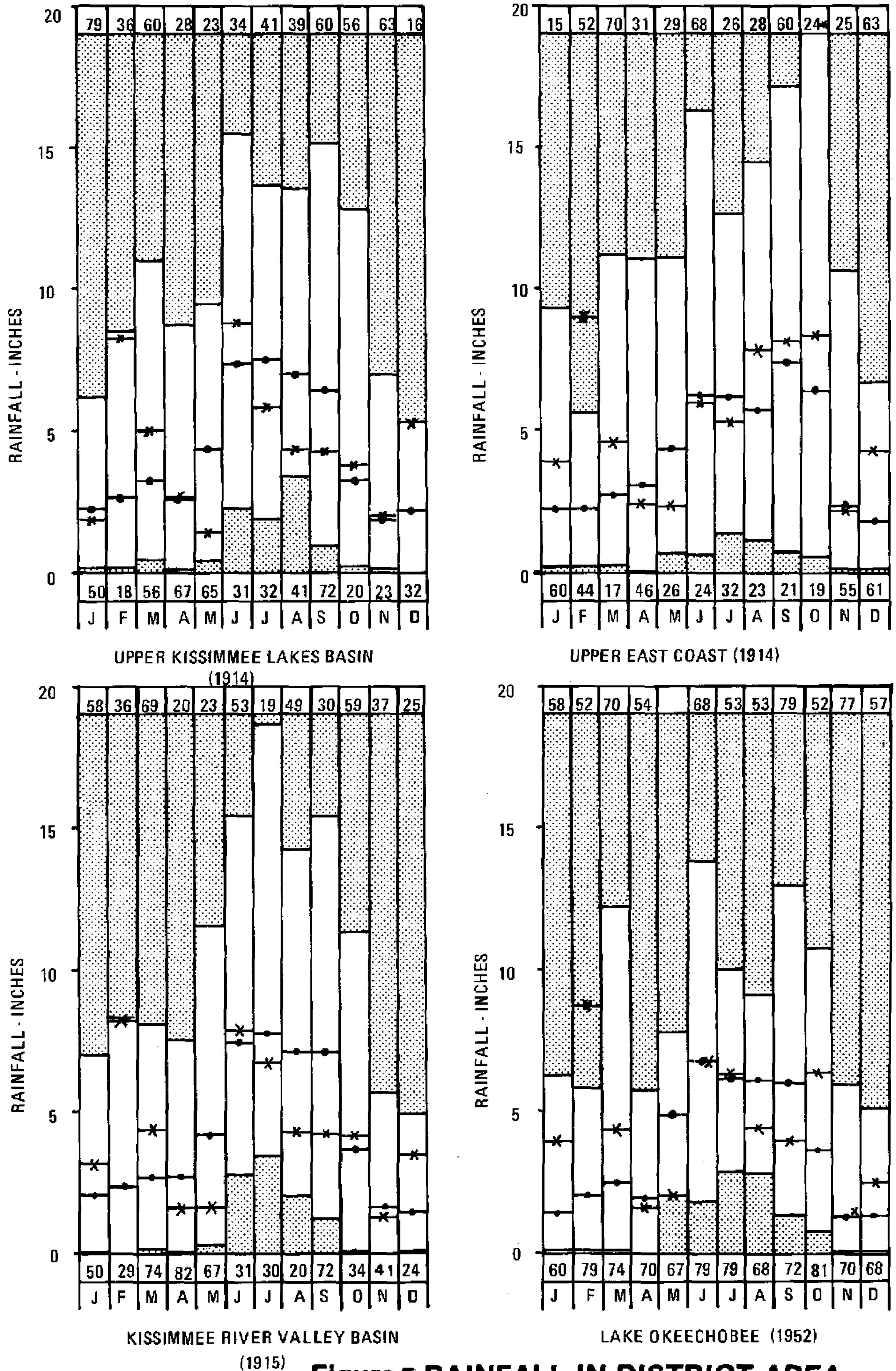


Figure 5 RAINFALL IN DISTRICT AREA

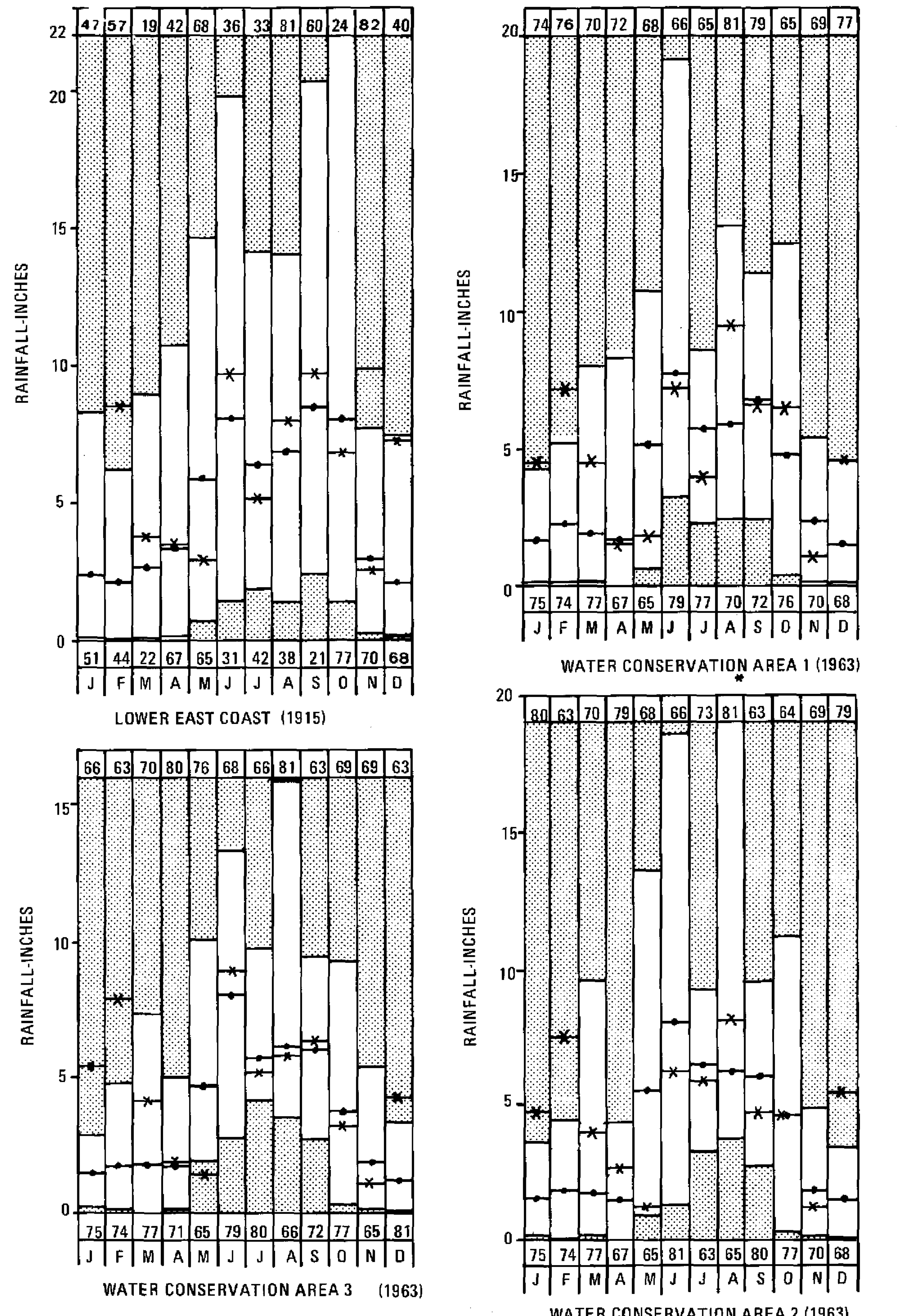


Figure 6 RAINFALL IN DISTRICT AREA

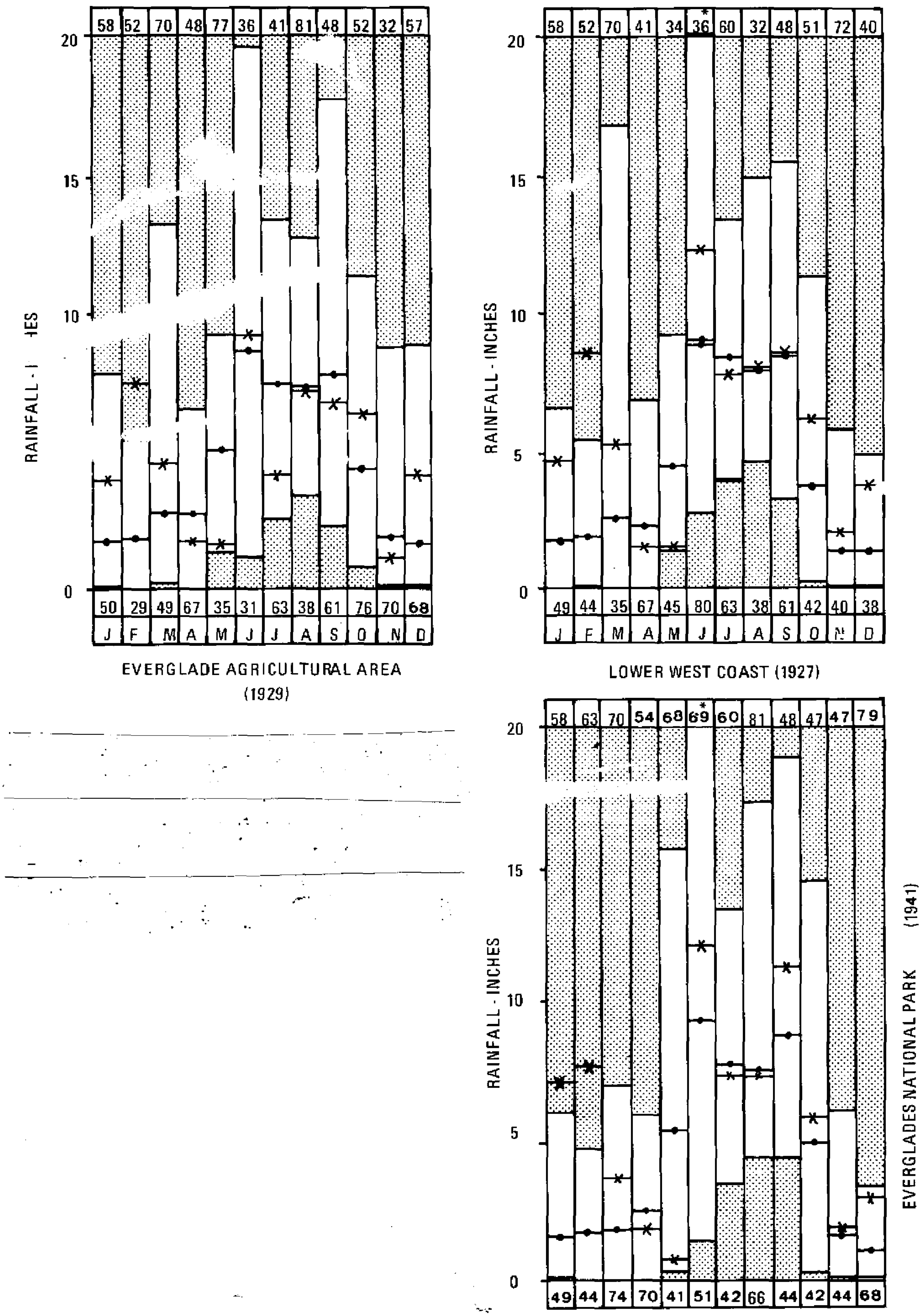


