STORM EVENT OF JANUARY 15 - 17, 1991

March 1991

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Water Quality Division
Department of Research and Evaluation

Operations Division
Operations and Maintenance Department

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South Florida Water Management District
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EXECUTIVE SUMMARY

The storm event of January 15-17, 1991 is particularly significant because it occurred in the dry season and it was most severe in an area that is especially vulnerable to flood damage in the dry season. Drought conditions preceded the event, and water storage areas were far below capacity. Lake Okeechobee was at a stage of 12.17 feet above sea level before the event, slightly more than 2 feet below the long-term average and approximately 5 feet lower than the regulation schedule. The stage decline over the two years of drought had created a concern for the impact on water supply and the ecology in the Water Conservation Areas (WCAs) and Everglades National Park (ENP).

This report documents the effects of the storm on flooding, water quality (total phosphorus), and the operation of canals and water control structures in the South Florida Water Management District (District). The storm was widespread throughout the District in varying intensities, but had the most impact in Palm Beach County. The main thrust of the report is directed to the impact on the water quantity and total phosphorus loadings to Lake Okeechobee and the WCAs, and project operations in the Everglades Agricultural Area (EAA).

The intensity of the storm varied considerably throughout the southern half of the District. Total rainfall amounts ranged from a low of approximately 0.5 inches at Flamingo in Monroe County to a high of almost 11 inches at S-155 in West Palm Beach. The storm over the EAA had an estimated return frequency of once in 50 years. It was the most severe dry season storm on record since the Central and Southern Florida Flood Control Project was built.

At the time the storm occurred, South Florida was in a drought. The water levels in the WCAs increased between 0.5 feet and 2.5 feet as a result of the storm, due both to direct rainfall and inflow from the EAA. The stage of Lake Okeechobee rose 0.45 feet, from 12.17 feet to 12.62 feet. Water quality samples were collected within the EAA during and after the storm, with the primary parameter of interest being total phosphorus.

Total phosphorus concentrations from individual pumps in the EAA varied by a factor of 50 (0.029 - 1.40 mg/L) during the event. Overall phosphorus loads to the WCAs through structures S-5A, S-6, S-7, and S-8 during this event (67 metric tons) represented about 34 percent of the historical annual average for these structures. Total phosphorus loadings to Lake Okeechobee during the event (27-37 metric tons) were significant (January average is about 18.2 metric tons).

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ACKNOWLEDGEMENTS

Several Divisions and Departments of the South Florida Water Management District contributed to the preparation of this report. The efforts of the Hydrologic Data Management Division staff in retrieving and processing of data was a major factor in the prompt completion of this report. Concerted efforts by the Chemistry Laboratory and Water Quality Division's staff members made timely collection and analysis of water quality data possible. Appreciation is extended to the engineering technician staff of the Water Resources Engineering Division for their indispensable contribution in data processing, analysis, and graphics preparation. Special thanks to Nettie Winograd for participation in the preparation of the text.

I. Meteorological Description

January began with weak weather fronts moving into the South Florida Water Management District (District) and stalling before returning north. They produced little rainfall in the District, but heavy rains occurred along the northern Gulf coast. By the afternoon of January 8, it became apparent that the upper air flow was shifting into a wetter pattern for the District's southern basins. In this new pattern, weather fronts would no longer dissipate before pushing through the District from the north and they would have ample opportunity to produce heavy rains as they returned north.

The first front in this new pattern stalled over central Florida on January 8 and then received a secondary push of cool air that moved it into the Florida Straits. This system produced a District-wide average of 0.57 inches of rain between January 10 and January 12 with the heaviest activity averaging approximately 1.25 inches along the southwest coast and the Caloosahatchee River. As this front began to return north from the Florida Straits on the morning of January 15, a low pressure system developed over the southeastern Gulf of Mexico. This is a classic rain producing pattern during the winter in Florida. The system developed rapidly, pulling moist tropical air over the surface front which resulted in rain. As the low pressure in the Gulf moved across the District from Naples to West Palm Beach, an upper air disturbance enhanced the rainfall intensity to produce the extremely heavy rain. This system produced an average of 3.5 inches on the District on January 15. Heaviest rainfall amounts occurred in the Everglades Agricultural Area (EAA) and eastern Palm Beach County with rainfall amounts of 7-8 inches commonplace. Approximately 11 inches of rain fell at S-155, the coastal control structure on the West Palm Beach Canal. An additional 0.25 inches fell inland on January 16, with about 0.5 inches along the east coast.

II. Rainfall Analysis

A. <u>Spatial and Temporal Distribution of the Storm</u>

At the time the storm occurred, South Florida was more than two months into the dry season and there was consideration of imposing further water restrictions. The EAA had been under a Phase III water shortage declaration for 14 months. Average rainfall in South Florida for January 1991 was slightly more than 1.5 inches prior to January 15, which was slightly above normal; Lake Okeechobee was at a significantly low stage of 12.17 feet. The decline in water levels in the Water Conservation Areas (WCAs) was a cause for concern for water supply and represented a threat to wildlife.

Figure 2-1 shows the spatial distribution of the storm. The isohyets indicate that the major part of the storm was concentrated along a narrow strip from the west coast of Collier County to the east coast of Palm Beach County, bounded by Lake Okeechobee on the north and WCA-3 on the south. The daily rainfall amounts and locations of recording stations (Figure B-1) used to develop this map are presented in the Appendix.

Although rainfall was reported for all gages in the area from January 14-17, the major portion of the storm occurred between the morning of January 15 and the morning of January 16. Figure B-2 shows the isohyetal map for the maximum 24-hour rainfall for this time period. As shown by the isohyets, the spatial distribution of the maximum 24-hour rainfall is similar to that of the total storm. The locations of the hourly rainfall stations that were used to construct this map are presented in Figure B-3. The maximum 24-hour rainfall data with the time of occurrence are shown in Table 1.

Rainfall stations with hourly readings offer the best data to evaluate the intensity of rainfall on an area and its temporal distribution. The intensity is also a factor that determines how fast runoff or flooding occurs. Using the hourly rainfall data from the stations shown in Figure B-3, hourly rainfall distributions (hyetographs) at various locations are shown in Figures B-4 to B-23 The time span of the hyetographs is from noon on January 14 until 11:00 on January 17. Most of the rain fell during the afternoon of January 15 and the morning of January 16, as is shown by the hourly hyetographs. The maximum one hour rainfall data for selected stations are shown in Table 2. It should be noted, however, that the values in Table 2 and the values used to plot the bar graphs in Figures B-4 through B-23 were derived from strip charts. While data from this type of chart are accurate for daily or weekly rainfall amounts, the resolution on the charts makes hourly data less accurate.

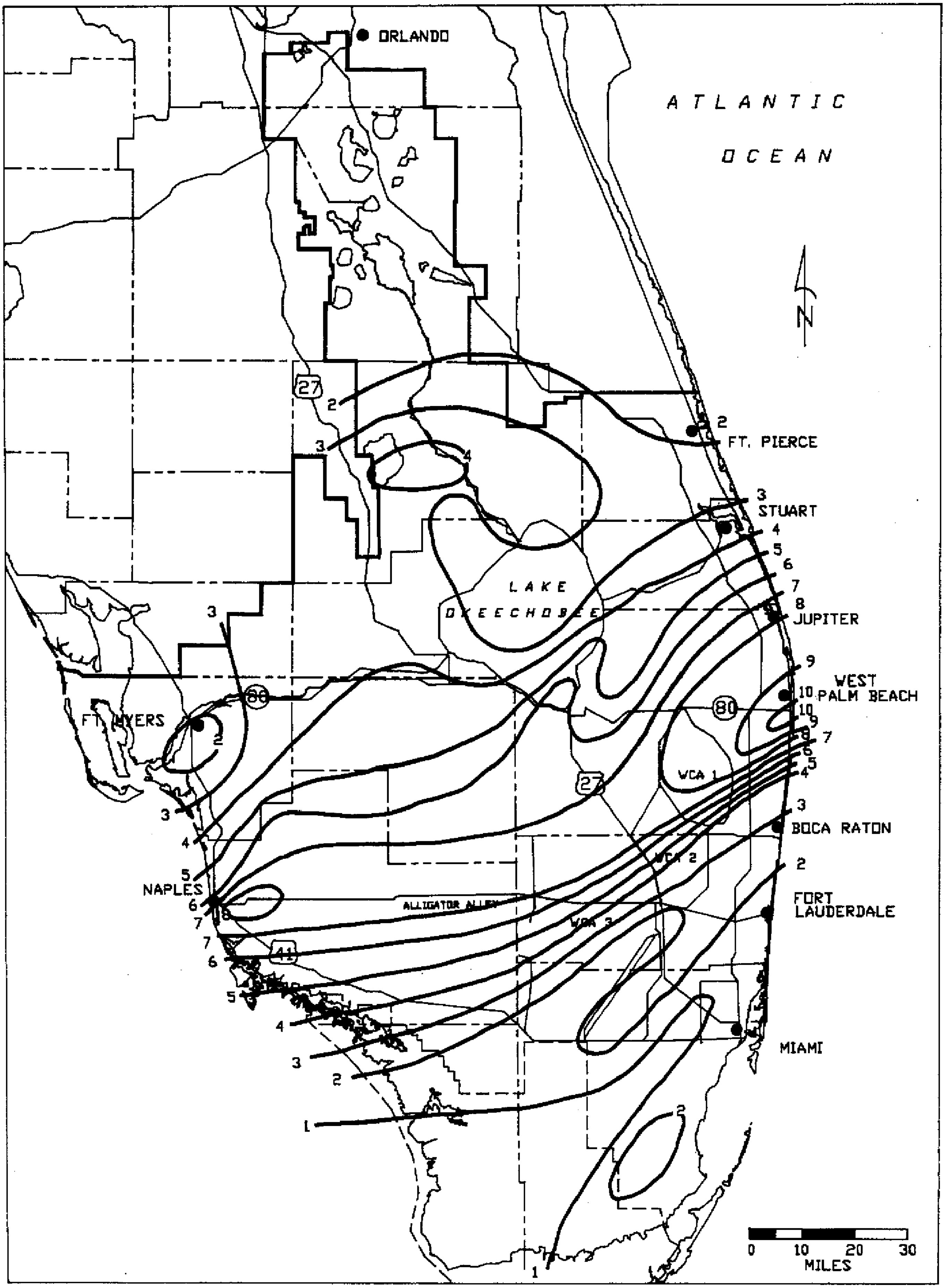


Figure 2-1. Isohyetal Map of the January 1991 Storm

TABLE 1. Maximum 24-Hour Rainfall

Station (MRF #)	Basin	Beginning Hour†	Rainfall (inches)
43	S-65D	1100	3.31
48	C-41	1000	3.74
52	S-131	0800	3.12
68C	S-236	0900	3.92M
71	S-3	0900	6.35
73	S-2	0900	5.52
76	S-5A	1300	7.21
89	C-16/WCA 1	1000	8.81
95	S-6	1200	7.50
98	S-8	0100	6.78M
99	S-7/WCA 2	0900	6.83
106	WCA 2	0800	3.75
115	C-11W/WCA-3	0800	1.28
131	S-5A	1000	4.35
145	WCA 3	0400	5.57
182	C-159	0400	4.75M
282C	S-3	1100	5.01M
311	West Collier	0900	8.02
379	C-159	0900	5.12
401	Dade County	0500	2.27

M - contains missing data; †January 15, 1991

B. Frequency Estimation

The total rainfall recorded for this event is not unusual for South Florida, but the timing of this event was. The average January rainfall for South Florida is 1.93 inches. The highest recorded January rainfall prior to 1991 was 11.82 inches in 1974 at station MRF 84, located at Boynton Road and Military Trail in Palm Beach County. This amount was exceeded in 1991 with 12.40 inches of rainfall recorded at station MRF 81 located at Lake Worth Road and Lake Worth Drainage District's E-1 canal, also in Palm Beach County. The significance of this storm event can be understood in relation to the historical data for the month of January. Fifteen stations in South Florida established new record rainfall amounts for the month of January in 1991. The isohyetal maps for January 1991 and for historical normal rainfall for January are shown in Figures B24 and B25 respectively. It can be seen by comparison that in many areas January 1991 was much wetter than normal.

TABLE 2. Maximum Hourly Rainfall Intensities at Selected Stations

Location	Beginning Hour and Date		Rainfall Intensity (in/hr)
S-3 Basin (MRF 71)	20:00	1/15	1.70
S-2 Basin (MRF 73)	01:00	1/16	1.12
S-5A Basin (MRF 76)	01:00	1/16	1.45
S-6 (MRF 95)	01:00	1/15	1.45
C-16/WCA-1 (MRF 89)	01:00	1/15	2.34
S-7/WCA-2 (MRF 99)	01:00	1/15	1.03
WCA-2 (MRF 106)	02:00	1/15	1.15
WCA-3 (MRF 145)	10:00	1/15	1.10
West Collier Co (MRF 311)	05:00	1/16	1.97

Rainfall in the EAA averaged 6.6 inches during January 15-17, 1991. This represents the greatest three-day dry season (November through April) rainfall event in the EAA on record. The previous record of 6.0 inches occurred March 25-27, 1970.

The three-day January 1991 EAA rainfall has a return period of 50 years, based on an extreme value frequency analysis performed on 31 years of dry season rainfall. In other words, there is but a 2 percent chance (1-in-50) the EAA would experience such a storm during any dry season. Maximum three-day EAA rainfall was determined for each of the dry seasons from 1960 to 1991. The values were fit to the Gumbel extreme value distribution. The fit of the data to the distribution was validated using the Kolmogorov-Smirnov goodness-of-fit test. The results gave a significance level of 0.80, which means the probability that the data do *not* follow the distribution is small (20 percent). The exceedance probability curve (assuming the data follow the Gumbel distribution) and the three-day EAA dry season maxima are plotted in Figure 2-2. Also from this analysis, the March 1970 storm has a return period of 30 years.

A distinction between wet season and dry season storms is important in terms of flooding potential for a given magnitude storm event and flooding effects on lands under agricultural production in South Florida. Three factors: areal storm distribution, cropping patterns, and antecedent moisture conditions make this distinction important.

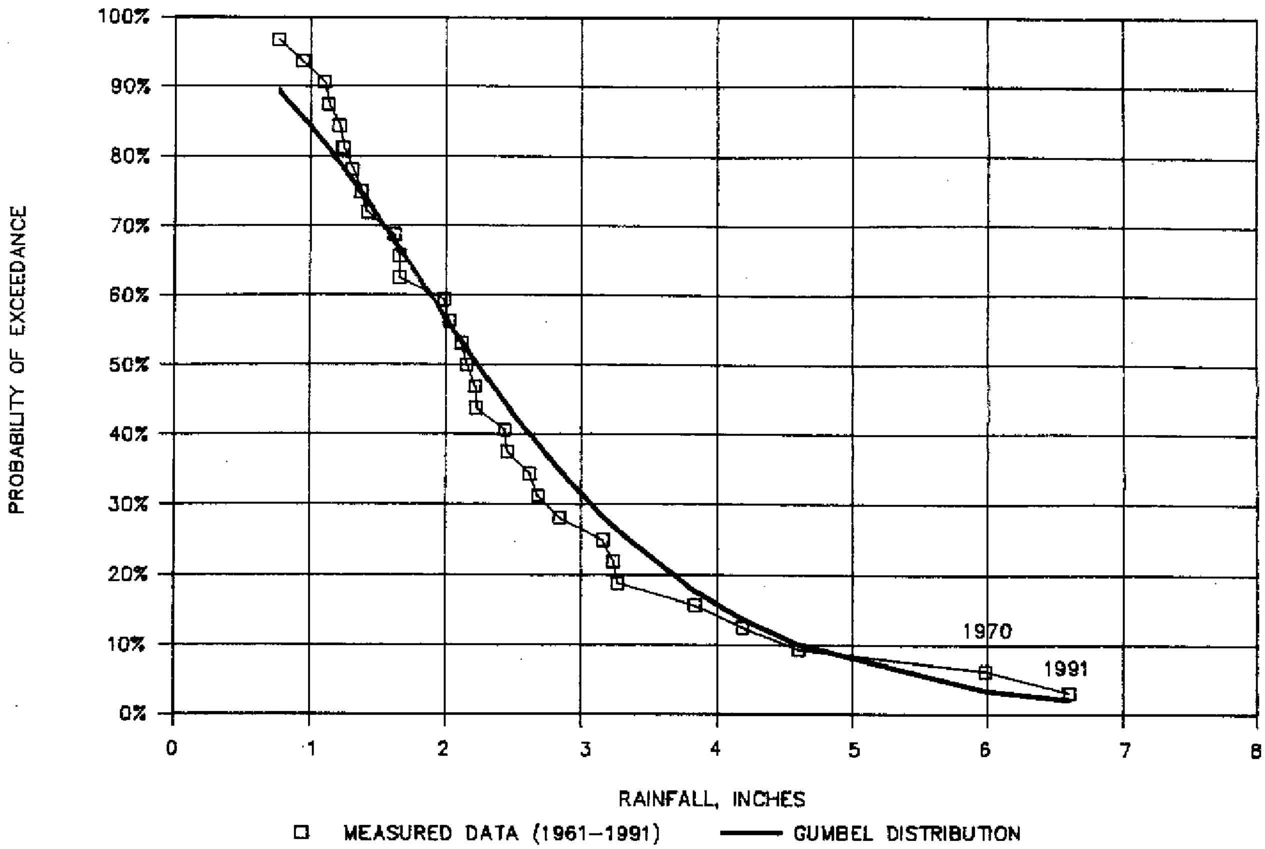


Figure 2-2. Exceedance Probability and Maximum 3-Day Rainfall Distribution Over the Everglades Agricultural Area in the Dry Season

Large dry season storms are most often the result of stalled frontal activity which is much more likely to cover large areas uniformly than the small and very intense thunderstorms associated with wet season rainfall. The terrain and flood control system characteristics in South Florida make the magnitude of flooding more dependent on the total volume of rainfall over a basin than on short-duration rainfall intensities or on isolated locations with very intense rainfall. The rainfall which occurred during the January 15-17 storm was of the type which covered large areas with uniformly high rainfall amounts.

Vegetables in South Florida are grown commercially mainly during the dry season because of disease and drainage problems during the summer months. Vegetables are much more sensitive to duration of flooding than other crops such as sugar cane, rice, and citrus which are grown year round. Dry season storms are thus likely to be more damaging.

In areas which are not devoted to irrigated agriculture, dry season storms generally produce less severe flooding for the same size rainfall event than wet season storms. This is because the soil is able to absorb more of the rainfall when it is dry than when it is saturated from previous rain events. This is not necessarily the case in areas like the EAA. The EAA had been undergoing water rationing prior to January 10. Water restrictions were severe enough to stress many of the crops being grown. This continuing shortage created an atmosphere where farm managers would retain as much water as possible on their lands from both irrigation supply and limited rainfall. Rainfall from January 10 to January 12 essentially filled all available soil moisture storage creating the potential for more severe flooding should a rare large dry season storm occur.