Figure 7 RAINFALL IN DISTRICT AREA

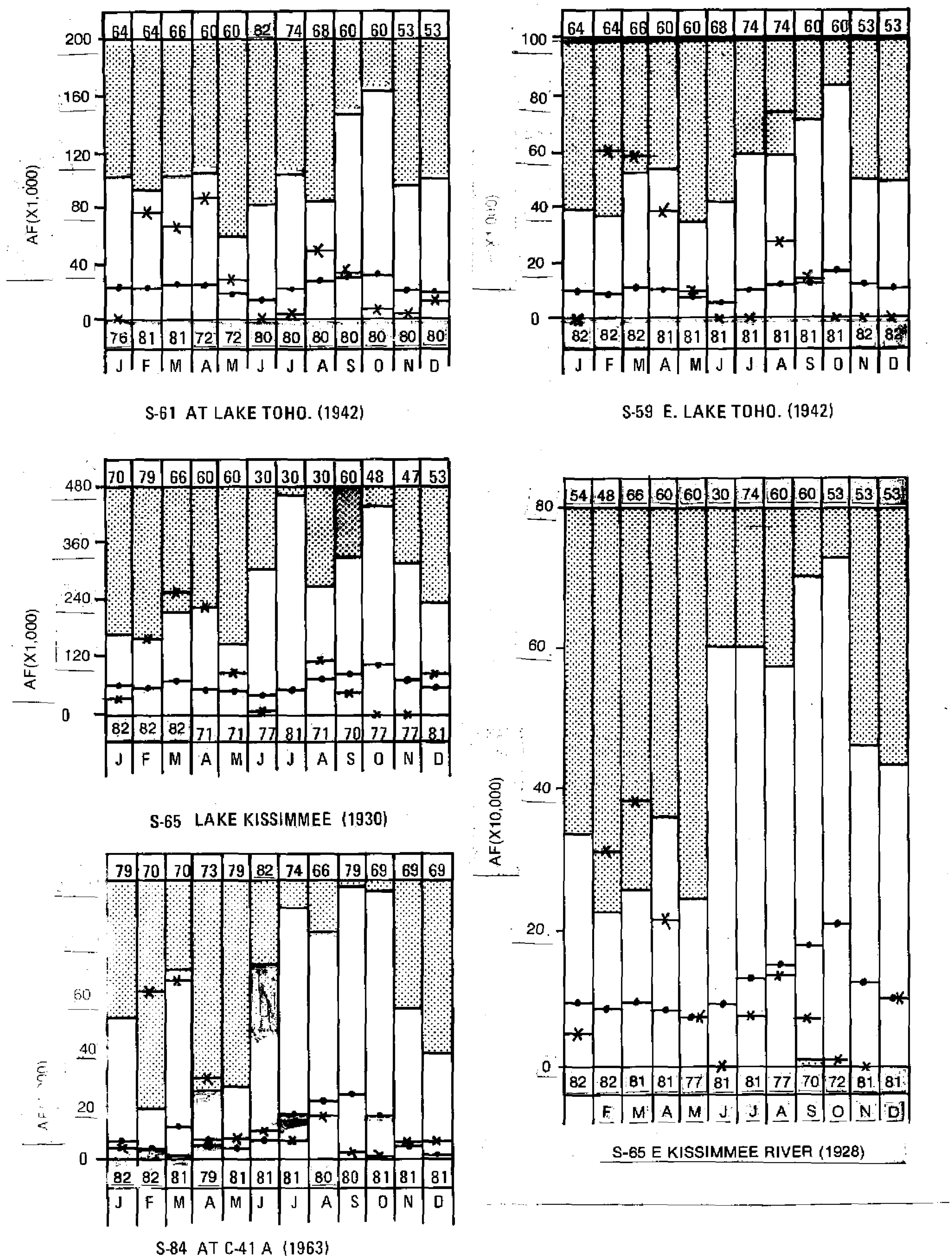


Figure 8 DISCHARGE AT UPPER AND LOWER KISSIMMEE BASINS

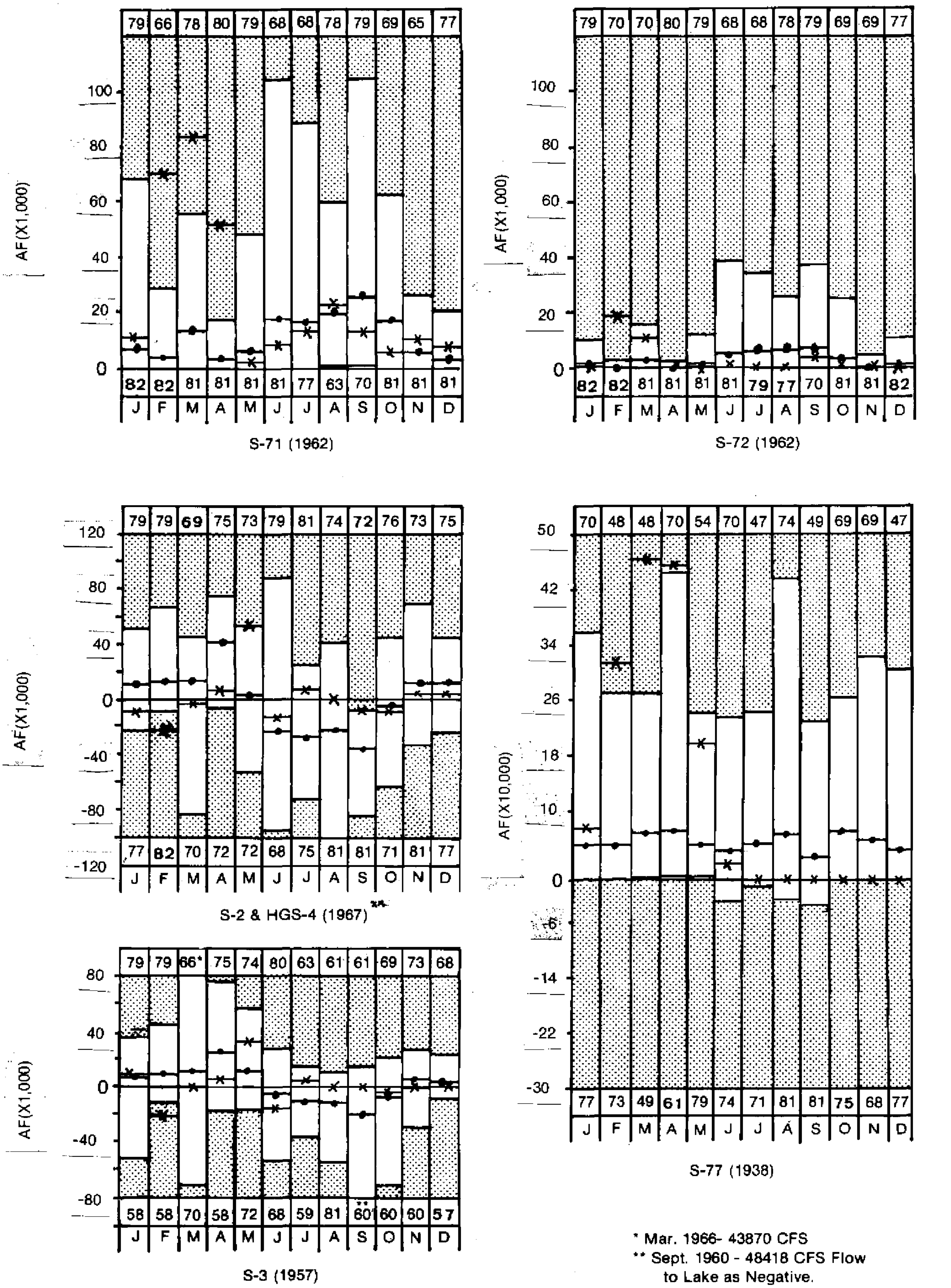
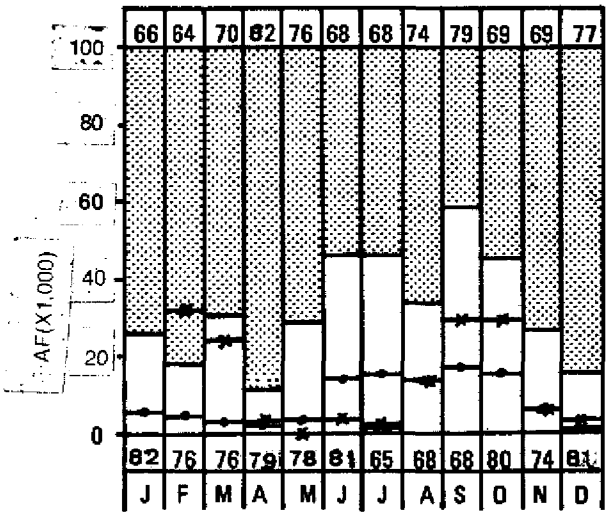
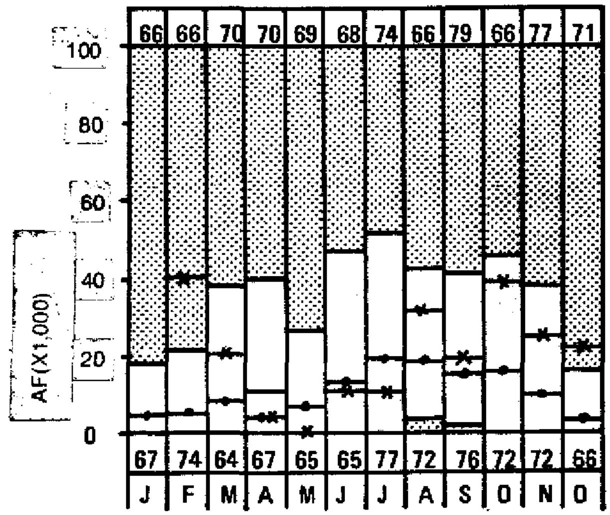


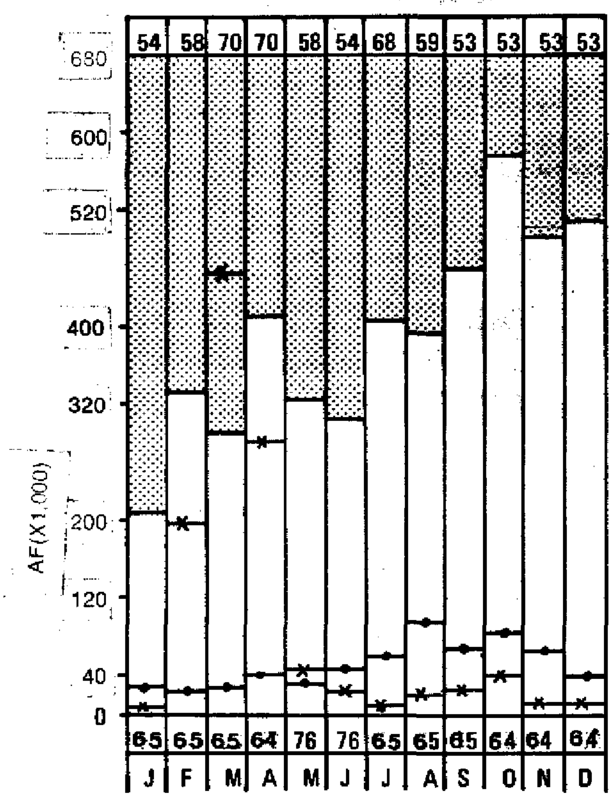
Figure 9 DISCHARGE AT LAKE OKEECHOBEE



S- 97 (1964)



S-99 (1964)