III. Effects in the Everglades Agricultural Area

The EAA was the area within the District most seriously affected by the January 1991 storm. The storm caused widespread, persistent flooding and resulted in significant economic losses to the vegetable industry in Palm Beach County, according to representatives from the agricultural industry. The EAA is unique in the complex relationships among the land itself, agricultural water control practices, the design of the federal flood control facilities, and state policy changes which affect the operation of the federal project. All of these factors came into play in the January 1991 storm.

A. The Federal Project in the EAA

The federal flood control system which was designed to serve the EAA consists of four major canals and six major pumping stations. The design drainage basins for these canals and their associated pumping facilities are shown in Figure 3-1. The West Palm Beach Canal basin is served by the S-5A pump station which pumps directly into the Arthur Marshall Loxahatchee National Wildlife Refuge (WCA-1). The Miami Canal basin contributes storm runoff to the S-3 pump station to the north into Lake Okeechobee and the S-8 pump station to the south, which pumps into WCA-3A. The Hillsboro and North New River Canal basins are interconnected by the S-2 Pump Station located at their northern intersection which pumps into Lake Okeechobee. The Hillsboro basin is also served by S-6 on its southern end which pumps runoff into WCA-1; the North New River basin is served by S-7 on its southern end which pumps runoff into WCA-2A.

This water control system, designed in the early 1950s, provides storm water removal capability of up to 0.75 inches in 24 hours from the contributing drainage areas. This capacity was selected based upon engineering studies by the U. S. Army Corps of Engineers (Corps) as being sufficient to keep crop damages to a minimum for storms with a return frequency up to once in six years. The duration of surface flooding for these events would be kept to less than 24 hours with these project facilities (Appendix Figure B-37, line A; Partial Definite Project Report, Part 1, Central And Southern Florida Project, USACE, 1951).

B. The Land

The defining feature of the EAA is the rich organic soil which has enabled the development of a large, productive agricultural industry. The land is flat, which requires that all water removal for flood control be accomplished with pumps both

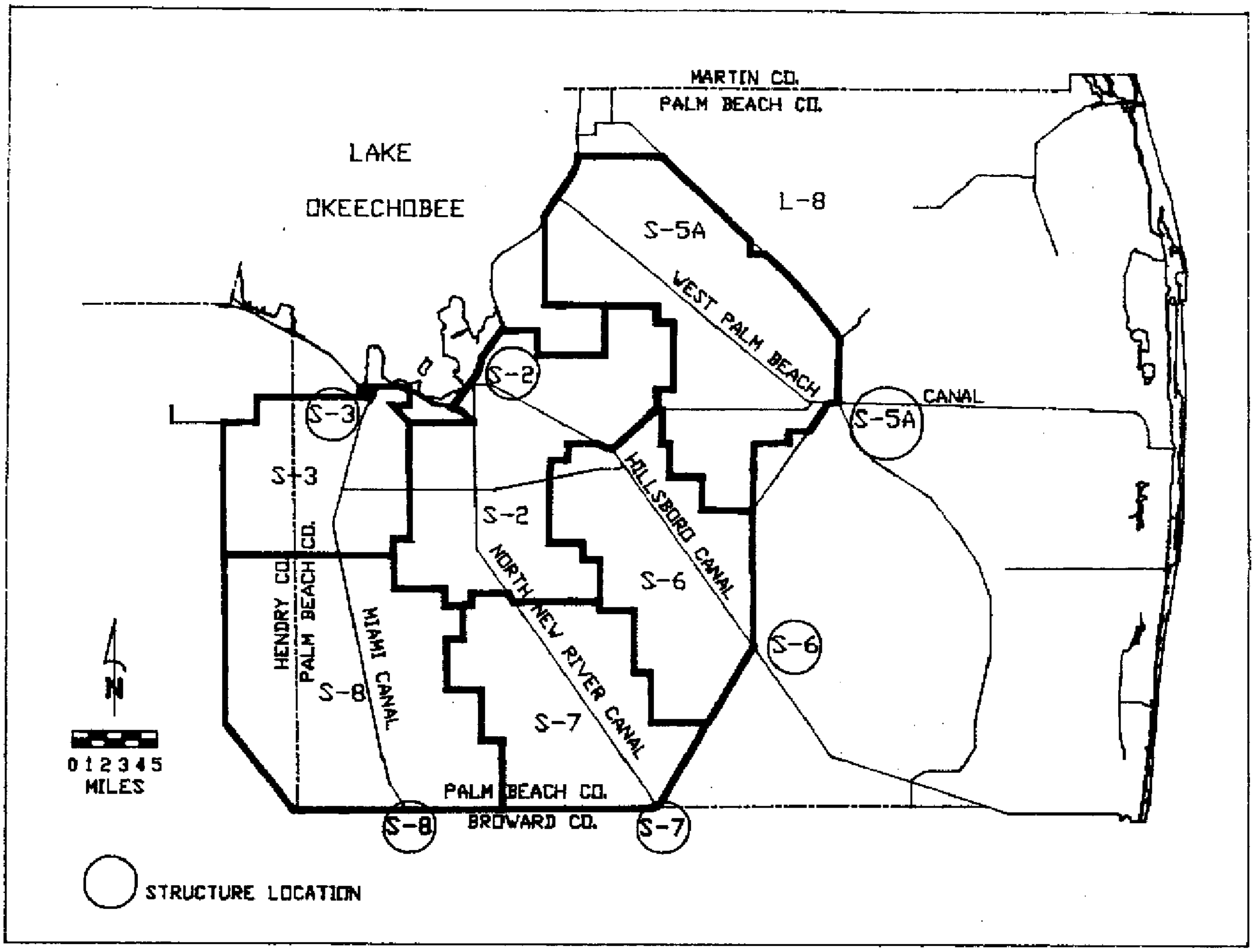


Figure 3-1. EAA Structure Locations

at the individual field level by the farmer and at the basin level by the District. In addition, the land surface is receding as a result of the subsidence of the peat soils. This is a critical factor affecting the performance of the flood control infrastructure. When the canals and pumps of the C&SF Project were designed and built in the 1950's the land surface of the adjacent farmland was a foot above the design water level in the canals. Now, it is not unusual for the water level in the primary canals to be two to three feet above the adjacent land surface. This puts increasing pressure on the secondary drainage facilities and during extreme events causes secondary containment failures such as occurred along the Bolles and Gladeview canals during this storm.

C. Farm Water Control

It is important to realize that unlike other areas where a design storm for flood control purposes is defined in terms of an expected rainfall amount, in the EAA the design event is determined by the cumulative effect of pumpage by individual farmers.

The primary flood control pumps operated by the District were intentionally designed with significantly less capacity then the sum of the individual farm pumps. This was done for economic reasons based on two assumptions; first it was assumed that a significant portion of the area would be fallow and therefore would not be drained immediately and, second, most storms would not be uniformly heavy in all areas so not all farms in cultivation would have to pump simultaneously. This second assumption was clearly not the case with this storm which dropped 6 inches of rain uniformly over the EAA.

Prior to January 15, the EAA had been under mandatory water use limitations for 14 months. The shortage was especially severe in December 1990 and early January 1991 with many growers having difficulty in providing sufficient irrigation water to their crops. The runoff generated from rain which fell between January 10 and 12 (prior to the storm on the 15th) was held on-site by farmers to counter the prolonged shortage. When the heavy rains began on the 15th many farmers were still concerned with the lack of irrigation water and therefore waited longer than normal to begin pumping water out of their fields. By the morning of the 16th, there was standing water in virtually the entire EAA and every farm was in flood control operation.

The seasonal aspect of farm operations in the EAA relative to this storm is particularly important. The dry season corresponds to the winter vegetable season as well as the cane harvesting and processing season. The vegetables grown in the EAA cannot tolerate significant flooding and must have excess water removed immediately. Sugarcane, while less affected by standing water, requires dry conditions for harvest. Consequently dry season storms are much more likely to result in heavy pumping by all sectors of the EAA. For this reason, a 3-inch rain in the dry season will test the design limits of the system while a 6-inch rain in the wet season may not.

D. Primary System Design

The primary purpose of the water control structures in the EAA is clear: to provide flood protection and water supply to agriculture and the conveyance of water from Lake Okeechobee to the urbanized coast. The actual design of the project is the result of a complex blend of hydrology, economics, risk analysis, and assumptions of future land and water use practices. For the EAA this led to two design conclusions which control project performance. One, the size of the pumps, is structural. The other, when the pumps are turned on, began as a purely structural issue, but, for the S-2 and S-3 pumps it is now controlled through a state permit to balance both water quality and flood protection.

The EAA and other agricultural areas in South Florida are designed to remove 0.75 inch of rainfall each day. This level of flood protection is less than that normally provided to urban areas. It is selected based on accepting a reasonable risk of crop failure due to flooding in exchange for making the flood control project economically feasible. A storm of this magnitude exceeds the design thresholds and flood damage should be expected.

A simple calculation indicates that it would take over nine days to remove a 7-inch rainfall event (7"/0.75), if all project pumps were operating at full capacity. In the actual case, it takes even longer (about 13 days) because at some time after pumping begins, channel capacity becomes the limiting factor and the pumps must operate at reduced capacity to prevent pump damage. This is longer than many crops can survive inundation. The project design document (Appendix Figure B-37, line B), indicates a 50-year return flood is expected to have flooding above the ground surface for 150 hours. Individual farm units generally have a much larger pumping capacity than the major drainage system into which they pump. This additional capacity is provided to take advantage of variations in inflow rates and shifting cropping patterns. The actual capacity varies with the size of the farm unit, but averages about 1.5 inches per day or 2 times the overall project capacity. Individual farm pumps cannot operate at full capacity during major storm events such as this because neighboring pumping units are all taking a share of the limited primary system capacity.

E. System Operation

When the primary pump stations were accepted for operation by the District, they were to be operated and maintained according to the official Corps manuals. When the operating level was originally specified at 13.0 feet, (mean sea level, msl), this was a simple design parameter which would allow the project objectives to be achieved. It was expected at the time that this level would have to be lowered periodically as subsidence lowered the surface of the adjacent farmland. The official operating manual has not been updated, but the actual practice has changed over the years to reflect changing conditions. Today, the District operates the pumps into the WCAs to maintain a canal level near 11.0 feet in the EAA. However, the District does not have this flexibility with the lakeshore pumps (S-2 and S-3).

In 1979 concern with the environmental health of Lake Okeechobee led the State of Florida to limit the use of the S-2 and S-3 pump stations. The goal was to pump as little storm runoff as possible into the lake, while preserving the capability of the major pumps for use in an emergency. This was accomplished through a state permit to the District which reduced the discretionary operation of S-2 and S-3 by the District and to impose an objective process (Table 3) for deciding whether or not to

TABLE 3a. Everglades Agricultural Area Interim Action Plan Pumping Factors and Assigned Points

Factor	Condition	Points	Condition	Points	Condition	Points	Condition	Points
Time of Week	Sat,Sun or Holiday	1	Monday-Thursday	2	Friday	3	--------	
Time of Day	4:00 p.m. 8:00 a.m.	1	Noon-4:00 p.m.	2	08:00 a.m.-Noon	3	--------	
Average Canal Level	Less than 11'	-1	11.0'-11.5' 11.5'-12.0'	1 3	12'-13'	4	greater than 13' *always pump*	6
Change in Canal Level	Negative	-1	Positive -0.25ft/hr increase	1	Positive greater than 0.25ft/hr increase	4	--------	
Pump Notification	None	0	Less than 100k gpm	1	Greater than 100k gpm	4	--------	
Rain Prediction	None	0	Less than 2" in next 6 hrs	2	Greater than 2" in next 6 hrs	4	--------	
Rain previous 2 hrs	None	0	Less than 1" total	1	1"-2"total	2	Greater than 2" total	6
Rain previous 2-48 hrs	None	0	Less than 4" total	1	Greater than 4" total	3	--------	
Raining now?	No	0	Yes	1	--------		--------	

TABLE 3b. Pumping Decisions

Total Points	Miami, North New River, and Hillsboro Canal Basins	West Palm Beach Canal Basin
0-11	No pumping required	No pumping required
12-20	Pump to WCA only	Pump to WCA 1
21-34	Pump to Lake Okeechobee and WCAs	Pump to WCA 1

pump based on a number of factors related to how the pumps were operated in the the 1970s. The environmental goals of the permit have been met with over ninety percent of the EAA runoff now pumped away from Lake Okeechobee. However, the point system used to control S-2 and S-3 has not been modified to reflect changing conditions in the basin. When the pumps have been used, it is usually because the canal level has exceeded the 13.0-foot level specified in the original corps manual and the pumps must be started to comply with the official federal guidelines.

The Corps has recommended canal levels between 11.5 and 12.0, but they have also recognized the state's legitimate concern with water quality for the lake and have decided so far to allow the state's attempt to balance the water quality and flood protection issues through restrictions on the use of S-2 and S-3. This process led to delays in the operation of the pumps during this storm. Given the magnitude of this storm, it is doubtful this delay contributed to the damage caused by the flooding. It does, however, clearly demonstrate the inadequacy of the present mode of operating if providing flood protection for agriculture is still to be an objective of the C&SF Project in the S-2 and S-3 basins.

F. The March 1970 Storm

The rainfall volume which fell over the EAA between January 15 and 17, 1991 was the largest comparable event observed in the area.

The previous record three-day dry season rainfall in the EAA occurred March 25-27, 1970. Six inches, on average, fell on the EAA, as compared to an average of 6.61 inches that the area received January 15-17, 1991. Crops damaged from the 1970 storm included corn, celery, radishes, carrots, endive, tomatoes, watermelon, cucumbers, and peppers. Approximately 20,000 acres of corn, and 5,000 acres of leafy vegetables were reported damaged, in addition to pastures, with losses in the millions of dollars. The Agricultural Stabilization and Conservation Committee of Palm Beach County requested that the area be declared a disaster area in order to qualify for federal financial assistance, with an estimated 150 to 200 agricultural operations qualifying for emergency loans. During the March 1970 storm, it took approximately five days to remove the floodwater from the EAA. At that time, there were no environmental constraints on pumping operations at pump stations S-2 and S-3, although today's advanced communication system was not yet in place, and mobilization took longer than it does now.

G. Flood Operations in EAA

Moderate rainfall began in the late morning of January 15. Pumping was started at S-5A at that time. By mid-afternoon enough rain had accumulated to start all pumps to the WCAs and pumping from the Miami Canal to the Holeyland through G-200. Pumping activity continued all night and throughout the next several days to the WCAs and to the Holeyland. Pumping to Lake Okeechobee was constrained by the Interim Action Plan which called for diverting as much water away from Lake Okeechobee as possible. Tables 4 and 5 provide an accounting of how the point totals used to trigger pumping to Lake Okeechobee from S-2 and S-3 developed prior to initiating pumping.

Very heavy rain throughout the night caused widespread flooding which damaged vegetable crops in the vicinity of the Bolles and Cross canals on January 16. Figure 3-2 presents rainfall in the area, pumping at the District pump stations, and the response of water levels to these factors in the largest of the EAA drainage basins, the Hillsboro/North New River basin. Flood control dikes were overtopped in the portion of the Bolles Canal between the North New River and Miami canals. Figure 3-3 indicates the situation in the water control basin to the west of this area, the Miami Canal basin.

S-3 was not started during the period when the farm dikes were overtopped due to the permitted point system detailed earlier and the fact that the area where dikes overtopped is in the S-2 basin. Pumping at G-200 into the Holeyland provided some additional relief for flooding problems which were not in the original design. Analysis indicates that maximum flood levels would not have improved had S-3 started earlier, but the duration of flooding would have decreased slightly. Figure 3-4 (West Palm Beach Canal basin) completes the picture of flood control activities in the EAA. Excess capacity was available for a few hours during the evening of January 15 and the morning of January 16. This allowed providing some relief to flooded areas in the L-8 and western C-51 basin. Full capacity at S-5A was required to meet flood control needs starting the morning of January 16. Water levels got very high at the north end of the West Palm Beach Canal, but extensive flood damage was not reported from this area, and no complaints were received.

TABLE 4. Interim Action Plan Point Score Decision Matrix: S-2 (January 16, 1991)

Factor	0000	0100	0200	0300
Time of week	2	2	2	2
Time of day	1	1	1	1
Average canal level	4	4	4	*6*
Change in canal level	1	1	1	1
Pump notification	4	4	4	4
Rain prediction	4	4	4	4
Rain previous 2 hours	1	1	1	2
Rain previous 2-48 hours	1	1	1	1
Raining now?	1	1	1	1
TOTAL POINTS	19	19	19	*22*

Point total greater than or equal to 21 requires pumping to Lake Okeechobee. Canal stage greater than 13.0 requires pumping to Lake Okeechobee regardless of point total.

TABLE 5. Interim Action Plan Point Score Decision Matrix: S-3 (January 16, 1991)

Factor	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200
Time of week	2	2	2	2	2	2	2	2	2	2	2	2
Time of day	1	1	1	1	3	3	3	2	2	1	1	1
Avg canal level	4	4	4	4	4	3	4	3	4	4	4	*6*
Change in canal level	1	-1	1	-1	-1	-1	-1	-1	1	1	1	1
Pump notif.	4	4	4	4	4	4	4	4	4	4	4	4
Rain prediction	4	4	4	4	4	2	2	2	2	2	2	2
Rain prev 2 hrs	1	1	2	1	0	1	1	0	1	0	0	0
Rain previous 2-48 hrs	1	1	1	3	3	3	3	3	3	3	3	3
Raining now?	1	1	1	0	0	1	0	0	0	0	0	0
TOTAL POINTS	19	17	20	18	19	18	18	15	19	17	16	*19*

Must pump regardless of point total when canal stage is above 13.0.

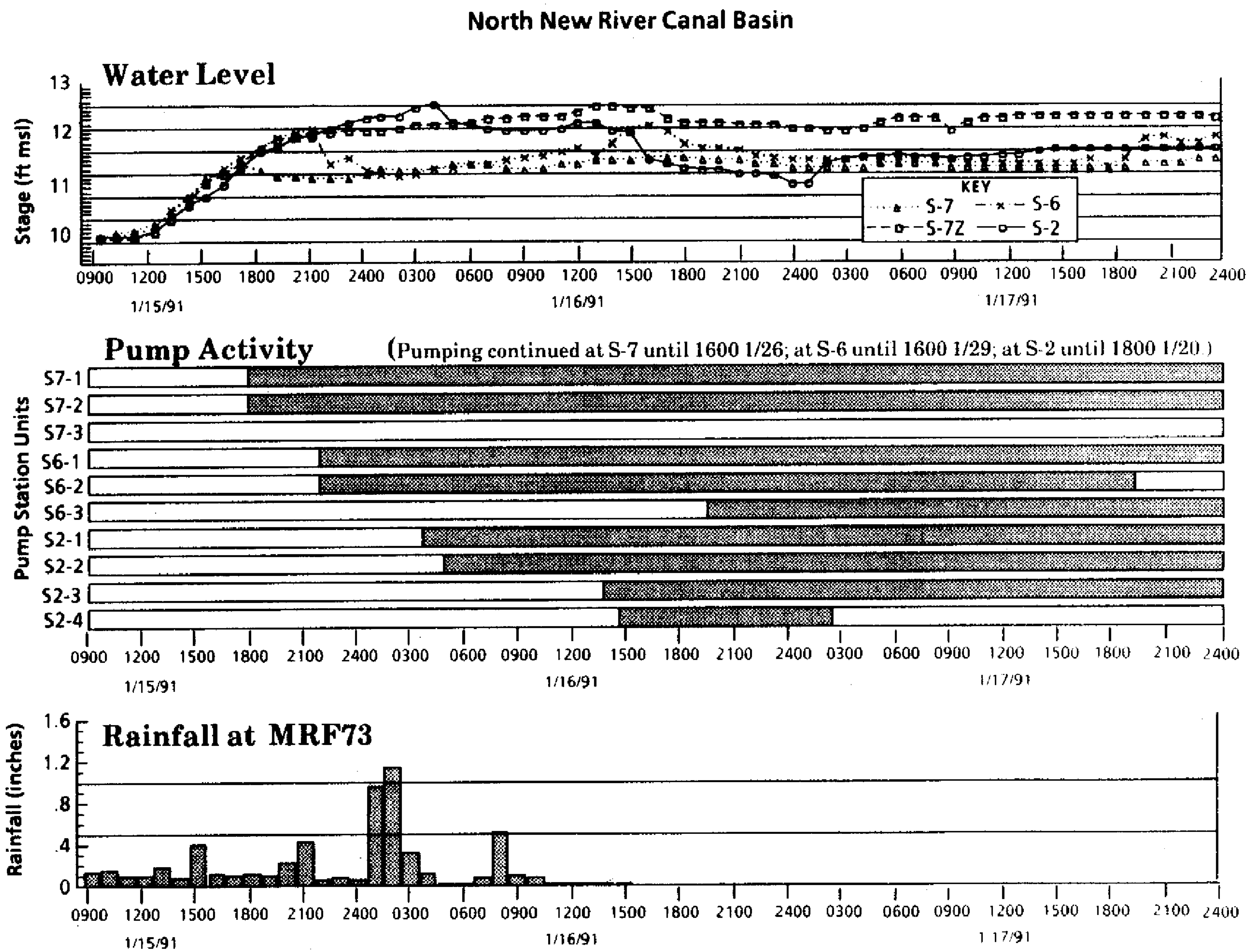


Figure 3-2. Water Level, Pump Activity, and Rainfall in North New River Canal Basin

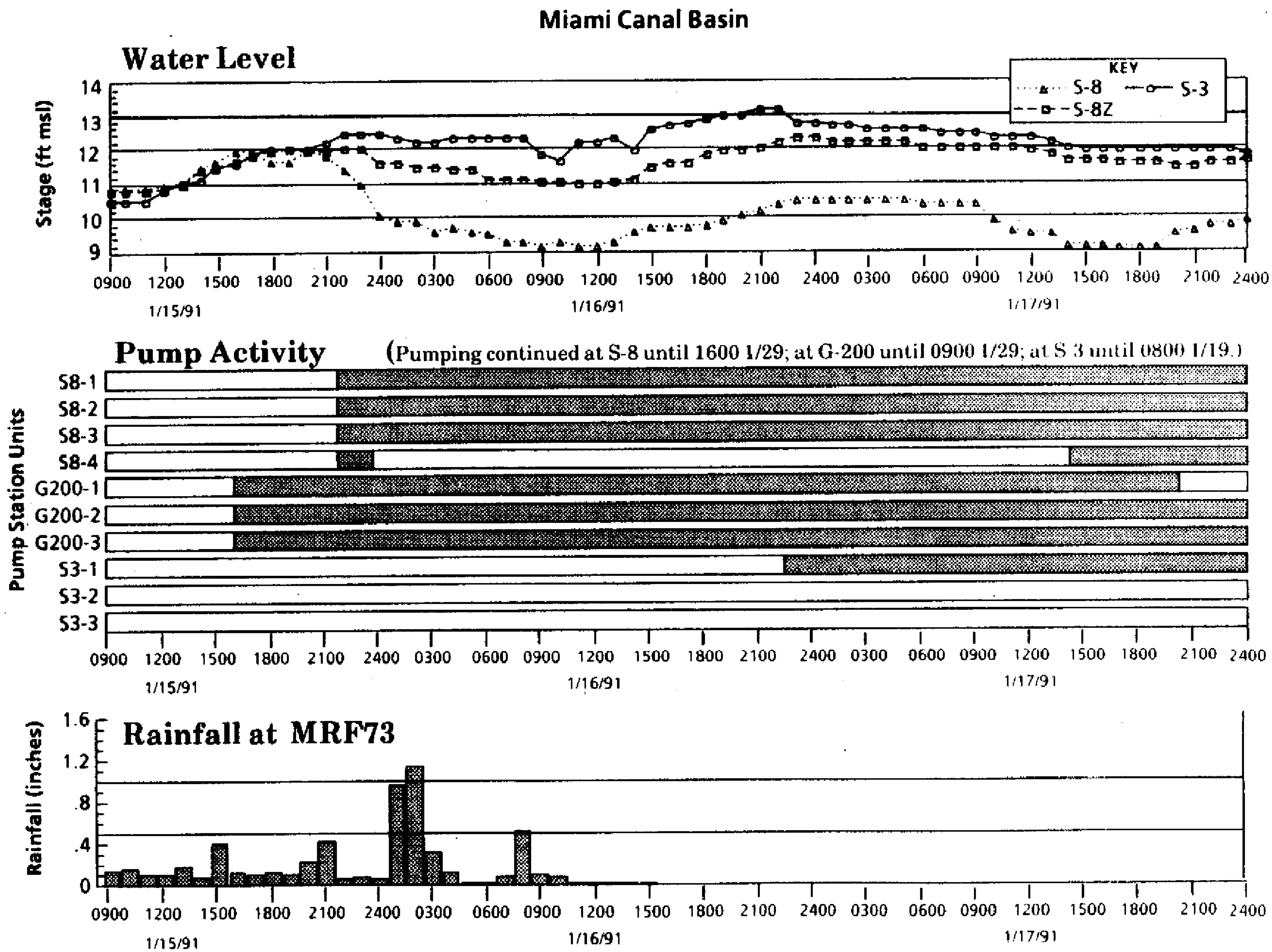


Figure 3-3. Water Level, Pump Activity, and Rainfall in Miami Canal Basin

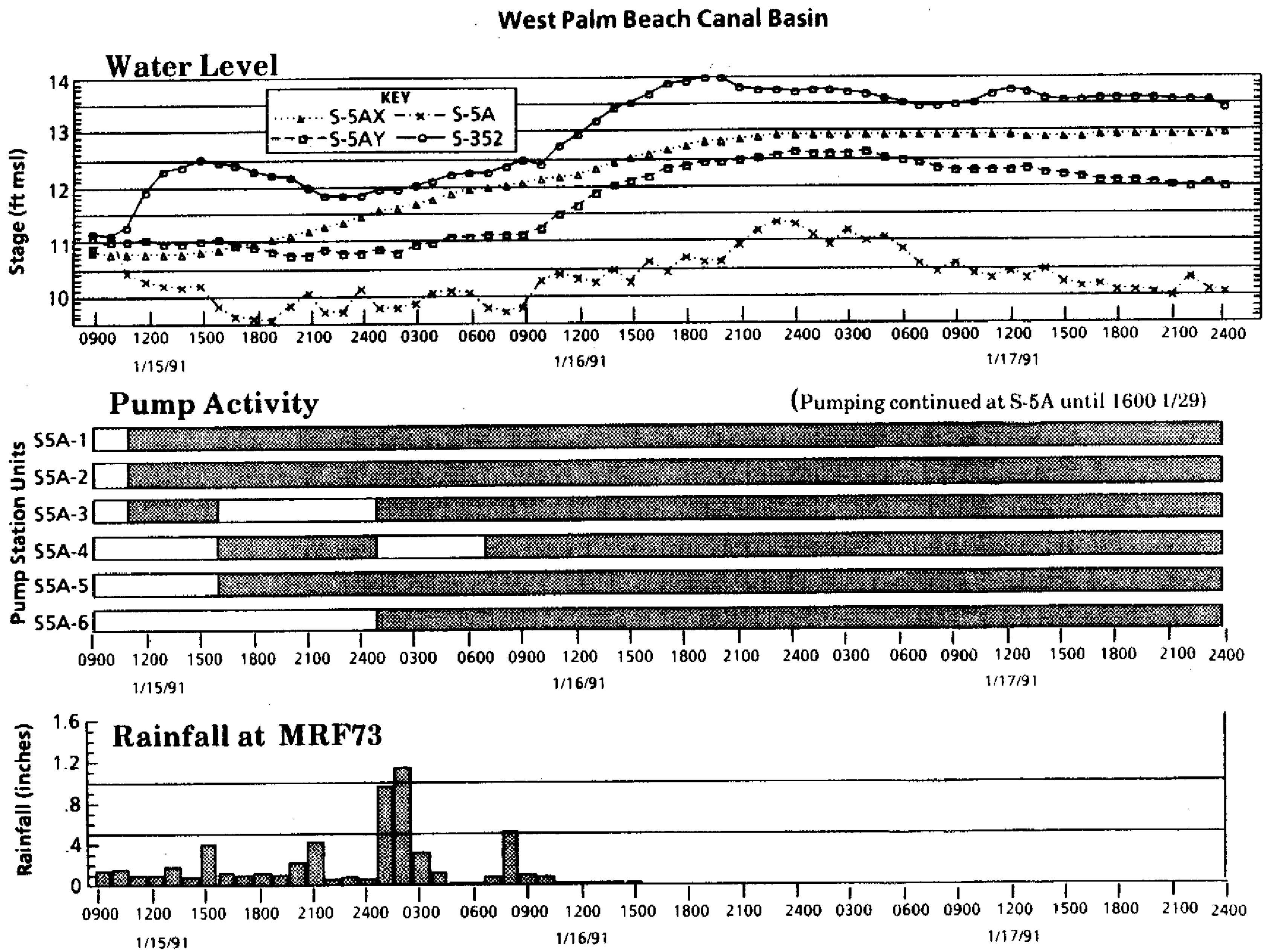


Figure 3-4. Water Level, Pump Activiy, and Rainfall in West Palm Beach Canal Basin

IV. Water Quality

A Total Phosphorus in the Everglades Agricultural Area (EAA)

Summary: Nearly 600 water quality samples were collected in the EAA during the storm period (January 15-29, 1991). Approximately 25 percent of the sampling effort was devoted to quality assurance/ quality control (QA/QC) requirements. Data collection was limited to pH, Specific Conductance, Temperature, Dissolved Oxygen, and Total Phosphorus. Only the total phosphorus data are presented in this report. The average phosphorus concentration varied by nearly a factor of 50 among sites (.03 - 1.4 mg/L), and there was a tendency for phosphorus concentrations to decline after the initial storm pulse. Total phosphorus concentrations tended to be lower in the L-8 and Miami Canal basins.

Methods: In response to the mid-January storm event, water quality sampling was conducted on major canals in the EAA from January 16-29, 1991. The water quality division staff collected 576 samples at 136 sites on the Hillsboro, Miami, Ocean, North New River and West Palm Beach Canals (Figure 4-1). . Standard QA/QC procedures were followed in sampling and sample analysis, and QA/QC requirements accounted for approximately 25 percent (148) of the total samples collected and analyzed in this effort. Because of time limitations, the data presented here 1) are restricted to total phosphorus, and 2) are preliminary and subject to revision.

Site identifiers were derived as follows with the first two characters indicating the major basin (canal) sampled:

HC = Hillsboro Canal
MC = Miami Canal
OC = Ocean Canal
NR = North New River Canal
WP = West Palm Beach Canal
L8 = Levee 8 Canal

The next four characters indicate location along the canal:

Hillsboro Canal	- Mileage measured from S6 toward S2
Miami Canal	- Mileage measured from S8 toward S3
Ocean Canal	- Mileage measured from L12 toward L1.
NNR Canal	- Mileage measured from S7 toward S2.
WPB Canal	- Mileage measured from S5A toward S352
L8 Canal	- Mileage measured from S5AS toward C10A

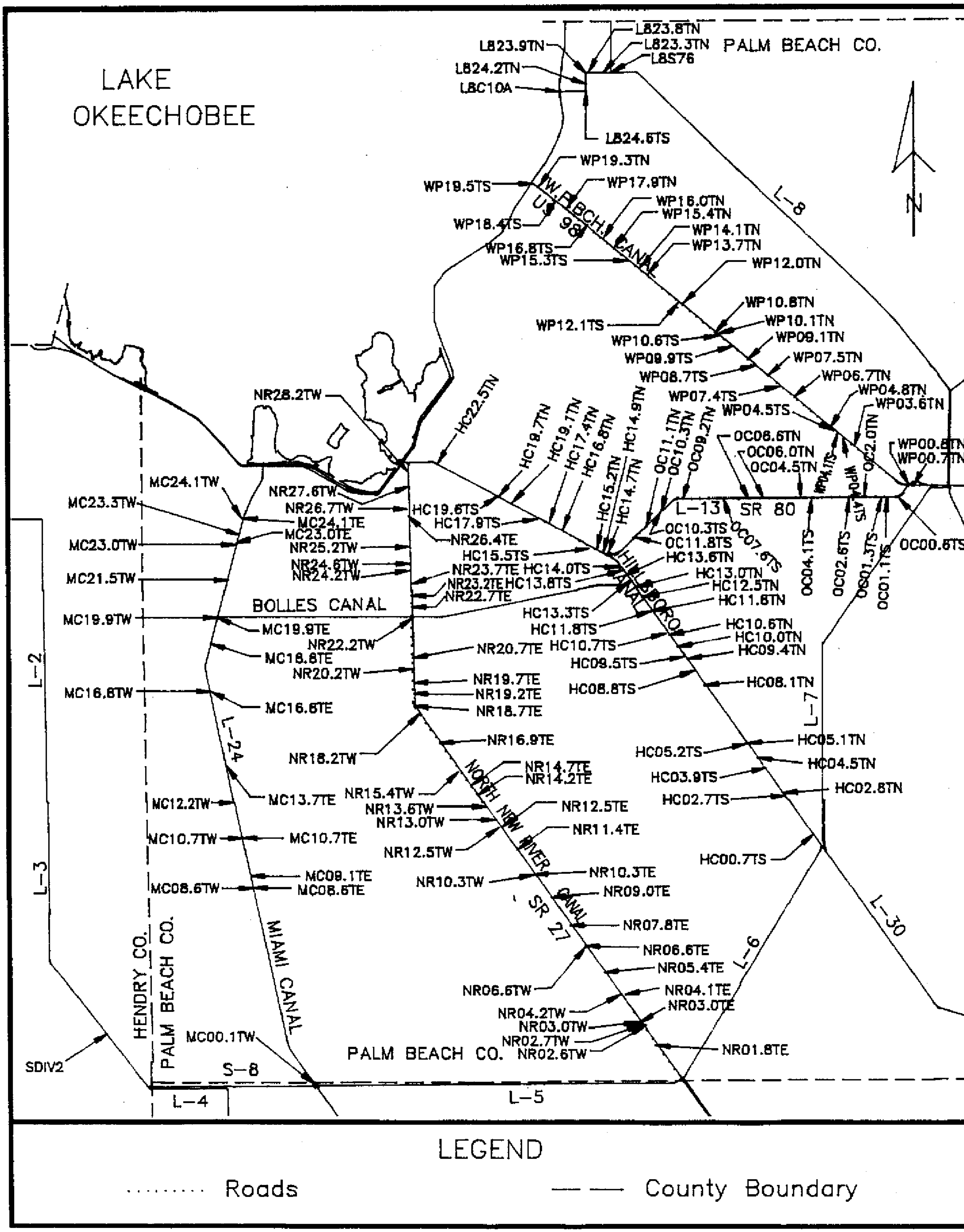


Figure 4-1. Water Quality Sampling Locations in the EAA

The last two characters denote specific sampling location:

T	=	Tributary Inflow Site
S	=	South Bank
N	=	North Bank
E	=	East Bank
W	=	West Bank

As an example, HC19.6TS is a site on the Hillsboro Canal, 19.6 miles from structure S-6 in the direction of S-2. Sampling was at a tributary inflow on the south bank.

Three general sampling techniques were used:

1. At the vast majority of sampled sites, private pumps discharged into a retention area or "middle bay" from which the water then flows via culverts beneath either a road or levee into the primary canal system. In this case the sample was taken from the middle bay near the point where the water entered the outflow culvert. If this was not possible due to accessibility or safety factors, then the sample was taken in the middle bay at or near the pump (tailwater side) or its abutment. In each case the exact location of sampling was noted.

2. Wherever a pump discharged directly into and beneath the surface of a SFWMD canal (such as NR26.4TE), the sample was taken on the intake side of the pump.

3. Wherever portable pumps discharged over the levee via flexible or temporary pipes, the sample was taken from the discharge end of the pipe providing the pipe discharged above the water line (such as OC10.3TN).

Samples were collected with a Van Dorn bottle at 0.5 m depth except in (3) above where samples were collected in hand-held polypropelene buckets. Samples were taken only when pumps were discharging.

Results: Average total phosphorus concentrations at the 136 EAA sites ranged from 0.029 mg/L to 1.40 mg/L. The median and mean (of site means) were 0.23 mg/L and 0.30 mg/L, respectively. The bottom and top seven sites represent the 5th and 95th percentiles, respectively, of the average total phosphorus concentrations. The distribution of site means is shown in Figure 4-2. This distribution follows a log-normal pattern, and the mean of the log-normalized data (geometric mean) is 0.21 mg/L.