ST. LUCIE LOCK (1952) S-80

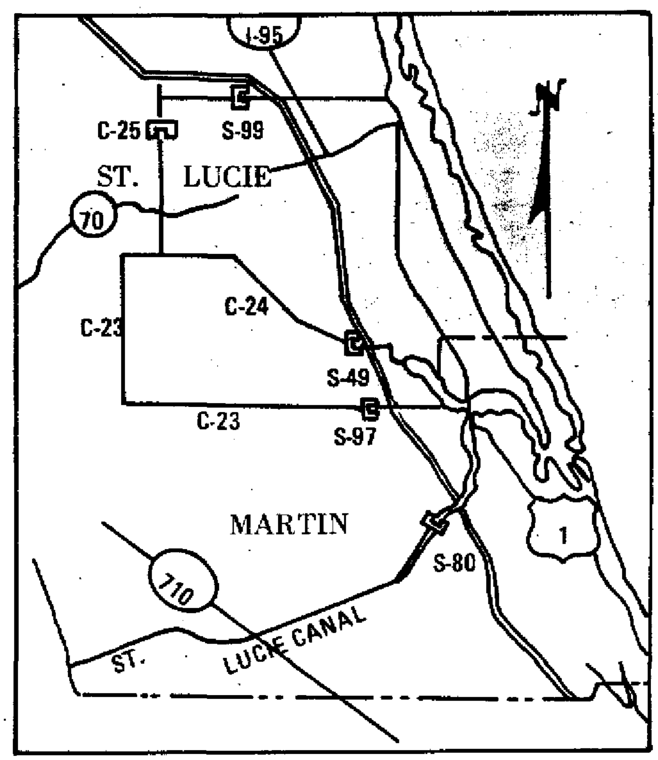


Figure 10 DISCHARGE AT UPPER EAST COAST

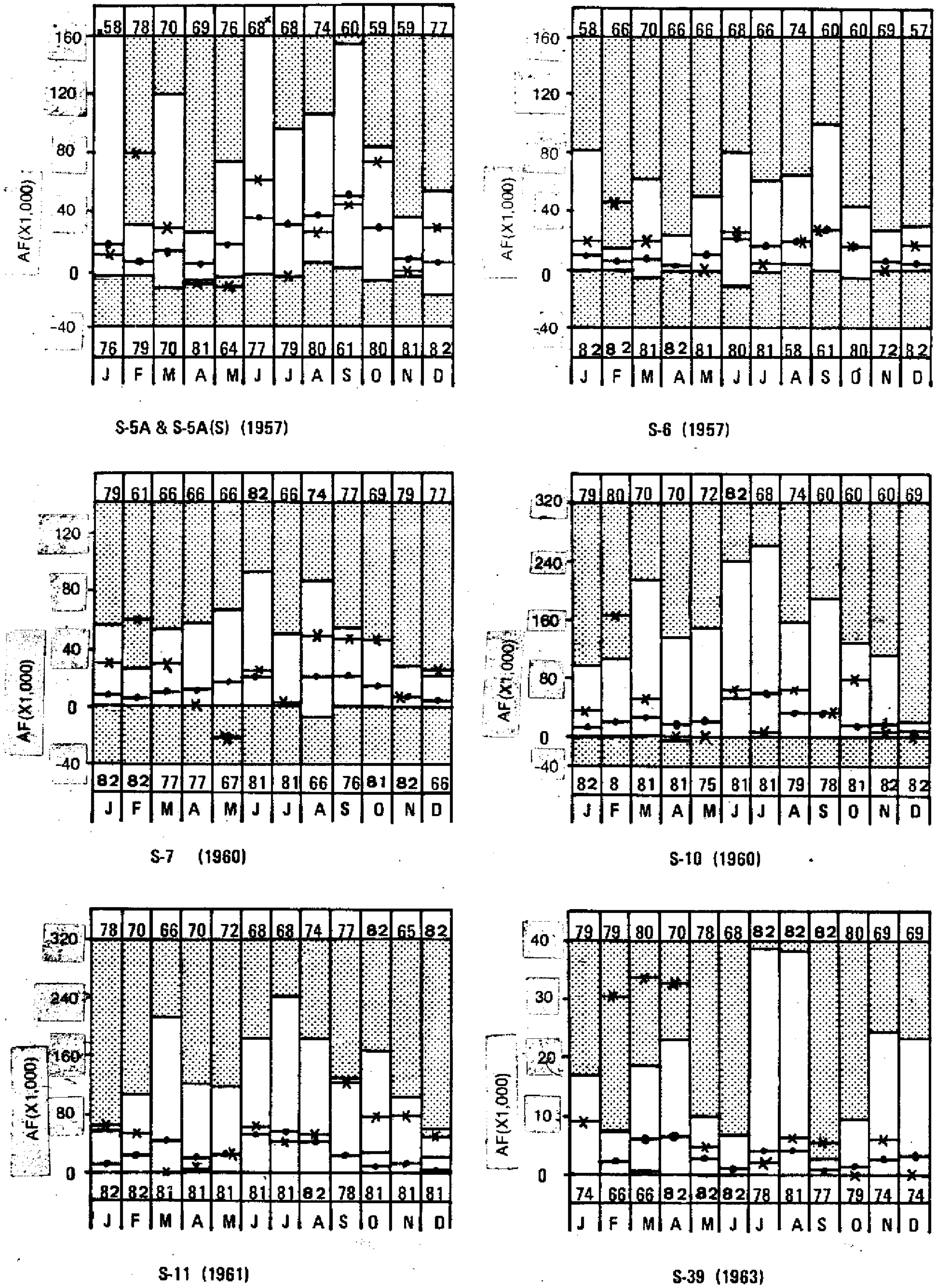


Figure 11 DISCHARGE AT WATER CONSERVATION AREAS

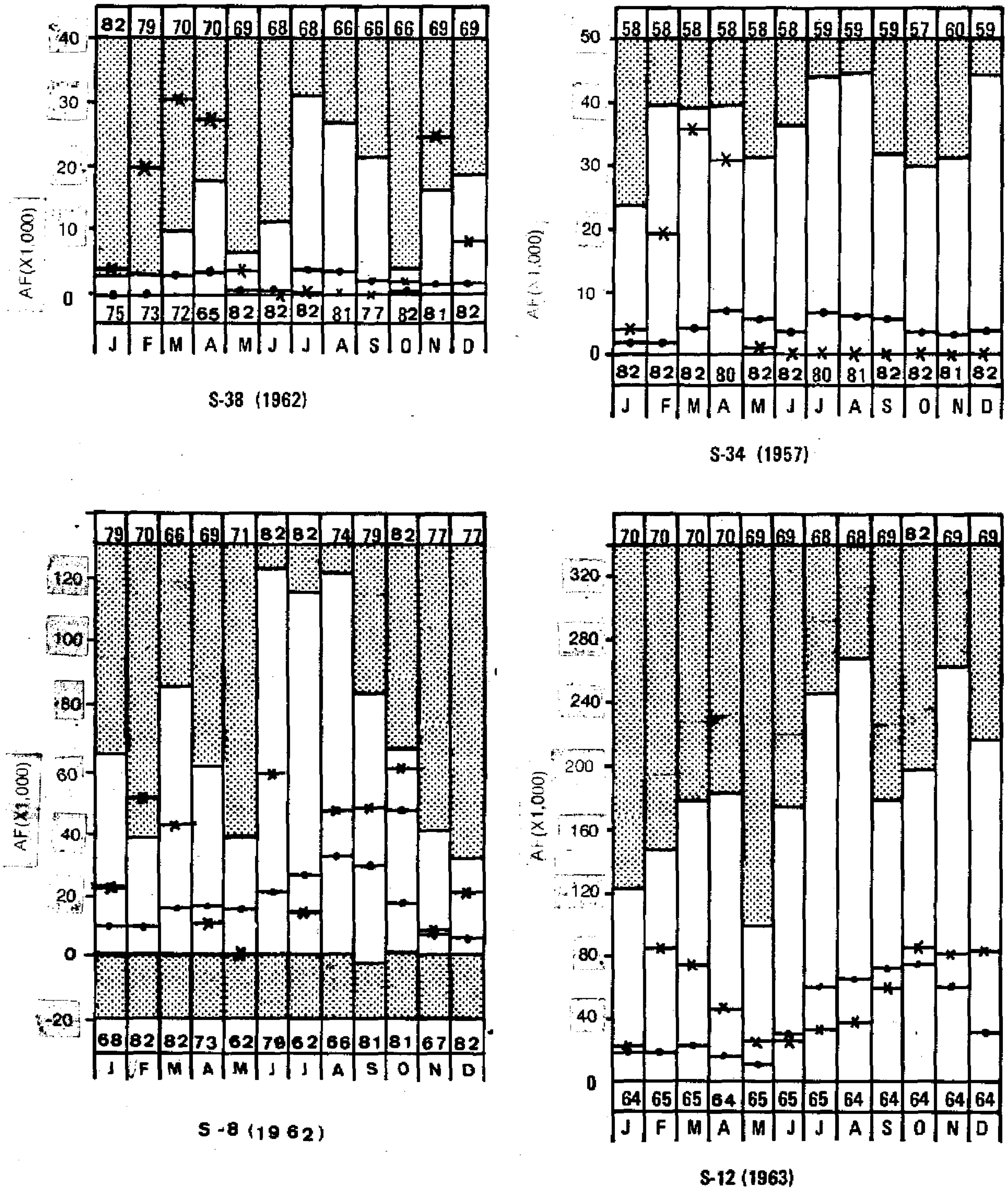


Figure 12 DISCHARGE AT WATER CONSERVATION AREAS

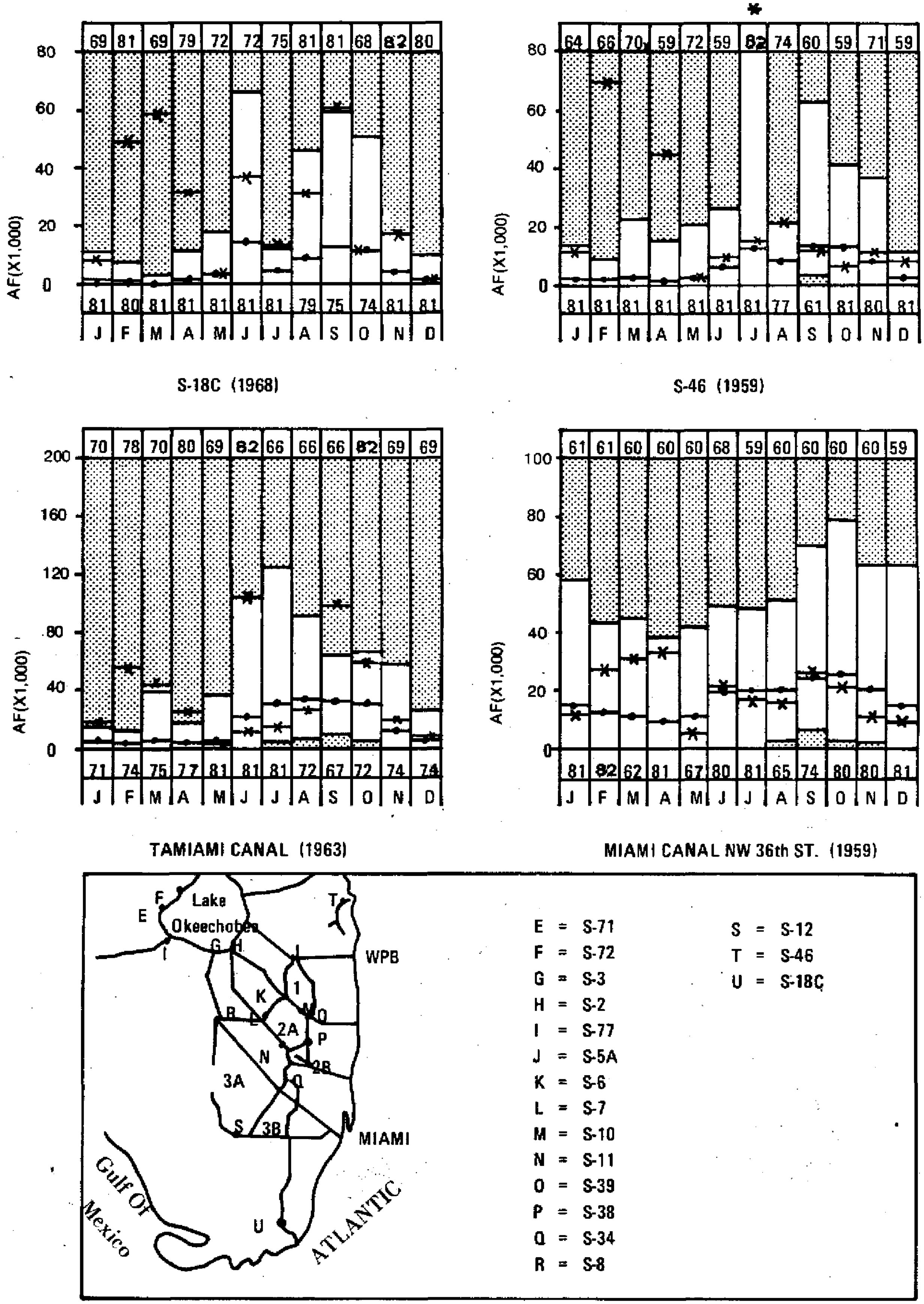
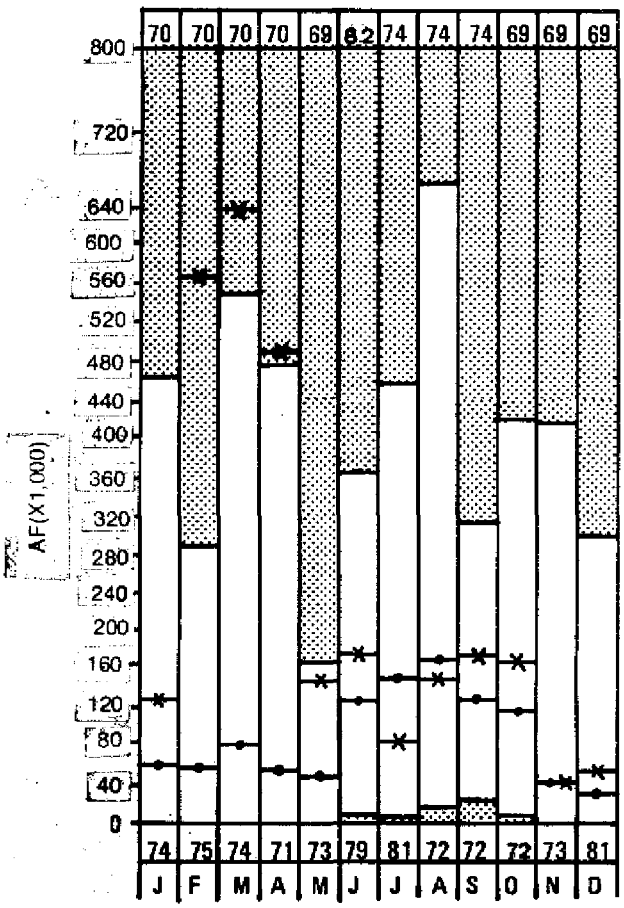
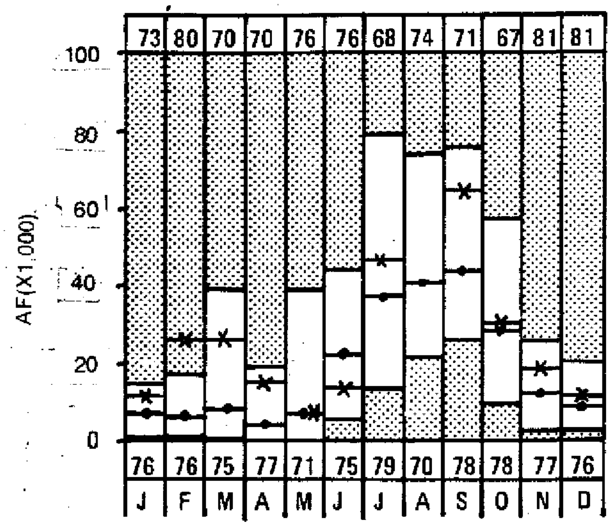