Spatial and temporal patterns are apparent in the total phosphorus data. For example, total phosphorus concentrations in the L-8 and Miami canal basins tended to be lower than in the other four major basins (Table 6). Further, the overall mean phosphorus concentration tended to decline after the initial (first flush) phase of the

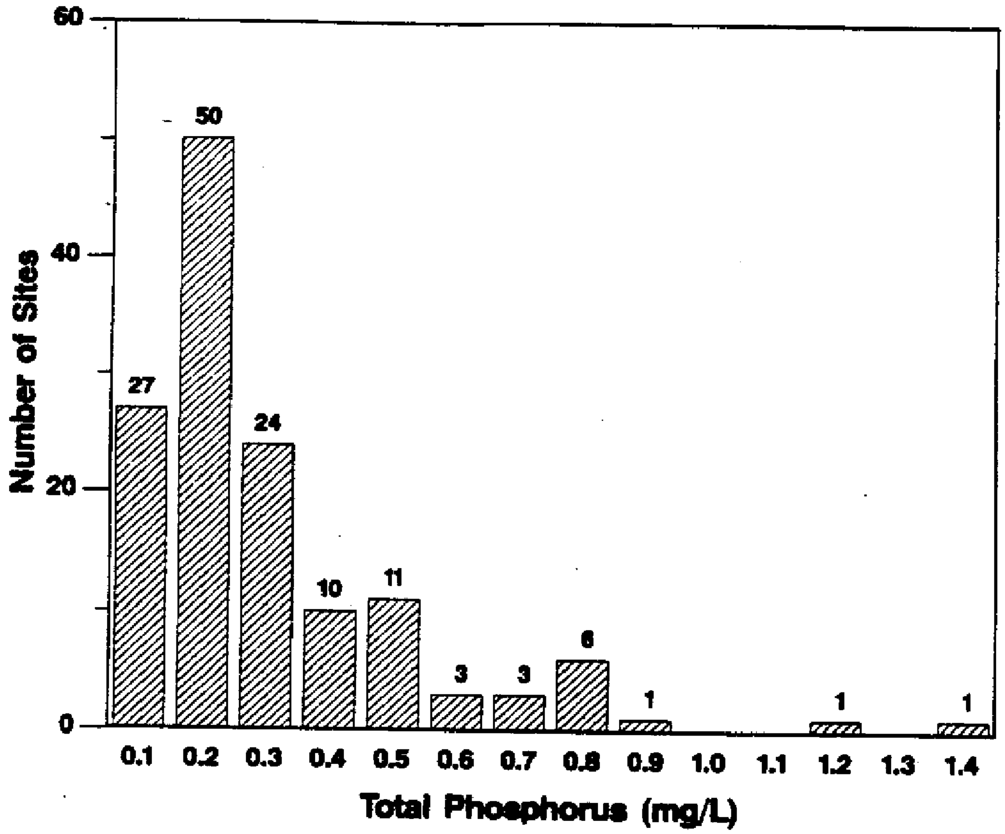


Figure 4-2. Distribution of Average Total Phosphorus Concentrations in the EAA, January 15-29, 1991

TABLE 6. Average Total Phosphorus Concentrations in the Major EAA Canals, January 15-29, 1991

Canal Basin	Total Phosphorus (mg/L)
Ocean	0.39
West Palm Beach	0.34
North New River	0.32
Hillsboro	0.28
Miami	0.20
L-8	0.16

The mean total phosphorus concentrations for the L-8 and the Miami canal basins are significantly ($p < 0.001$) lower than for the other four canal systems.

storm event (Figure 4-3). This trend represents the overall average tendency of the 136 sites sampled; each of the 136 individual sites will not follow this exact pattern, and may deviate significantly.

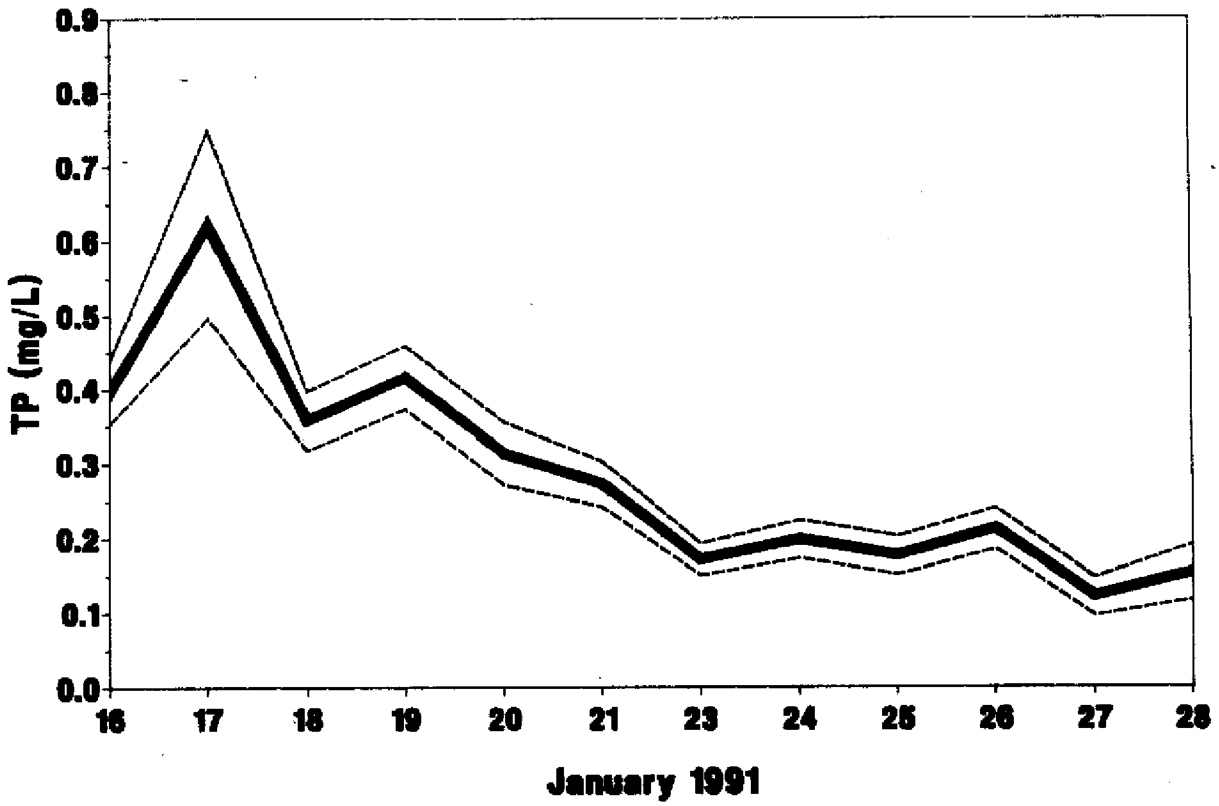


Figure 4-3. Time Series of Total Phosphorus Concentrations at EAA Sites
[Dashed lines are one standard error above and below mean value.]

B. Water Conservation Area Phosphorus Loads

Summary: Routine water quality sampling was conducted at the four major inflow structures to the water conservation areas (S-5A, S-6, S-7, and S-8) during the period January 15-29, 1991. The total phosphorus discharged by these structures (approximately 67 metric tons) into the WCAs during this one event (Table 7) was about 34 percent of the historic average for these structures for an entire year (as reported in the Everglades SWIM plan).

Methods: Routine water quality samples (grab and flow proportional autosampler) were used to estimate total phosphorus concentration in the discharges at S-5A, S-6, and S-7. The concentration for S-8 (0.2 mg/L) was estimated from the average concentration in the Miami canal inflows obtained during EAA sampling. Comparison of S-5A, S-6, and S-7 concentrations (Table 6) to West Palm Beach, Hillsboro, and North New River canals respectively (Table 7) shows good agreement between structure and average-canal concentrations.

Results: About 67 metric tons of total phosphorus was transported into the WCAs via structures S-5A, S-6, S-7, and S-8 during the period January 15-29, 1991

TABLE 7. Total Phosphorus Loading to the WCAs through Structures S-5A, S-6, S-7, and S-8, January 15-29, 1991

Site	Storm Flow (AF) Jan. 15-29	Storm TP (mg/L) Jan. 15-29	Historic TP (mg/L)	Storm Load (metric tons) Jan. 15-29	Historic Annual Load (metrictons)	Storm Load as % of Annual Load
S-5A	64,000	0.36	0.19	23	74	31
S-6	82,000	0.32	0.12	23	22	105
S-7	38,000	0.30	0.11	12	28	43
S-8	48,000	0.20	0.20	9	77	12
Total	232,000			67	201	33

Concentrations for S-8 are estimated from average canal input concentrations.

(Table 7). This one event contributed about 34 percent of the average total annual load for these structures, but at individual structures represented between 12 percent and 100 percent of the historical annual load. With the exception of S-8 (total phosphorus concentration was estimated), total phosphorus concentrations at these structures were higher than the historic flow-weighted averages (Table 7).

C. Lake Okeechobee Phosphorus Loads

Summary: Special storm-related sampling was conducted in association with backpumping at the south end of Lake Okeechobee (S-2, S-3, and the Chapter 298 Drainage Districts). A combination of grab-sampling and automatic flow-proportional sampling was used. Water quality monitoring (grab and auto-sampling) was also conducted at major inflows on the north side of the lake (S-65E, S-191, and S-71). Flow and total phosphorus data from these inflow sites were combined with estimates of direct rainfall on the lake surface to estimate total lake phosphorus loading during the storm period (January 15-29, 1991). The total phosphorus load to the lake was significant (27-37 metric tons), but not exceptional (January average is about 20 tons). When combined with the abnormally high loads experienced in October, the lake is 40-50 tons (35-45 metric tons) ahead of the average cumulative loading that is normally expected by the end of January. If loading for the remainder of the year proceeds at the historical average rate, the total load to the lake will exceed the historic average (about 600 tons/year or 545 metric tons/year) and will greatly exceed the phosphorus loading target (397 tons or 361 metric tons). However, the total annual load to the lake cannot be accurately predicted prior to the wet season (July-September).

Methods: Storm samples for water quality analyses were collected as (a) part of routine sampling of Lake Okeechobee inflows, (b) special storm-related sampling at stations S-2, S-3, S-236, Culvert 4A, Culvert 10A, Culvert 12, and Culvert 12A. The effort included both grab samples and short-term, flow-weighted automatic sampling. Total phosphorus loads at each sampled site were calculated by multiplying mean daily concentration (measured from either grab or automatic sampler, or estimated) by the daily flow (either measured or estimated). Rainfall volume was estimated by multiplying the approximate direct rainfall on the lake (0.095 m or 3.76 inches) by the lake surface area (1540 km^2 or 380,000 acres). Rainfall phosphorus load was estimated by multiplying rainfall volume (1.46×10^8 m^3, 122,000 acre-feet, or 61,000 cfs-days) by the historical average phosphorus concentration in bulk precipitation around the lake (0.051 mg/L). As with the EAA storm data, the water quality data presented for Lake Okeechobee inflows are approximate and provisional.

The total load to the lake was estimated from (a) estimated direct rainfall on the lake, and (b) inflows at S-2, S-3, S-65E, S-191, and S-71 (S-154 was not used because the structure was closed during this event). A regression method (based on the 1973-1987 period) was used to extrapolate the total phosphorus loads from these six sources to the entire lake phosphorus load.

Results: Most of the rainfall in this event fell to the south of Lake Okeechobee and runoff from the northern portion of the drainage was relatively minor. Direct rainfall was the largest contributor of water to Lake Okeechobee during the storm event (Figure 4-4), but backpumping at S-2 appears to have been the largest single contributor of total phosphorus (Figure 4-5). Total Phosphorus loading at S-2 accounted for about 1/3 (11 metric tons) of the total estimated phosphorus load to the lake (27-37 metric tons) during this event.

Among the lake inflows monitored during this event, the highest total phosphorus concentrations occurred at S-191 (Figure 4-6). This is a typical pattern; over the period of record (1973-present) the Taylor Creek - Nubbin Slough basin (S-191) on the lake's north side been a major source of concentrated phosphorus. However, the average concentration observed in S-191 discharge during this event (0.52 mg/L) was substantially lower than the historical average for this site (0.94 mg/L). Relatively high total phosphorus concentrations were observed in the backpumped water from S-2 and S-3, the average total phosphorus concentrations (0.34 and 0.25 respectively) in the discharge at these sites were substantially above their historical average (about 0.16 mg/L).

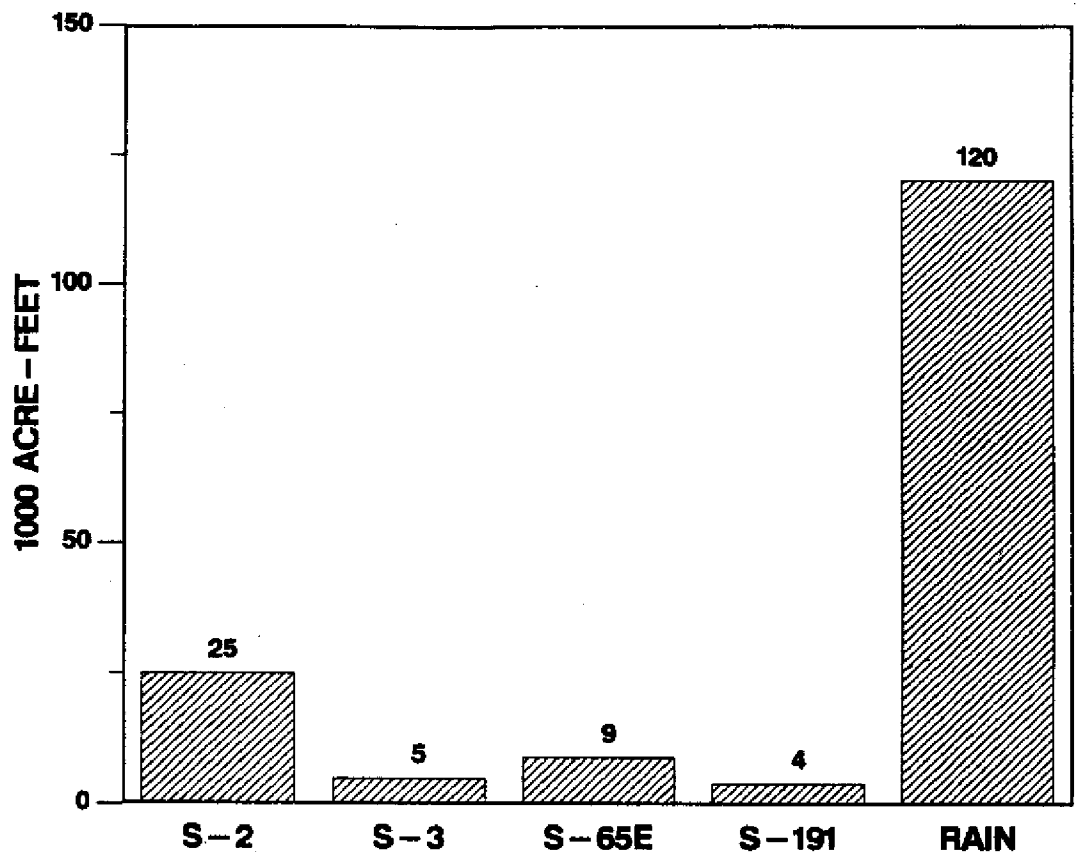


Figure 4-4. Storm-related Inflow to Lake Okeechobee from Major Sources, January 15-29, 1991

Discharges into Lake Okeechobee from the Chapter 298 Districts on the south and east side contributed relatively little to the total lake phosphorus load. The inflows at these sites were a small contribution to the total inflow volume, and these sites exhibited total phosphorus concentrations that were similar to their historic average. The total phosphorus load East Shore, South Shore, East Beach, and S-236, was less than 2 metric tons (Table 8).

The mid-January storm event of 1991 produced a substantial inflow of water to Lake Okeechobee, increasing the total lake volume by about seven percent (total lake volume exceeds "available storage" by about 1.8 million acre-feet). A large fraction of the total inflow was direct rainfall on the lake surface and this input carried relatively little phosphorus. The total phosphorus loading to the lake associated with rainfall and backpumping during this event was significant but not exceptional. January inputs of phosphorus to Lake Okeechobee are normally quite low and have averaged around 20 tons from 1973-1987, but have varied dramatically over the period of record. On a percentage basis, this event represents a near doubling of the normal January input (18 metric tons). However, on a total load

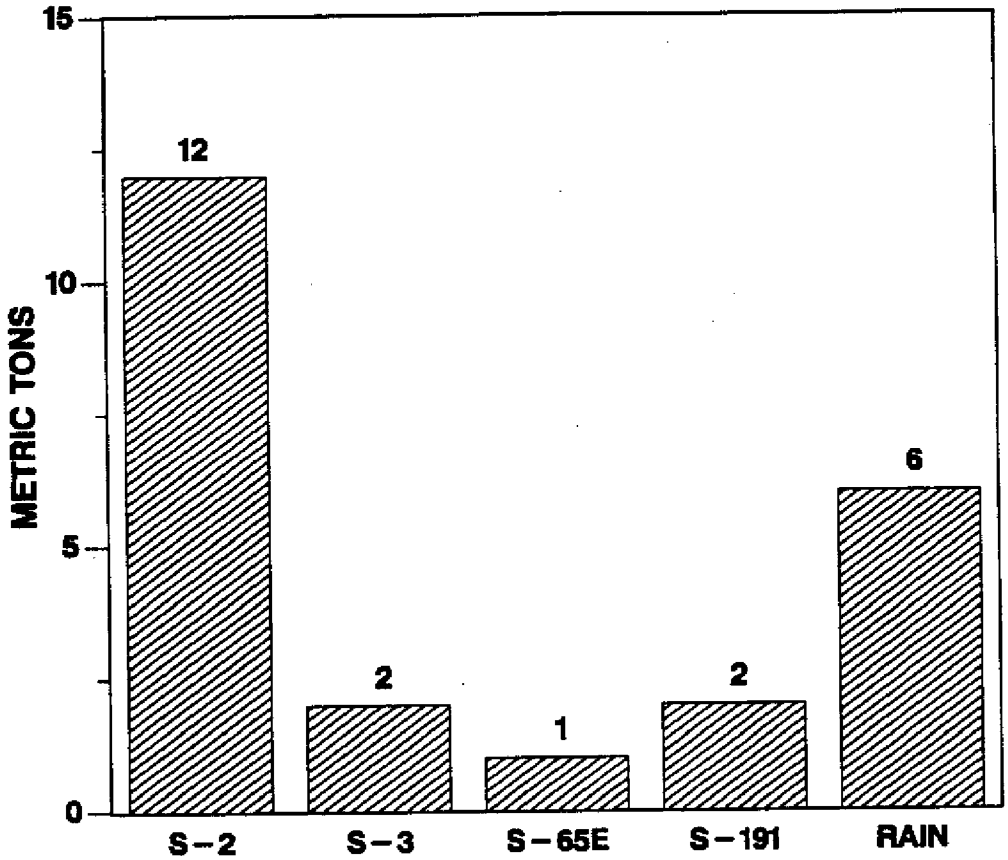


Figure 4-5. Storm-related Total Phosphorus Loads to Lake Okeechobee from Major Sources, January 15-29, 1991

TABLE 8. Flow, Total Phosphorus Concentrations and Loads at Chapter 298 District Inflows

Site	Flow (acre feet)	TP (mg/L)	Load (metric tons)
East Shore D.D.	2,400	0.25	0.8
South Shore D.D.	1,100	0.21	0.3
East Beach D.D.	1,000	0.28	0.4
S-236	1,100	0.10	0.2

Concentrations for East Beach and S-236 are estimated (historical average).

basis this storm contributed an additional 5 percent to the average annual load (about 600 tons or 545 metric tons). If phosphorus loading for the remainder of the water year proceeds at the historic average rate, the final total load will exceed the target for the water year (397 tons). However, the majority of inflow and load to the lake occurs in August and September, and thus the annual total cannot be accurately predicted from data available through the end of January 1991.