Figure 13 DISCHARGE AT LOWER EAST COAST





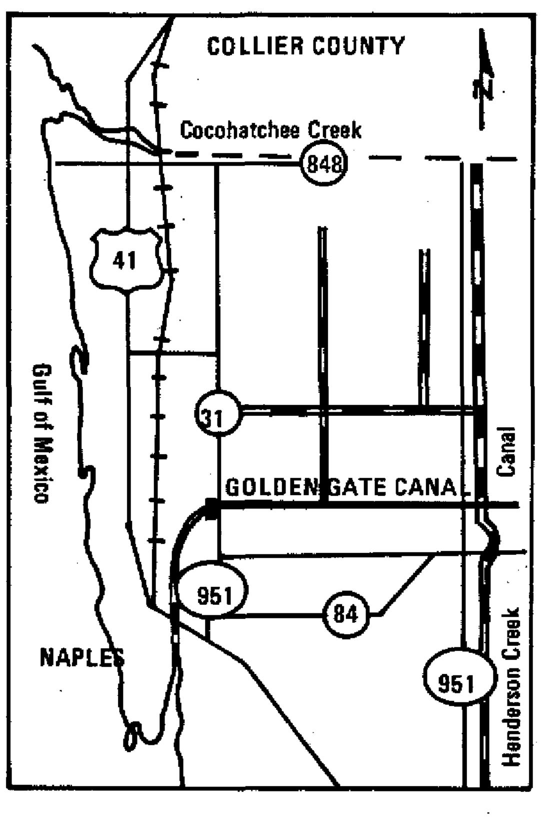
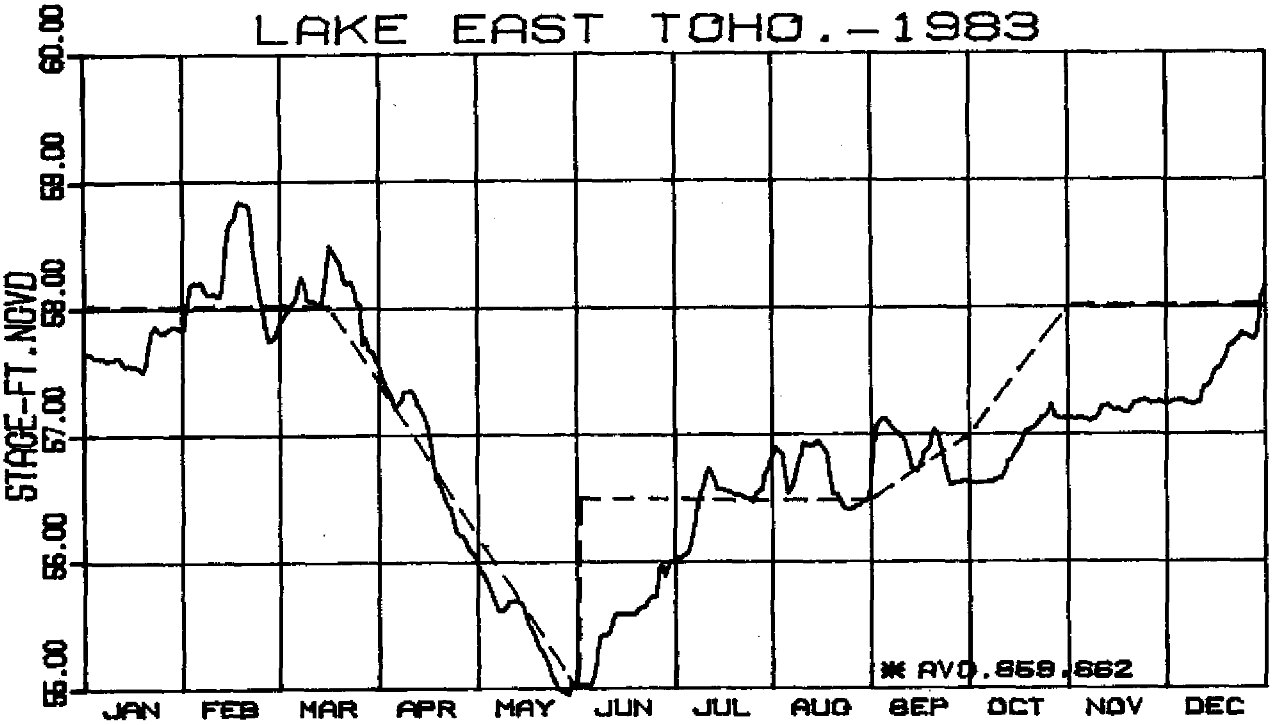
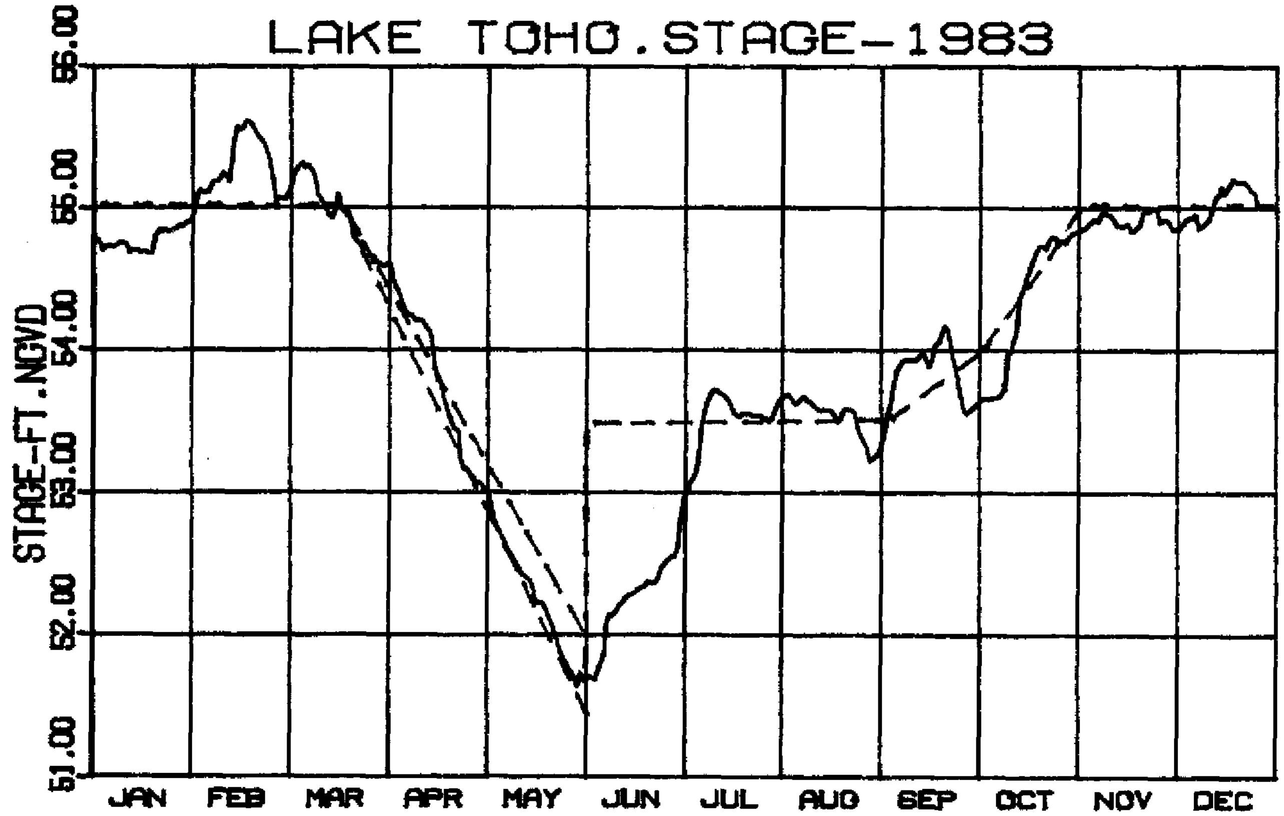