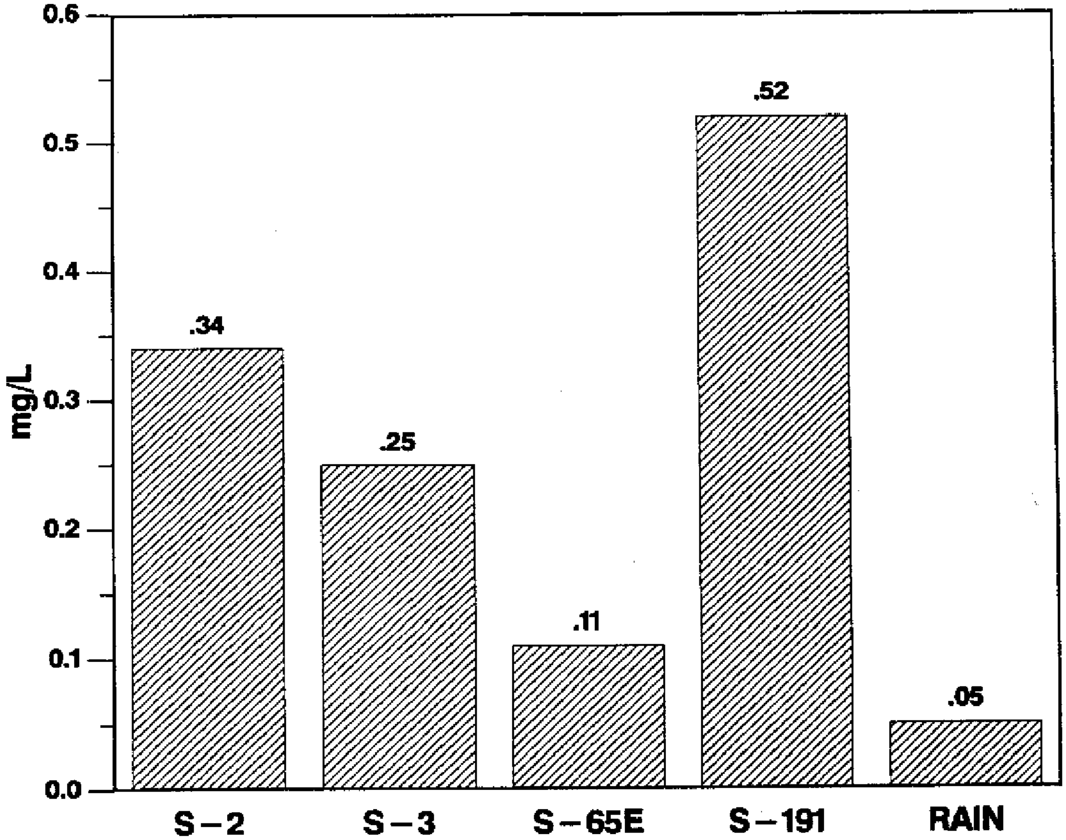


Figure 4-6. Total Phosphorus Concentrations in Storm-related Inflows to Lake Okeechobee , January 15-29, 1991

V. Water Levels and Systems Operation

A. Field Inspection Activities

Personnel from the Field Engineering Division within the District's Regulation Department inspected various areas of reported flooding during and immediately following the January 15-16, 1991 rainfall event. A description of these areas (see Figure 5-1 for locations) and respective comments follows:

Inspections showed considerable nuisance flooding of yards and roads within the western C-51 basin. Minor short term street flooding was observed in the general Royal Palm Beach area (A). The Saratoga development in Royal Palm Beach (B) had considerable street and yard flooding. Yard and unpaved roadway flooding was also observed in the Acreage (C).

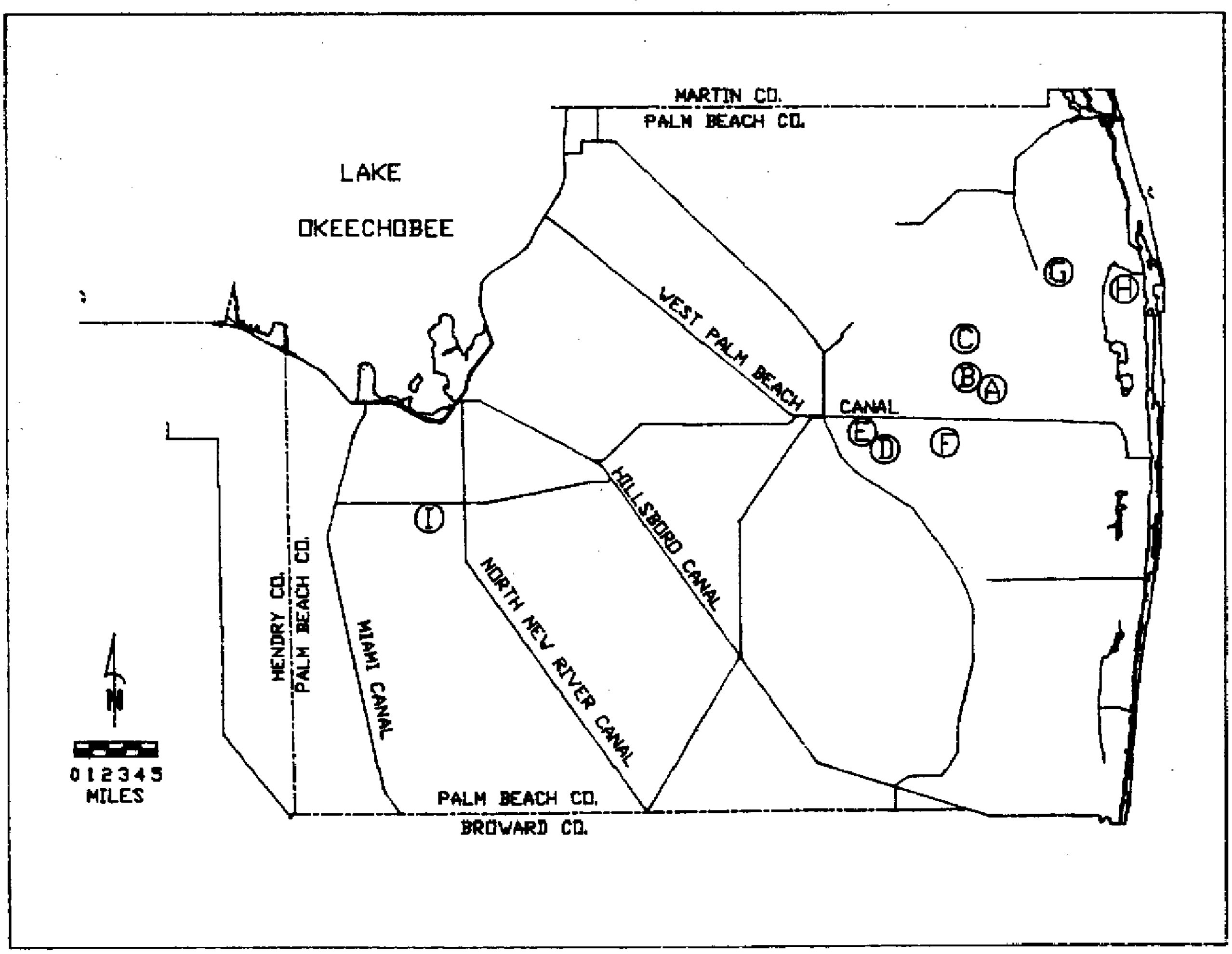


Figure 5-1. Location Map of Field Investigations

Residents of the Rustic Ranches residential area (D) reported street flooding. Flooding was reported by the managers of Macklen Groves (E). Street flooding was observed by Field Engineering staff along portions of Wellington Trace, Big Blue Trace, South Shore Boulevard, Greenview Shores Boulevard and other roads in Wellington (F), primarily where internal drainage canals intersect the roadways.

In the C-17 basin, within the Steeplechase development (G), along Haverhill Road (north of Bee Line Highway-SR 710 and south of Lake Park Road West), standing water in yards and roadways was observed. Water, up to 1.5 feet deep, was encountered along Haverhill Road where canals overflowed their banks.

Members of the public reported extensive street flooding near another area within the C-17 basin, east of the intersection of Interstate I-95 and the C-17 (H). However, by the time Field Engineering staff were able to inspect this area (noon, January 16), no significant flooding was found.

Flooding of Palm Beach County agricultural areas (I) was documented by Field Engineering staff utilizing a District helicopter and video camera. Sporadic widespread field flooding occurred at the north end of the EAA. The Bolles Canal (L-21) had a total of five washouts in three areas along the south bank of the east/west muck-earthen levee, which contributed to additional field flooding to the south, approximately midway between the North New River and Miami canals. The location of the three washout areas were on the Bolles Canal west of Highway 27, 0.5 miles, 0.75 miles. and 2 .25 miles,. respectively.

The Okeechobee-based Field Engineering team received reports of flooding from the Cedar Cover 2 subdivision and observed yard and road flooding at the Dark Hammock area of Okeechobee County. They also received complaints from the Lakewood subdivision in St. Lucie County.

The Fort Myers area team responded to approximately 20 complaints from residents in the areas of north Fort Myers, Estero, Bonita Beach, central Fort Myers, and the Del Tura development.

B. Pump and Water Control Structure Operations During the Storm

Background: Drought conditions preceded the storm event of January, 1991. Lake Okeechobee was at elevation 12.17 feet. The most significant operational activity prior to the event was preparation for water deliveries from Lake Okeechobee to Dade County. Light rain and moderate releases from Lake Okeechobee had allowed water levels throughout the EAA to recover from extremely low water levels. Structures 150 and 151 had been opened in preparation for gravity releases to South Dade via S-351, S-150, S-151, S-337. Structure 151 must be opened approximately 24 hours before S-337 is opened to prevent fish kills downstream of S-151, which could be caused by the amount of low dissolved oxygen groundwater. The normal route for South Dade deliveries through S-8 was not used so that S-339 and S-340 could remain closed for environmental reasons. Showers during the evening of January 14 had lessened the demand for irrigation water.

The S-6 and S-7 pump stations each had one of three pumps inoperable. S-6 was in the process of having engines replaced on all three pumps. The second of three pumping units had just been reinstalled, but had vibration problems which did not allow operation. S-7 had one pump disassembled to allow replacement of defective instrumentation. A high priority was placed on getting all possible pumps on line as soon as possible after the storm began. Pump station S-6 was fully operational by January 16 and S-7 had all pumps working on January 18.

January 15 Tuesday: Early morning weather forecasts indicated a strong probability of heavy rains (3 inches or more) later in the day.

08:30 Based on the weather forecast, S-150 was closed to conserve water in the EAA in the event that rain in Dade County eliminated the need to deliver water through S-337. S-151 was left open to save labor costs for an unnecessary set of operations should the rain not materialize. Under existing conditions, this would do no harm. Water levels in the West Palm Beach Canal were high enough to warrant pumping S-5A, considering the weather forecast.

Noon: Rain began showing up on the weather radar.

13:30 S-5A was notified to terminate pumping at 20:00. Irrigation releases through S-39 to the eastern Hillsboro Canal were terminated. Notification was received that a few EAA interests would be pumping runoff rather than taking irrigation water. S-169 was opened in preparation for receiving pumped runoff.

14:15 Water levels at S-6 and S-7 began to rise - S-150 was opened again to make moderate releases from the S-2/S-6/S-7 basins, again with the thought of using the excess runoff in Dade County after things settled down.

15:30 Heavy rainfall was occurring in West Palm Beach. The stage at the Waterview mobile home park was starting to rise. Western C-51 was starting to rise. S-155 was opened to the maximum. Both gates on G-124 were opened to hold western C-51 within banks.

16:20 It was apparent that the EAA pumps would have to be operated. All three pumps at the Holeyland pump station (G-200) were started. The order was rescinded for S-5A to terminate pumping at 20:00. S-5A, S-6, S-7, and S-8 were instructed to pump all night. The S-7 pumps were started, S-6 and S-8 personnel were allowed to return home to eat and prepare for a long night. S-8 pumping was started at 20:00 and S-6 at 21:00. The S-8 spillway was opened at 18:00 until pumps started at 20:00. Palm Beach International Airport requested permission to turn on its pumps; permission was granted.

17:00 Waterview area in eastern C-51 began experiencing serious flooding levels. No further action could be taken since S-155 was discharging at its maximum capacity. Lake Worth Drainage District requested suspending plan to divert water away from the Hillsboro Canal during construction of G-56; permission was granted. The possibility of large discharges during the night was discussed with the contractor on G-56. District staff agreed to make changes slowly and warn the contractor when the gates were to be opened to 6 feet or more.

21:00 All boards were pulled out of the emergency spillway at G-124 to get western C-51 under control. G-56 gates were opened to 6.0 feet; the contractor was notified.

23:00 Western C-51 was still rising rapidly and it was apparent that the maximum capacity at G-124 was inadequate to bring water levels down; permission was secured from the District's Operations Division to utilize excess capacity at S-5A to provide relief to western C-51 via S-5AE and S-5AW. One gate at S-5AE was inoperable and could not be opened. The decision was made to postpone fixing the gate until daylight for safety reasons. Instructions were given to call S-2 to be prepared to operate the pumps if and when the water level approached 12.8. The G-56 gate was opened to 8.0 feet and the contractor was notified.

January 16 Wednesday:

03:30 The stage at S-2 exceeded 13.0 feet and it was still raining. The IAP point total reached 22 and instructions were given to start the S-2 pumps just before 04:00.

08:00 Water levels were being monitored at S-44. Stages were very high but appeared to be stable. Pumps at S-140 and S-9 were started. USGS and District staff were mobilized for stream gaging activities. The inoperable S-5AE gate was repaired and fully opened.

10:30 No additional capacity remained at S-5A to handle flow from the western C-51 basin and S-5AW was closed. S-5AE was left open until the flow direction reversed to provide maximum relief to the western C-51 basin.

11:00 The S-11 structures changed to a small gate opening at the request of the Corps (WCA-2A was now above the regulation schedule). The C-17 basin was no longer in danger (the S-44 water level was declining under maximum discharge conditions).

12:00 Okeelanta Sugar requested that the S-3 pumps be started because water was overtopping the levee on the Bolles Canal. The IAP point total was inadequate. District staff were sent to investigate the problem and confirmed that overtopping was a problem, but that it was in the S-2, not S-3. Sugar cane interests offered assistance in solving the levee overtopping situation.

13:00 A check showed that S-2 had excess capacity to bring an additional pump on-line. This was expected to provide necessary relief to the Bolles Canal. S-2, S-5A, S-6, S-7, S-8, and S-140 were scheduled for a night shift to continue pumping. S-9 stopped pumping at the end of the normal shift.

18:00 Agricultural interests in the western C-51 basin were calling to complain that C-51 water levels were exceedingly high and that they were about to lose their vegetable crops. The reply was that all capacity was being used and that the situation was likely to get worse. No relief was expected for at least 24 hours and they were advised to take action to reduce their losses.

19:00 Third pump went on-line at S-6.

20:00 Danger appeared to be over for the G-56 basin. Gate openings were still large, but water levels were declining.

21:00 The stage at S-3 exceeded 13.0 feet, but the IAP point total was still not adequate. Approval was given for the operation of S-3.

21:30 The S-3 pumps were started.

23:00 Water levels in L-8 increased to the point where no further relief was available for the western C-51 basin. S-5AE was closed to prevent water from entering C-51 from L-8.

January 17 Thursday: S-2, S-3, S-5A, S-6, S-7, S-8, and S-140 pumped through the night.

09:00 The District conferred by telephone with Lake Worth Drainage District officials and it was agreed to temporarily divert as much water as possible away from C-51. (the stage in the western C-51 had overtopped its banks, eastern

C-51 water level was under control with very high discharges - G-56, S-41, and S-40 had additional capacity).

10:00 At the request of the Corps of Engineers, gate openings at the S-11 structures were increased.

11:00 S-337 and S-335 were opened to deliver a portion of the excess water in WCA2 to South Dade. A pump malfunction at the Holey Land pump station (G-200), took 1 pump off-line (2 pumps were still operating).

13:00 Overnight pumping was scheduled at S-2, S-3, S-5A, S-6, S-7, and S-8.

January 18 Friday: S-2, S-3, S-5A, S-6, S-7, and S-8 pumped throughout the night.

11:00 The weir crest at G-155 was lowered to 13.0 feet.

13:00 Overnight pumping was scheduled at S-2, S-3, S-5A, S-6, S-7, and S-8. Complaints were still being received about high water levels in the Cross Canal.

13:45 A portable pump was started at S-6 because the #2 pump was giving problems.

15:00 Third pump was brought on-line at S-7.

January 19 Saturday: S-2, S-3, S-5A, S-6, S-7, and S-8 pumped throughout the night.

08:00 Pumping was discontinued at S-3. Pumping continued at S-2, S-5A, S-6, S-7, and S-8. Pumping was started at S-140.

10:00 More rain was forecasted. Excess capacity was available at S-5A. S-5AW was opened to bring water levels down in L-8.

13:00 Permission was given to utilize excess capacity at S-5A to provide margin for possible rain in the western C-51 even though water level was within banks. S-5AE was opened. Pumping was scheduled for all night plus daytime Sunday at S-2, S-5A, S-6, S-7, S-8.

15:00 S-5A engine was reported to be overheating; silting at the cooling water intake was suspected to be the problem. Pumping was reduced to maintain an elevation of 9.5 feet in lieu of 9.0 feet at the intake.

23:00 S-5AW was closed. Instructions were given to close S-5AE when water levels equalized across the structure (telemetry gage was malfunctioning).

January 20 Sunday: S-2, S-5A, S-6, S-7, and S-8 pumped throughout the night.

03:00 Cross canal water level was under control (< 12.5 at S-5AX)

04:00 S-5AE was closed as a consequence of instructions to close it when the water level in L-8 was equal to that in the western C-51 (approximately. 13.0 feet NGVD).

08:00 S-9 and S-140 began limiting pumping to daylight hours.

13:00 Pumping was scheduled for all night and throughout the Monday holiday at S-5A, S-6, S-7,and S-8.

18:00 Pumping was discontinued at S-2.

January 21 Monday: S-5A, S-6, S-7, and S-8 pumped through the night.

10:00 S-140 scheduled for daylight pumping only.

January 22 Tuesday: S-5A, S-6, S-7, and S-8 pumped through the night. S-9 and S-140 pumped daylight hours only.

05:00 Pumping with the portable pump at S-6 was terminated.

13:00 S-5A, S-6, S-7, and S-8 were scheduled to pump throughout the night.

January 23 Wednesday: S-5A, S-6, S-7, and S-8 pumped through the night.

08:00 S-12 and S-333 were opened in accordance with Corps instructions for the ENP delivery schedule. Flow was increased at S-335, S-337, and G-211 for larger deliveries to South Dade and eastern ENP at S-18C.

12:30 S-10E was opened after consultation with Corps of Engineers on prevailing Water Conservation Area 1 stages relative to its regulation stage.

13:00 S-5A and S-6 were scheduled to pump all night. Instructions were given to open S-150 after S-7 pumping terminated at 18:00.

January 24 Thursday: S-5A and S-6 pumped through the night.

08:00 S-7, S-8, S-9, and S-140 operated during the daylight shift only.

13:00 S-5A, S-7, and S-8 crews were instructed to terminate pumping after long (18:00) shift. Night crew was continued at S-6.

15:40 Flow was increased at S-176 and S-177

January 25 Friday: S-5A and S-6 pumped throughout the night.