Figure 14 DISCHARGE AT LOWER WEST COAST

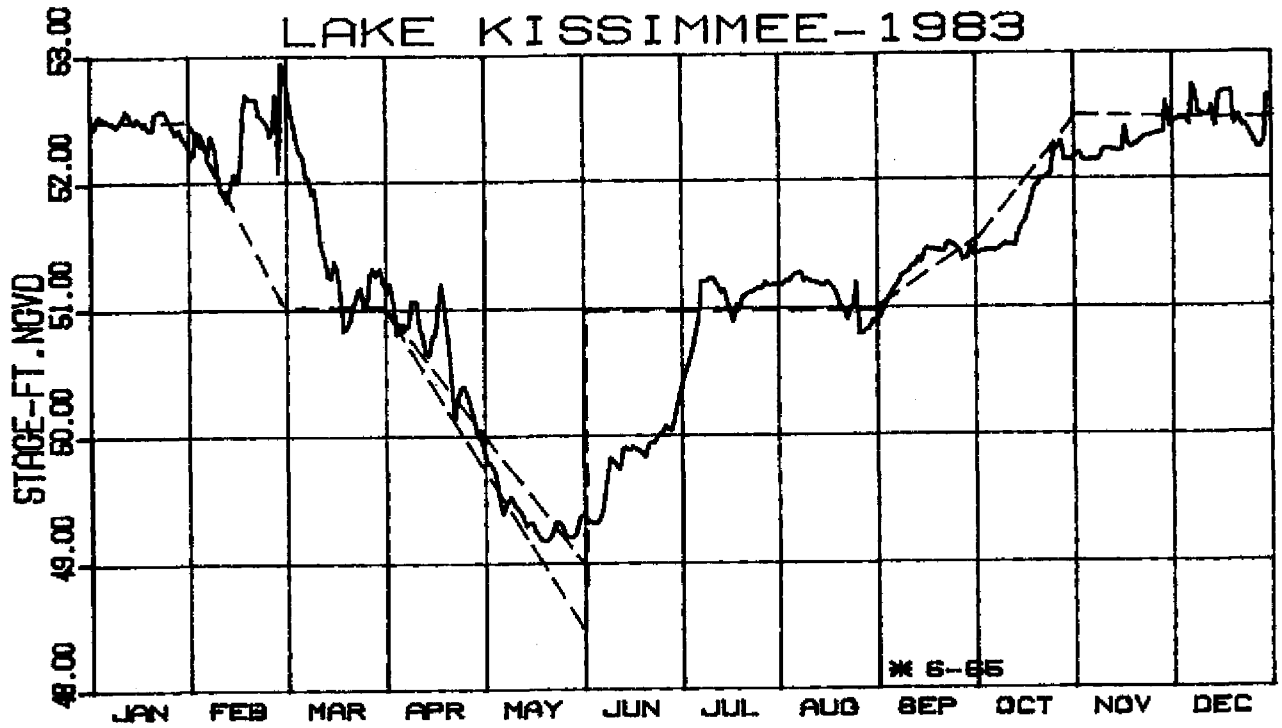


	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1983 MONTH END	57.84	57.75	57.66	56.09	55.05	55.96	56.74	56.57	56.64	57.13	57.25	58.16
MONTH END MEAN	56.26	56.10	56.07	55.52	54.90	55.14	55.58	55.99	56.87	57.14	56.89	56.58
DEVIATION	+1.58	+1.65	+1.59	+0.57	+0.15	+0.82	+1.16	+0.58	-0.23	-0.01	+0.36	+1.58

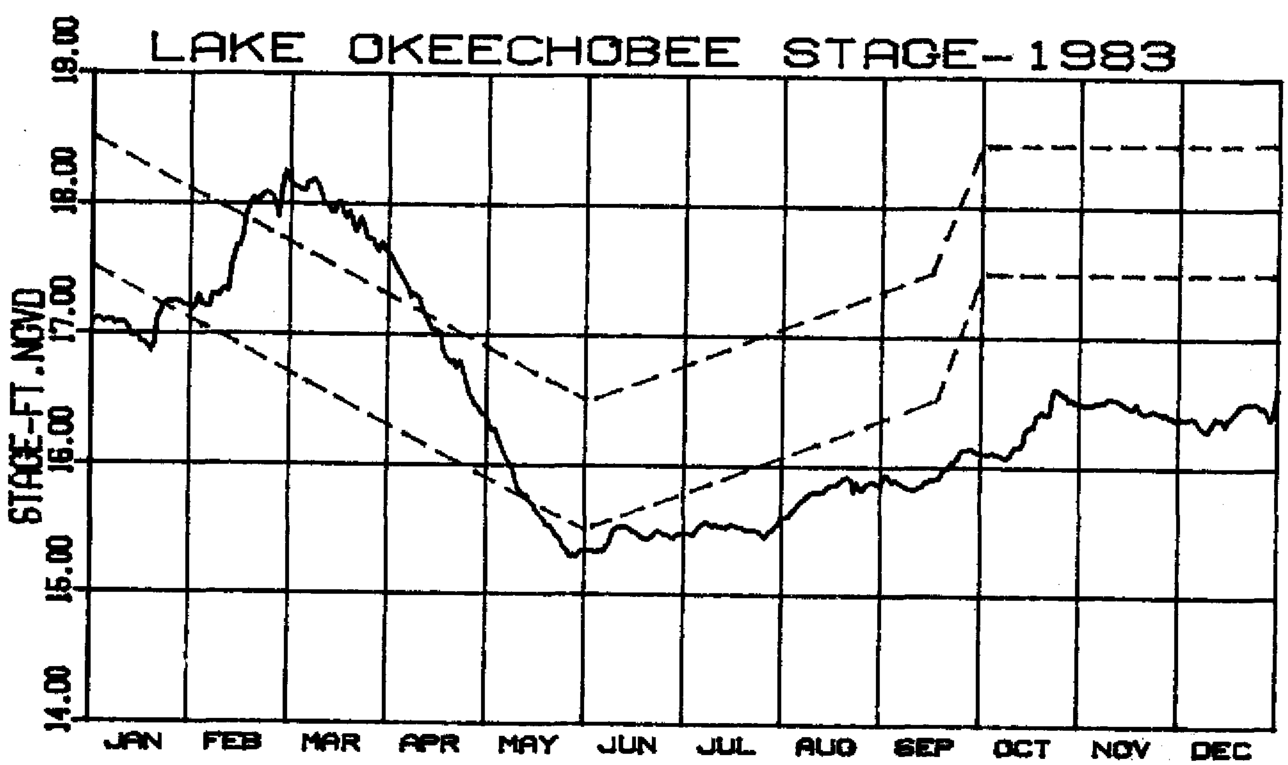


	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1983 MONTH END	54.91	55.07	54.59	53.07	51.73	52.63	53.64	53.34	53.63	54.84	54.85	54.99
MONTH END MEAN	53.58	53.38	53.33	52.68	52.17	52.45	52.81	53.27	54.01	54.22	53.97	53.79
DEVIATION	+1.33	+1.69	+1.26	+0.39	-0.44	+0.18	+0.83	+0.07	-0.38	+0.62	+0.88	+1.20

Figure 15 DAILY STAGE HYDROGRAPHS

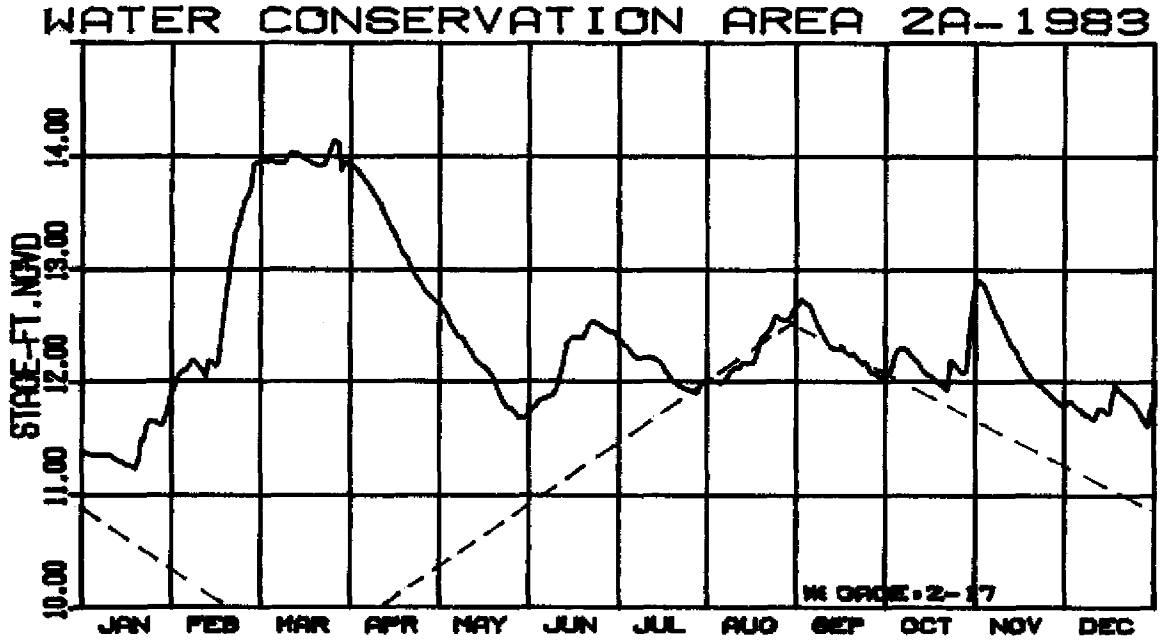


	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1983 MONTH END	52.31	52.09	51.33	50.00	49.35	50.16	51.19	50.91	51.41	52.16	52.42	52.65
MONTH END MEAN	50.51	50.83	50.08	49.66	49.17	49.48	49.88	50.41	51.30	51.50	51.16	50.78
DEVIATION	+1.80	+1.76	+1.25	+0.34	+0.18	+0.68	+1.31	+0.50	+0.11	+0.66	+1.26	+1.87