13:30 The small portable pump used for 4 hours.

C. Water Levels

Headwater and tailwater stages of canals reflect water conveyance capacity before, during, and after a storm. Stage hydrographs for the month of January at selected sites on several major canals in the storm area are in the Appendix (Figures B26-B31). The locations of structures and canals are also in the Appendix (Figure B32). In all the canals impacted by the storm event, a sudden rise in stages is illustrated. Table 9 presents peak stage data for major canals in the area affected by the storm.

The storm of January 1991 contributed to the replenishment of storage in Lake Okeechobee and WCAs 1, 2, and 3. At the start of the dry season in November there

TABLE 9. Peak Stages of Canals and Time(s) of Peak

Canal	Peak Stage (ft. NGVD)	Date of Peak	Time(s) of Peak
Miami at 15-Mile Bend	12.25	01/16	23:00
West Palm Beach Canal at S-5A	12.42	01/18	22:12
S-3 Pump Station, Canal Side	13.15	01/16	23:00
North New River Canal at South Florida Sugar	12.99	01/16	12:52
Hillsboro Canal at 6-Mile Bend	13.00	01/18	17:57
Miami Canal at S-8	12.27	01/16	23:07
West Palm Beach Canal at S-5AE	16.21	01/17	13:00
West Palm Beach Canal at G-124 Upstream	05.45	01/16	02:01
C-17 at S-44	08:15	01/16	06:30
Golden Gate Canal at Weir #1 (Naples)	05.45	01/16	10:00 21:00

was a steady decline of the lake stage and available water storage. After the occurrence of the storm, the lake stage and volume of available water displayed sharp increases. The increase was due mainly to rainfall on the lake, backpumping from the EAA, and inflows from the north and west. The chronology of the events of flooding and backpumping to Lake Okeechobee is presented in the previous subsection, "Pump and Water Control Structure Operations During the Storm." The estimated amount of backpumping to Lake Okeechobee is shown in Table 10.

TABLE 10. Discharges to Lake Okeechobee

Source		Discharge (acre-feet)
South Shore Drainage District	(Jan. 16-20)	1070
S-236 Basin	(Jan. 16-20)	1130
East Beach Drainage District	(Jan. 16-20)	990
East Shore Drainage District	(Jan. 16-20)	2380
Hillsboro and North New River Canals (S-2)	(Jan. 16-20)	22,950
Miami Canal (S-3)	(Jan. 16-19)	4,470
Total		32,990

Values are preliminary and subject to revision.

The Lake Okeechobee stage on January 14 was 12.17 feet, which is in a critical water supply level of Zone A. It indicated that with normal rainfall and average water demand for the remainder of the dry season the lake would be below 11.0 feet on June 1. After the storm, the lake stage of 12.62 feet improved the condition to a warning stage, which meant that there was roughly a storage supply to meet the demands of a one in three year drought. Stages and available storage in Lake Okeechobee during and after the storm are shown in the Appendix (Figure B33).

Stages and available storage in the three WCAs before and after the storm are included in the Appendix (Figures B34-B36). It is apparent that this storm event improved the drought situation which had existed for more than two years. Rainfall in the WCAs was the major component contributing to their rise in stage and storage volume, along with inflows through S-5A, S-6, S-7, and S-8. The estimated amount of discharges to the WCAs are shown in Table 11.

TABLE 11. Discharges to the WCAs

Source	Receiving Body	Discharge (acre-feet)
S-5A (West Palm Beach Canal)	WCA-1	63,890
S-6 (Hillsboro Canal)	WCA-1	81,950
S-7 (North New River Canal)	WCA-2A	36,750
S-8 Pump Station	WCA-3A	46,950
S-8 Spillway (Miami Canal)	WCA-3A	130
Total		229,670

Values are preliminary and subject to revision

APPENDIX A

Daily Rainfall Values at Various Stations During the Storm

APPENDIX A
Daily Rainfall Values at Various Stations During the Storm

MRF No.	Station Name	County	1/14	1/15	1/16	1/17	Recording Time AM	Total
106*	WCA 3-36	Broward	0.00	0.02	3.75	0.07	8:00	3.84
113	S-13	Broward	0.00	0.00	M	1.68	7:00	1.68
115	S-9	Broward	0.03	0.00	1.31	0.00	7:00	1.34
145	S-140	Broward	0.45	0.02	5.98	0.57	7:00	7.02
151	Fort Lauderdale Fld Sta	Broward	0.04	0.00	1.90	0.78	7:00	2.72
6069	Fort Lauderdale	Broward	0.00	0.00	0.90	0.40	7:00	1.99
243	Corkscrew Sanctuary	Collier	0.00	0.00	4.65	1.50	8.00	6.15
311*	Naples Court House	Collier	0.00	0.08	7.62	0.54	8.00	8.24
6046	Naples	Collier	0.04	0.00	5.40	0.28	7:00	5.72
6048	Everglades	Collier	0.14	0.00	M	M	7:00	0.14
5005	Immokalee	Collier	0.23	0.00	4.92	0.37	7:00	5.52
117	Miami Field Station	Dade	0.07	0.00	0.65	0.17	7:00	0.89
121	Homestead Fld Station	Dade	0.09	0.03	0.40	1.50	7:00	2.02
302	S331/S173	Dade	0.08	0.15	0.70	0.00	7:00	0.93
401*	S12-D	Dade	0.00	0.32	1.95	0.00	8:00	2.27
6054	Tamiami @ 40 mi Bend	Dade	0.00	0.12	1.09	0.00	8:00	1.21
7065	Miami WB Airport	Dade	0.00	0.78	0.11	0.26	8:00	1.15
48*	S70	Glades	0.00	0.00	3.18	0.00	8:00	3.18
52	S131	Glades	0.04	0.00	2.35	0.86	7:00	3.25
64	S78(Ortona Lock)	Glades	0.00	0.00	4.00	0.04	7:00	4.04
152	S129	Glades	0.00	0.00	2.80	0.06	7:00	2.86
198	S4	Glades	0.06	0.00	3.20	0.23	7:00	3.49
63	Clewiston Field Station	Hendry	0.00	0.37	3.72	0.25	7:00	4.34
142	3R Ranch	Hendry	0.00	3.85	0.60	0.00	8:00	4.45
282C*	Paige Ranch	Hendry	0.00	0.00	4.59	0.60	8:00	5.19 M
286	Devils Garden Tower	Hendry	0.00	0.00	4.10	0.60	8:00	4.70
379*	Six L's Farm	Hendry	0.00	0.00	4.10	0.60	8:00	4.70
6044	LaBelle	Hendry	0.00	0.00	3.50	0.00	8:00	3.50
7039	Clewiston HG-2	Hendry	0.00	0.00	3.85	0.20	8:00	4.05
7045	Felda	Hendry	0.00	0.00	3.76	0.80	8:00	4.56
41	S68	Highland	0.02	0.00	4.15	0.00	7:00	4.17
46	Brighton	Highland	0.00	0.00	2.02	0.00	8:00	2.02
6023	Vero Beach Airport	Indian River	0.50	0.00	0.74	0.03	7:00	1.27
227	S79	Lee	0.00	0.00	3.48	0.00	7:00	3.48
250	Alva Farms	Lee	0.00	3.70	0.02	0.00	8:00	3.72
6093	Fort Myers	Lee	M	0.00	1.26	0.00	7:00	1.26
49	St.Lucie Lock	Martin	0.00	0.00	3.80	0.10	7:00	3.90

* Hourly Station
M Missing Hourly Data

APPENDIX A
Daily Rainfall Values at Various Stations During the Storm

MRF No.	Station Name	County	1/14	1/15	1/16	1/17	Recording Time AM	Total
51	Port Mayaca Lock	Martin	0.00	0.00	3.32	0.11	7:00	3.43
150	S135	Martin	0.00	0.00	2.50	0.00	7:00	2.50
6125	Flamingo	Monroe	0.00	0.35	0.11	0.04	8:00	0.50
35	S65B	Okeechobee	0.00	0.00	3.02	0.00	7:00	3.02
38	S65C	Okeechobee	0.00	0.00	4.02	0.00	7:00	4.02
43	S65D	Okeechobee	0.00	0.00	3.98	0.00	7:00	3.98
44	Okeechobee Fld.Sta.	Okeechobee	0.04	0.00	3.72	0.00	7:00	3.76
45	S65E	Okeechobee	0.00	0.00	3.46	0.00	7:00	3.46
144	S133	Okeechobee	0.00	0.00	3.87	0.00	7:00	3.87
9	Kissimmee Fld.Sta.	Osceola	0.00	0.00	1.83	0.00	7:00	1.83
13	St. Cloud Air Park	Osceola	M	0.00	1.23	0.00	7:00	1.23
18	S61	Osceola	0.00	0.00	1.52	0.00	7:00	1.52
32	S65A	Osceola	0.01	0.00	1.95	0.00	7:00	1.96
68C*	Ritta	Palm Beach	0.00	0.00	3.93	0.20	8:00	4.13 M
69	S3	Palm Beach	0.06	0.00	6.12	0.21	7:00	6.39
71*	Miami Lock	Palm Beach	0.00	0.00	6.23	0.23	8:00	6.46
73*	South Bay	Palm Beach	0.00	0.00	5.02	0.73	8:00	5.75
76	S5A	Palm Beach	0.47	0.00	6.98	0.89	7:00	8.34
81	Lake Worth Rd. & E1	Palm Beach	0.16	0.12	8.55	0.00	8:00	8.83
84	Boynton Rd. & Mil.Tr.	Palm Beach	0.27	0.03	6.70	0.00	8:00	7.00
89*	WCA 1-8	Palm Beach	0.00	0.00	8.79	0.07	8:00	8.86
95	S6	Palm Beach	0.18	0.00	6.97	0.84	7:00	7.99
98	S8	Palm Beach	0.00	0.00	6.15	1.20	7:00	7.35 M
99	S7	Palm Beach	0.19	0.02	7.05	0.00	7:00	7.26
131*	Pelican Lake	Palm Beach	0.00	0.00	4.26	0.22	8:00	4.48
183	S2	Palm Beach	0.10	0.00	5.80	0.30	7:00	6.20
213	Rangeline & lateral	Palm Beach	0.04	0.00	3.70	0.17	8:00	3.91
222	West Palm Bch Fld.Sta.	Palm Beach	0.00	0.00	8.65	0.43	7:00	9.08
6119	Belle Glade Exp. Sta.	Palm Beach	0.00	0.00	5.46	0.71	8:00	6.17
7041	Canal Point @ HG-5	Palm Beach	0.00	0.00	4.86	0.25	8:00	5.11
S-155	C-51	Palm Beach	0.01	0.00	10.76	0.37	7.00	11.14
27	S65	Polk	0.00	0.00	1.35	0.00	7:00	1.35
37	Fort Pierce	St. Lucie	0.02	0.00	2.53	0.02	7:00	2.57

* Hourly Station
M Missing Hourly Data

APPENDIX B

Figures

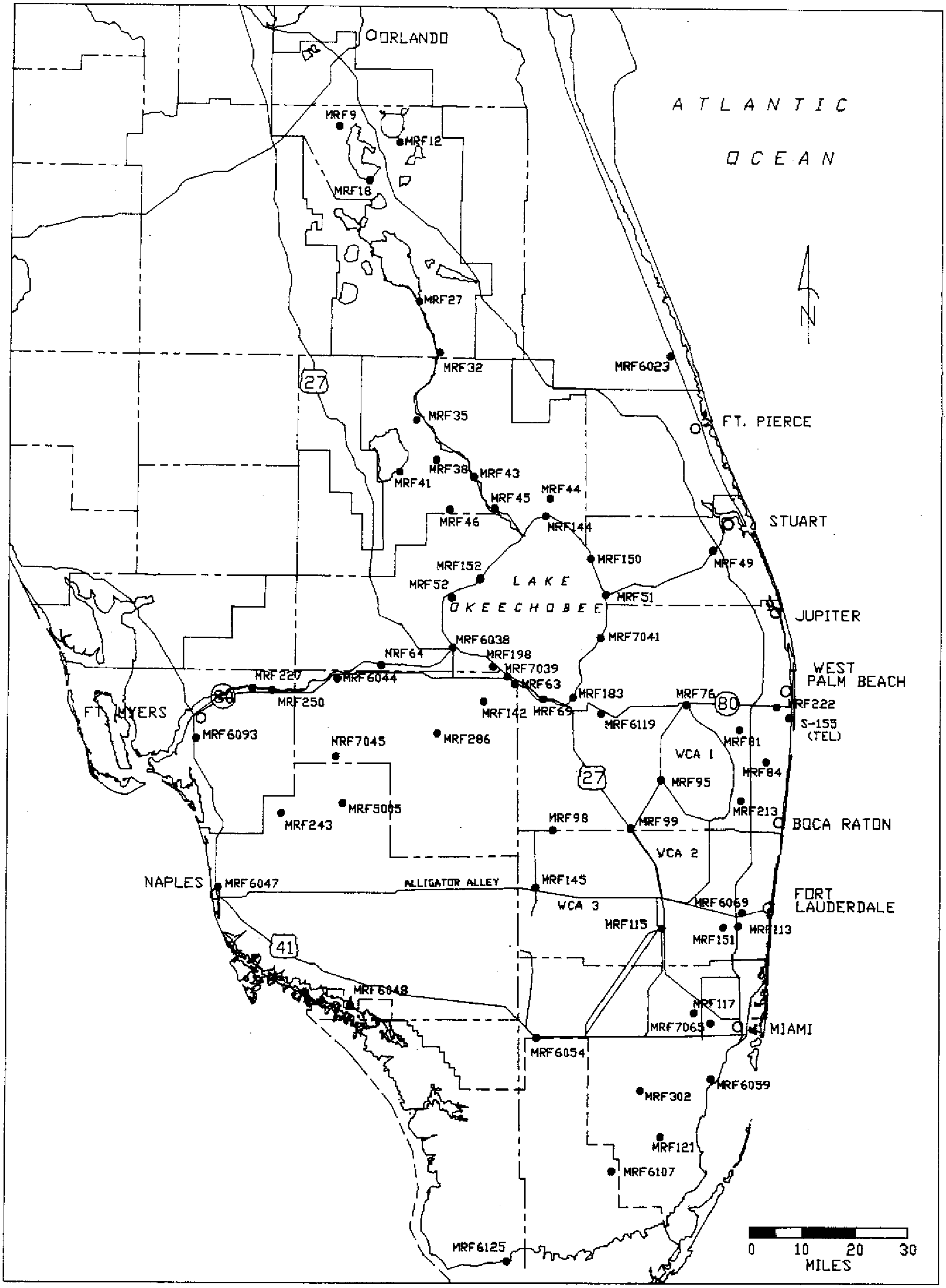


Figure B-1. Location Map for Daily Rainfall Gauges

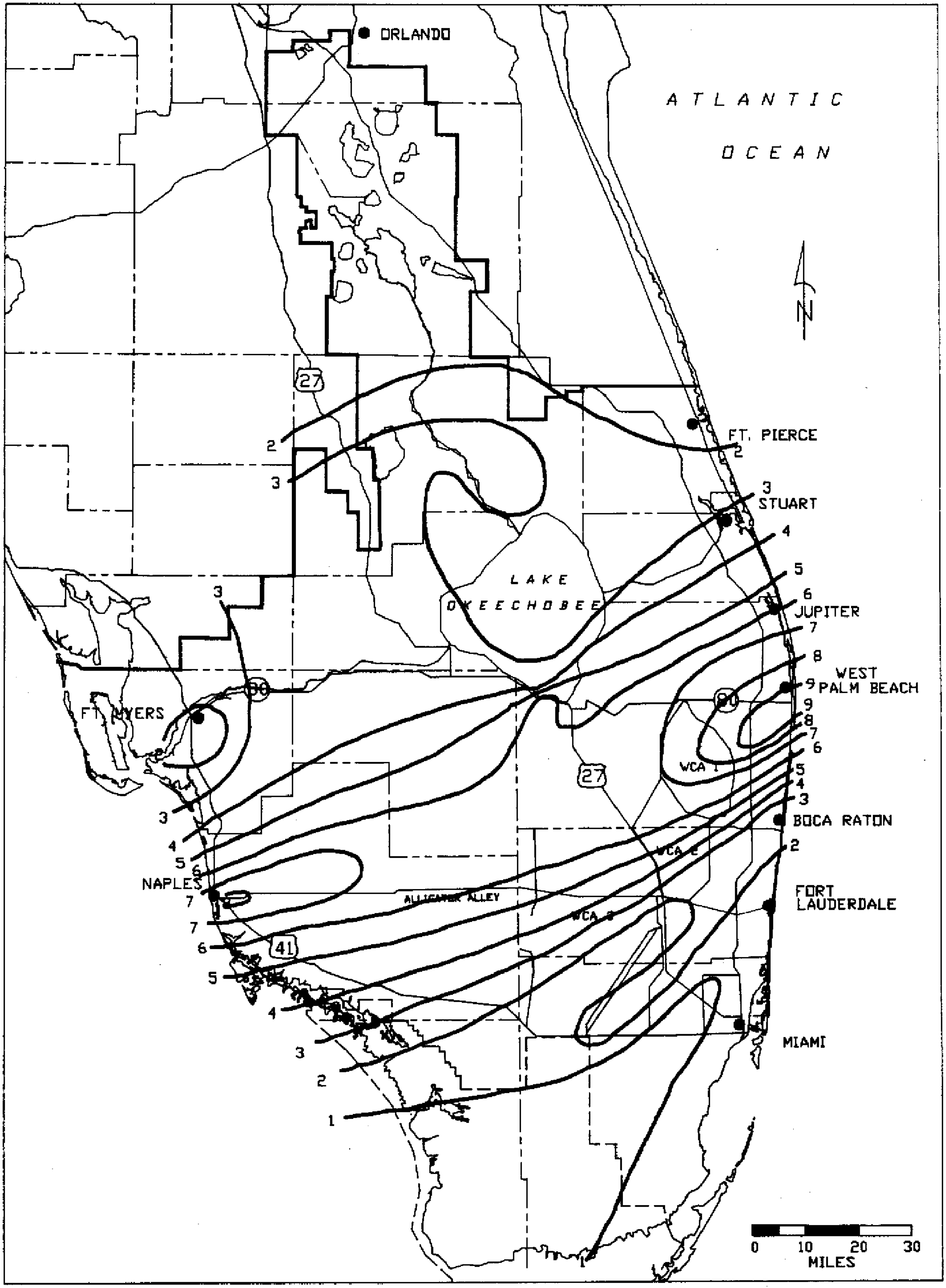


Figure B-2. Isohyetal Map of Maximum Recorded 24-Hour Rainfall

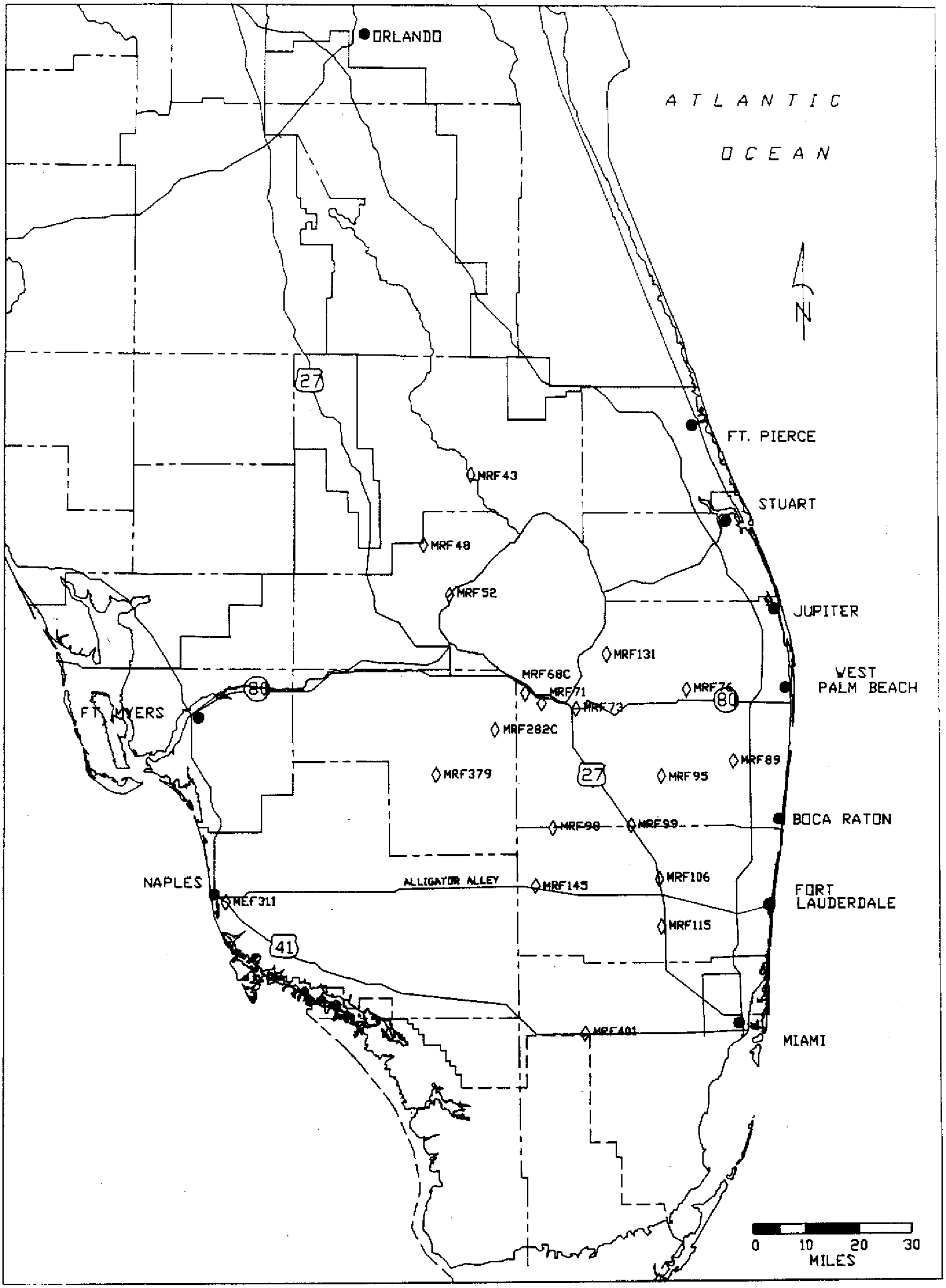


Figure B-3. Location Map for Hourly Rainfall Gauges

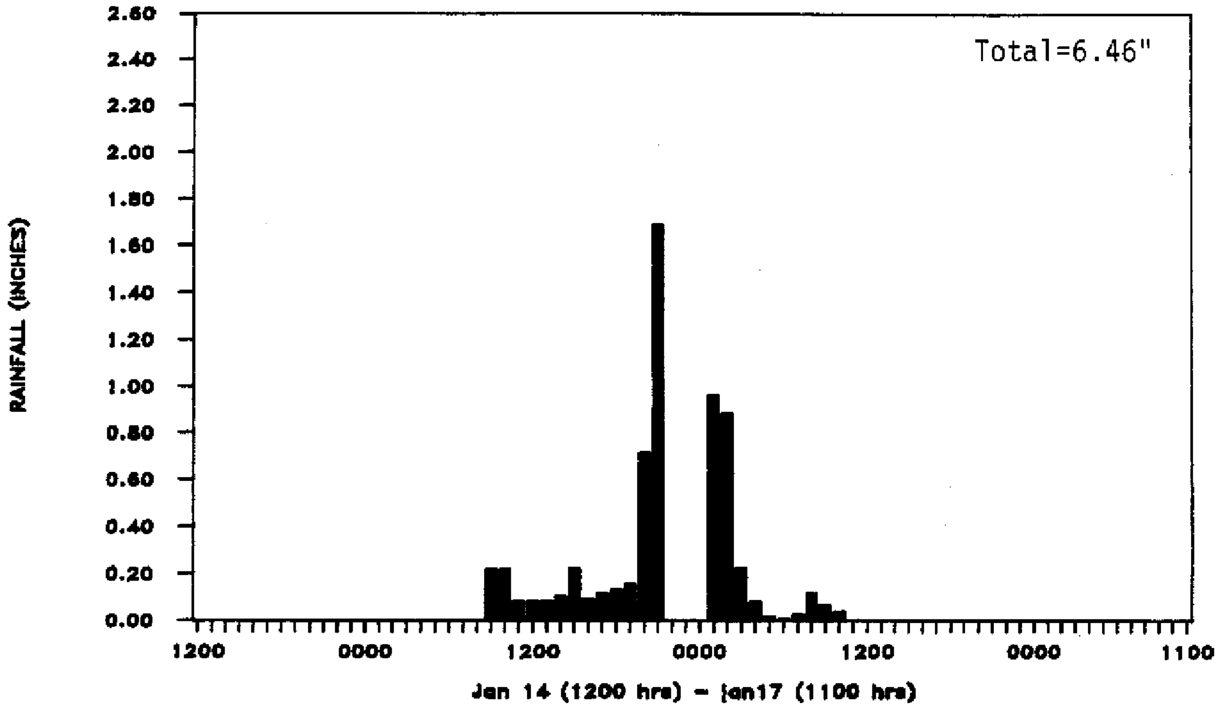


Figure B-4. Hourly Rainfall Distribution in S-3 Basin at Station MRF 71

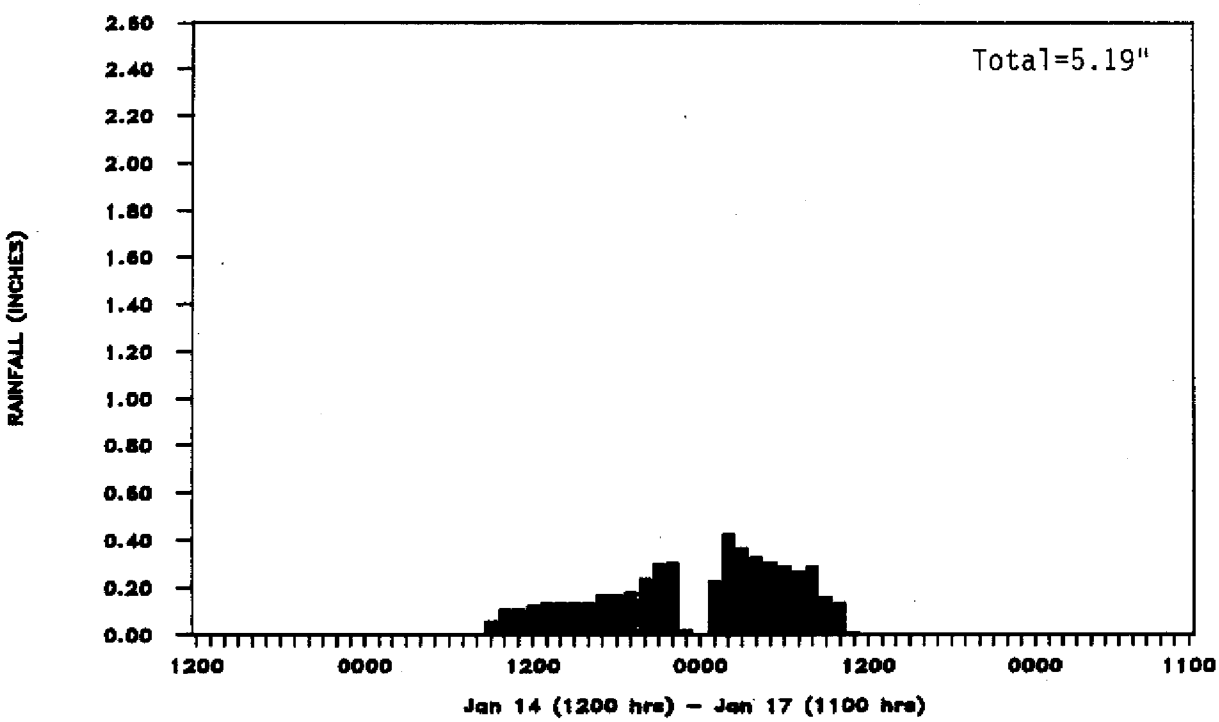


Figure B-5. Hourly Rainfall Distribution in S-3 Basin at Station MRF 282C

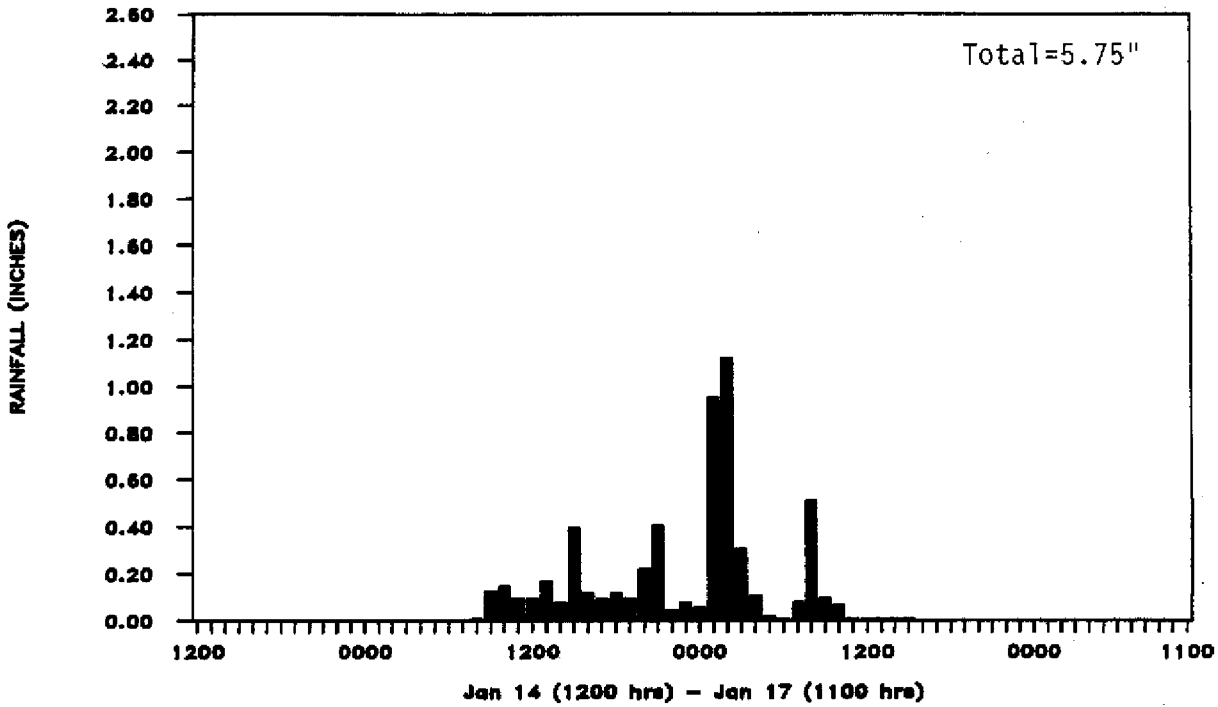


Figure B-6. Hourly Rainfall Distribution in S-2 Basin at Station MRF 73

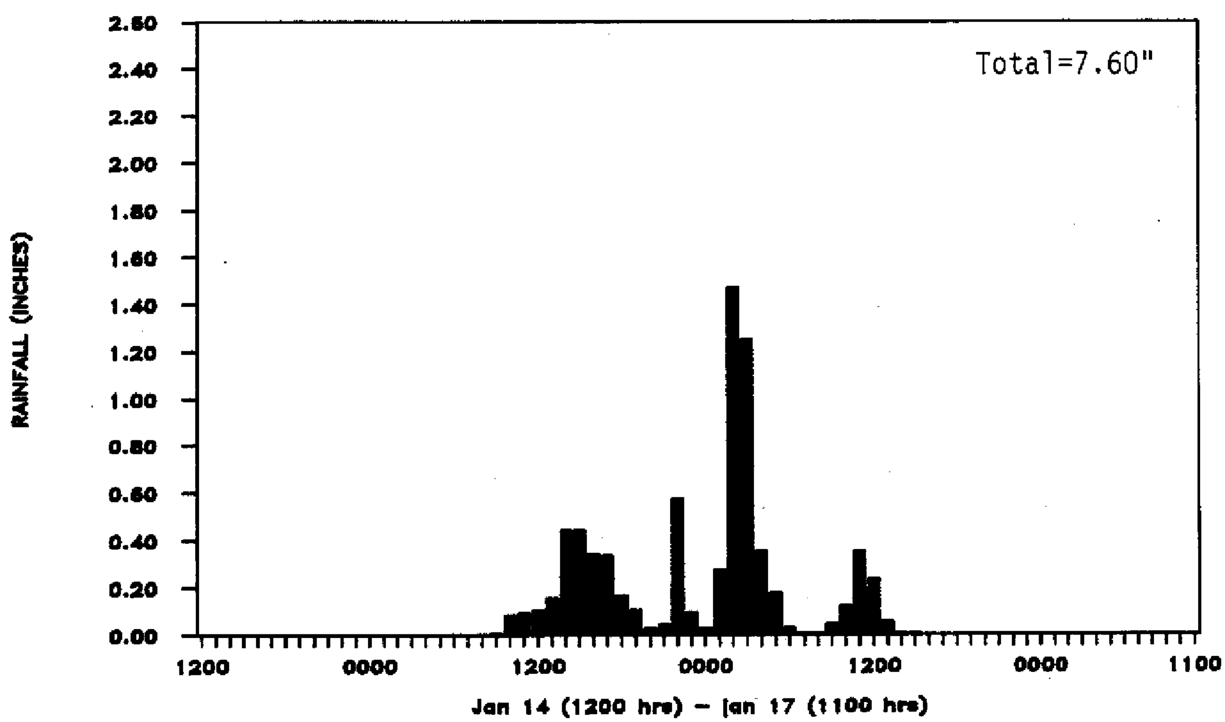


Figure B-7. Hourly Rainfall Distribution in S-5A Basin at Station MRF 76

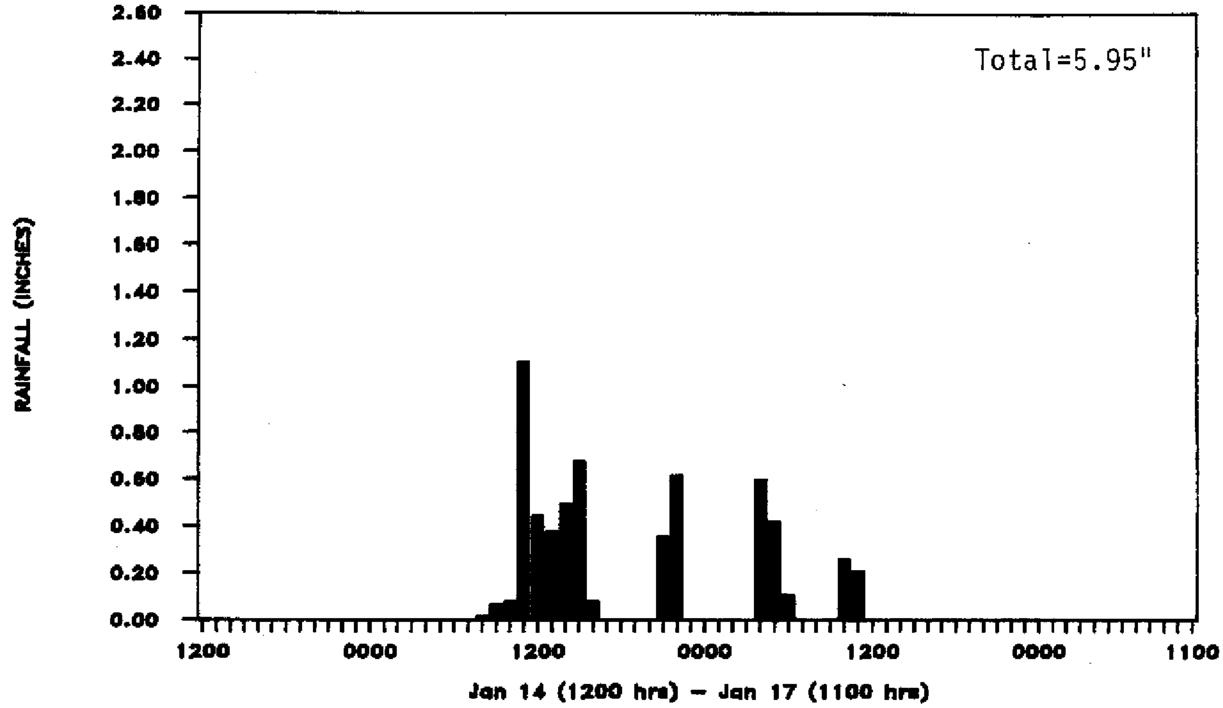