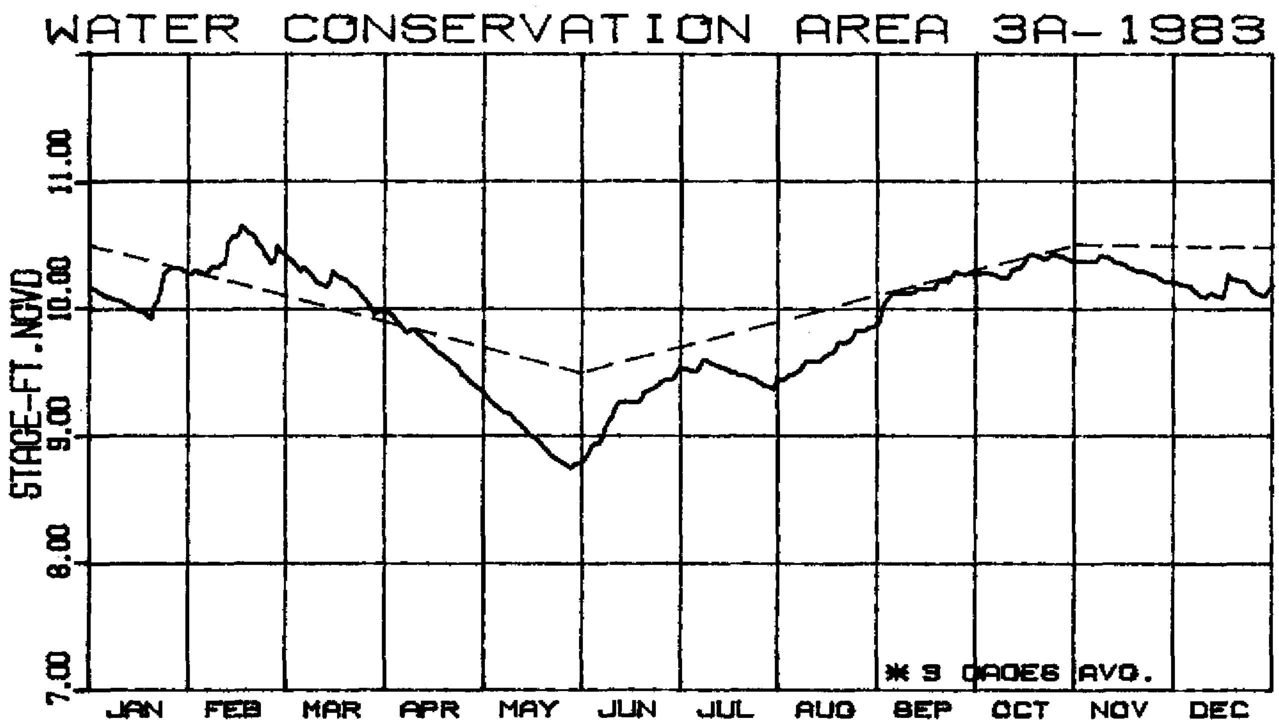


	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1983 MONTH END	12.21	18.12	17.71	16.43	15.33	15.47	15.55	15.86	16.12	16.50	16.37	16.61
MONTH END MEAN	14.62	14.49	14.25	13.71	13.37	13.63	13.89	14.19	14.91	15.17	14.98	14.79
DEVIATION	+2.59	+3.63	+3.46	+2.72	+1.96	+1.84	+1.66	+1.67	+1.21	+1.33	+1.39	+1.82

Figure 16 DAILY STAGE HYDROGRAPHS

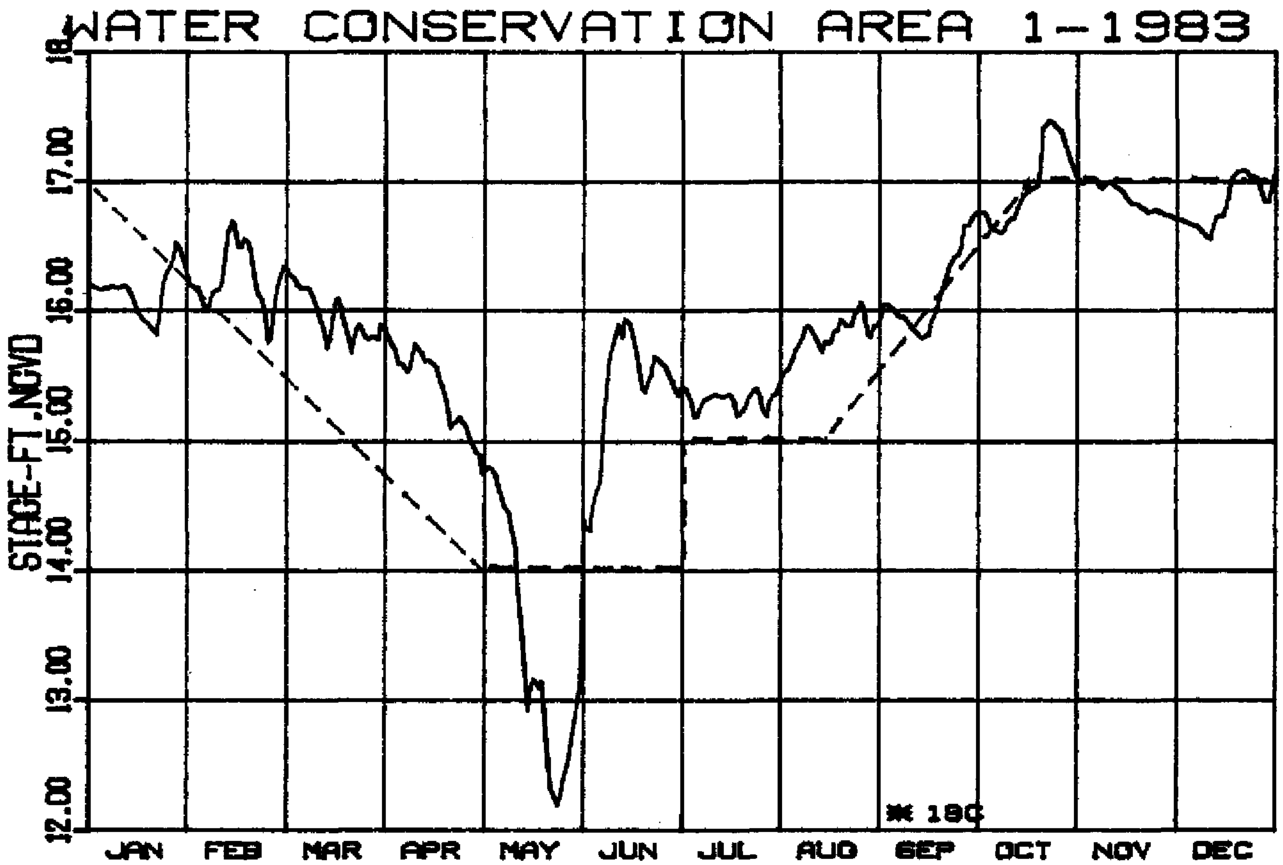


	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1983 MONTH END	11.85	13.92	13.94	12.74	11.69	12.46	12.00	12.66	12.04	12.76	11.80	11.86
MONTH END MEAN	12.77	12.61	12.28	11.91	12.08	12.62	12.85	12.94	13.29	13.30	13.09	12.89
DEVIATION (ft.)	-0.92	+1.31	+1.66	+0.83	-0.39	-0.16	-0.85	-0.28	-1.25	-0.54	-1.29	-1.03



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1983 MONTH END	10.30	10.49	9.98	9.40	8.78	9.45	9.37	9.87	10.29	10.38	10.22	10.18
MONTH END MEAN	9.18	9.02	8.71	8.15	8.34	9.24	9.54	9.82	10.17	10.06	9.80	9.49
DEVIATION	+1.12	+1.47	+1.27	+1.25	+0.44	+0.21	-0.17	+0.05	+0.12	+0.32	+0.42	+0.69

Figure 17 DAILY STAGE HYDROGRAPHS



1983 MONTH END	16.32	16.18	15.78	14.91	12.98	15.40	15.36	15.89	16.75	17.03	16.72	17.10
MONTH END MEAN	15.86	15.54	14.89	13.92	14.20	15.20	15.12	15.70	16.33	16.48	16.32	16.02
DEVIATION	+0.46	+0.64	+0.89	+0.99	-1.22	+0.20	+0.24	+0.19	+0.42	+0.55	+0.40	+1.08

Figure 18 DAILY STAGE HYDROGRAPHS