Figure B-8. Hourly Rainfall Distribution in WCA3 at Station MRF 145

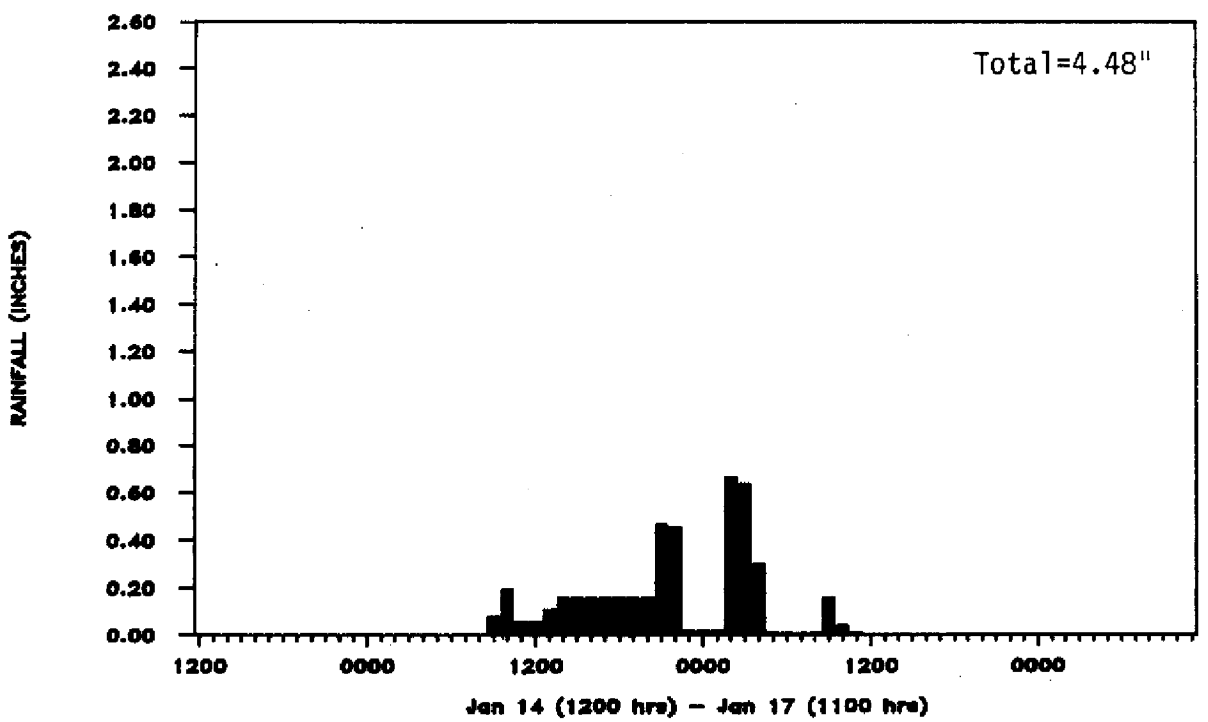


Figure B-9. Hourly Rainfall Distribution in S-5A Basin at Station MRF 131

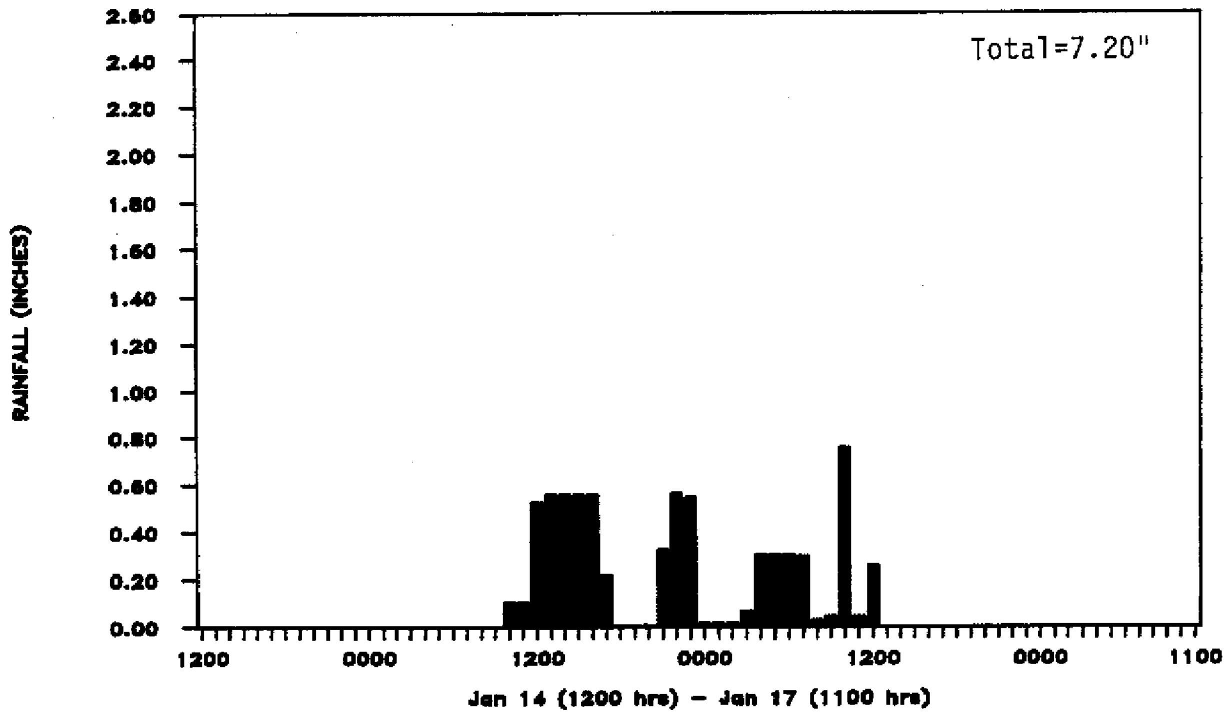


Figure B-10. Hourly Rainfall Distribution in S-8 Basin at Station MRF 98

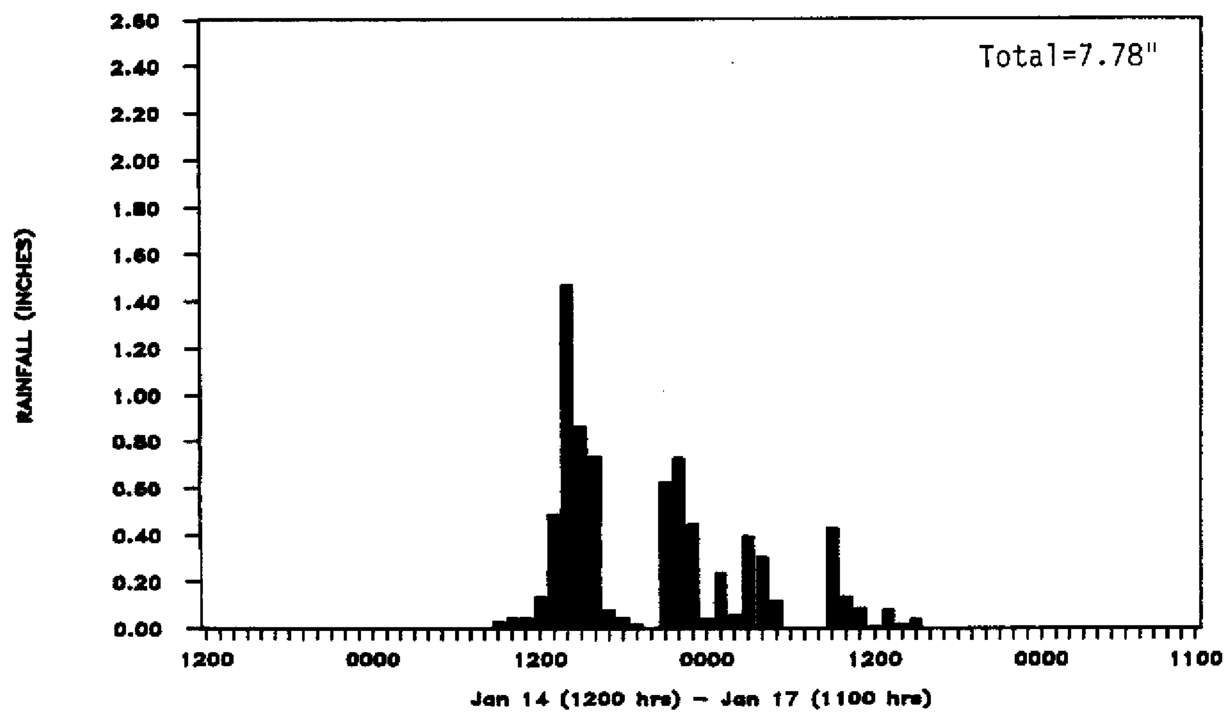


Figure B-11. Hourly Rainfall Distribution in S-6 Basin at Station MRF 95

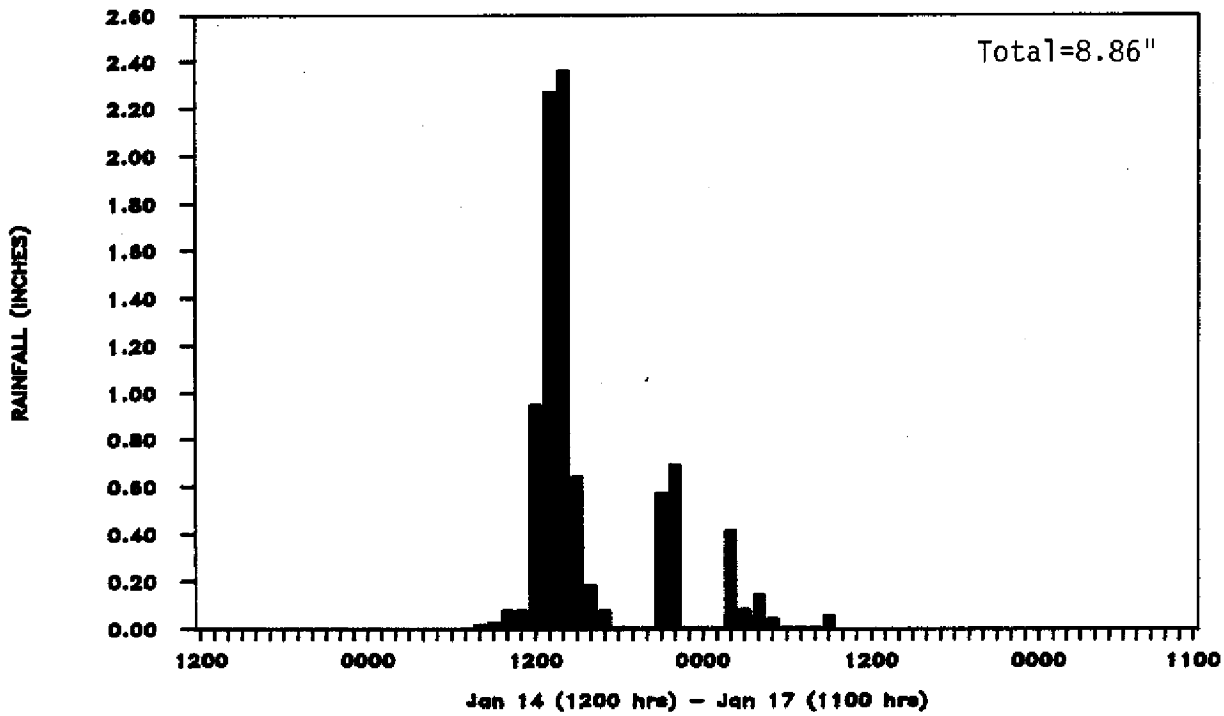


Figure B-12. Hourly Rainfall Distribution in C-15/WCA1 at Station MRF 89

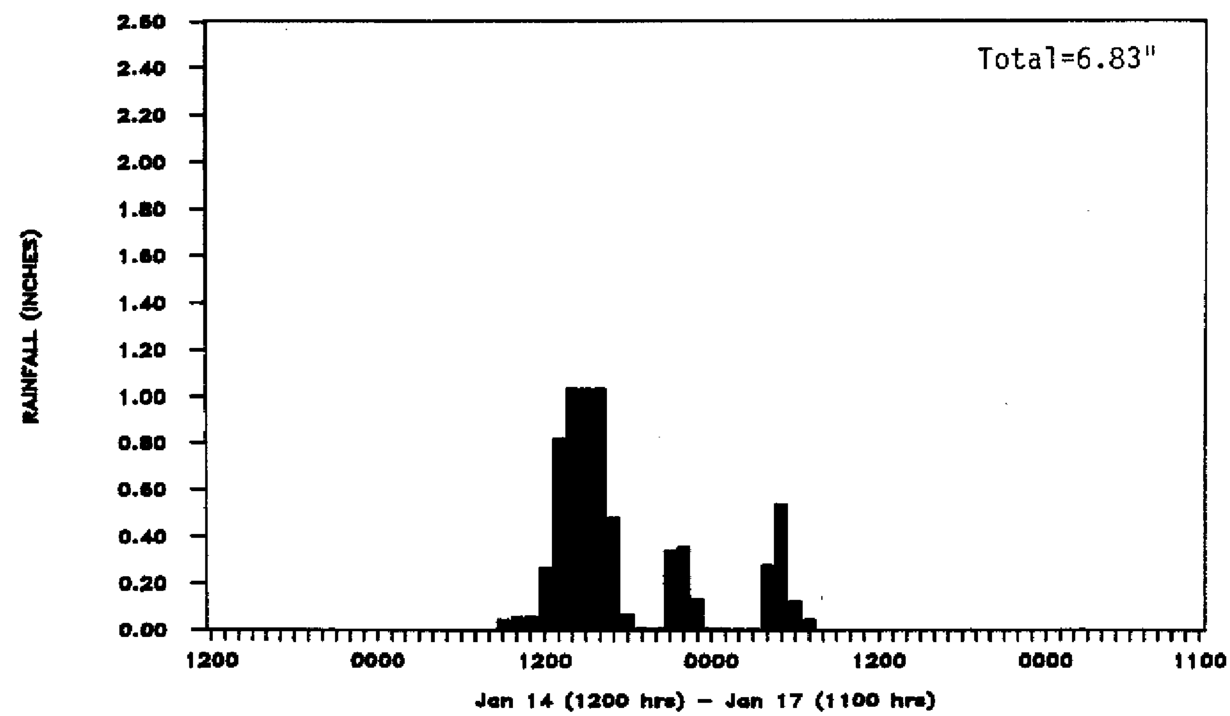


Figure B-13. Hourly Rainfall Distribution in S-7/WCA2 at Station MRF 99

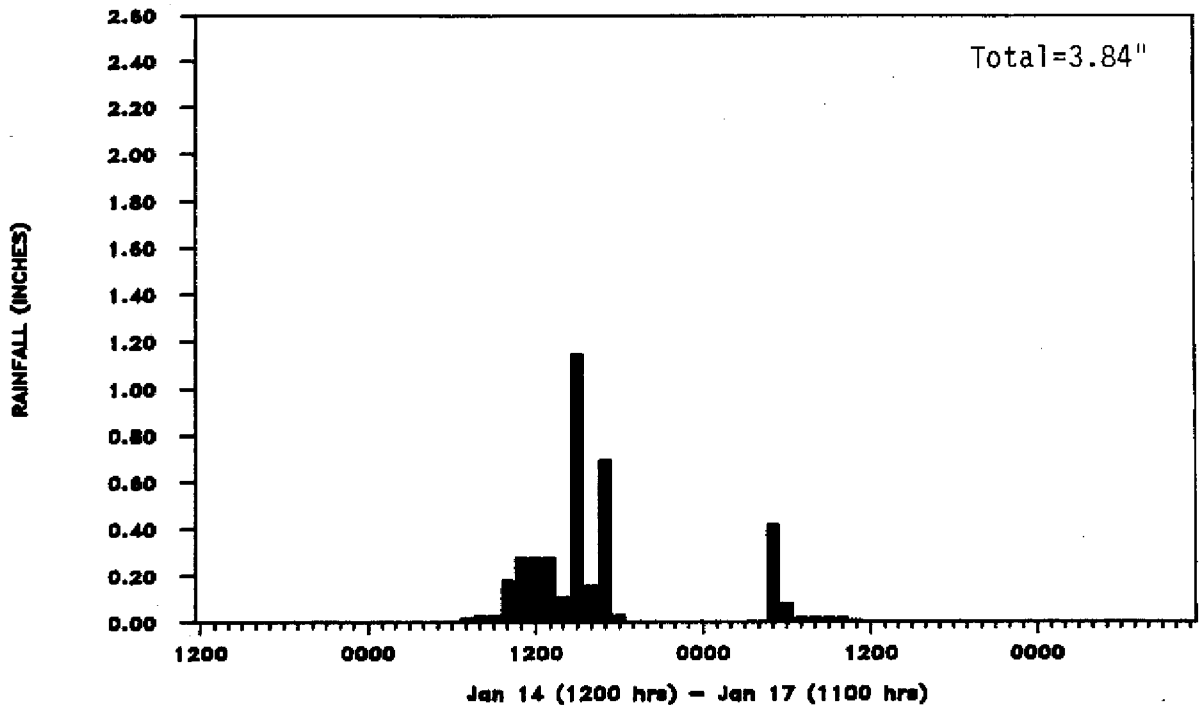


Figure B-14. Hourly Rainfall Distribution in WCA2 at Station MRF 106

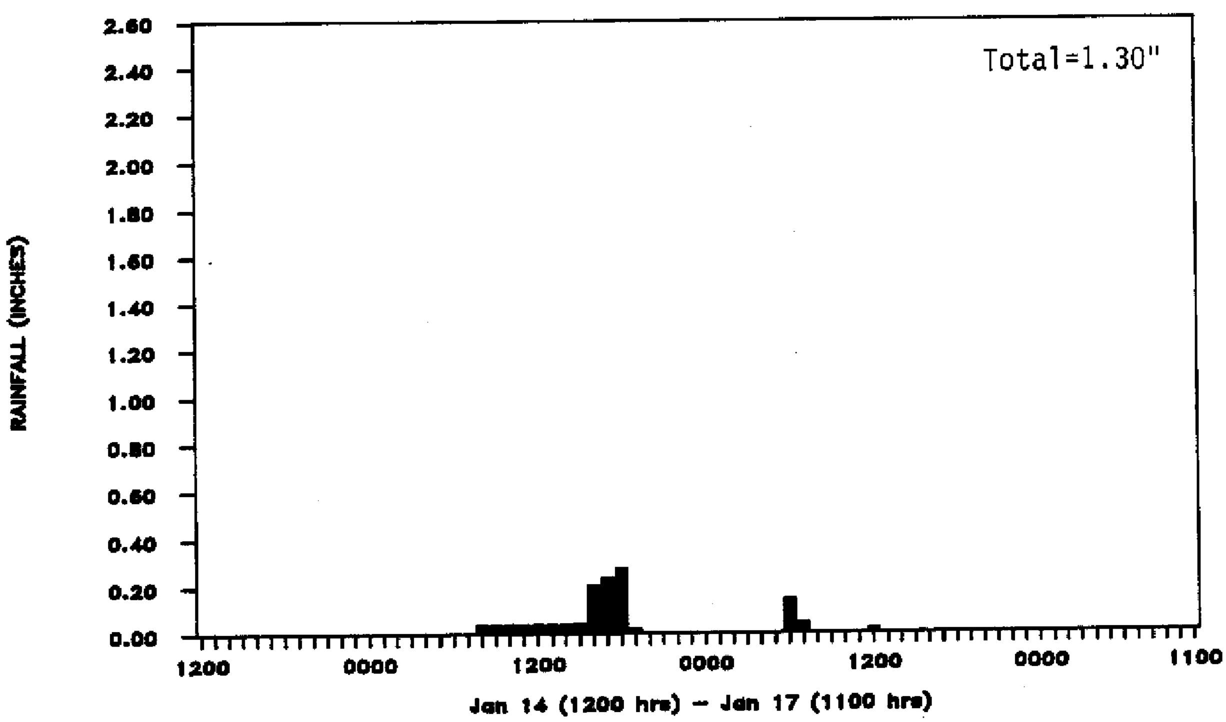


Figure B-15. Hourly Rainfall Distribution in C-11W/WCA3 at Station MRF 115

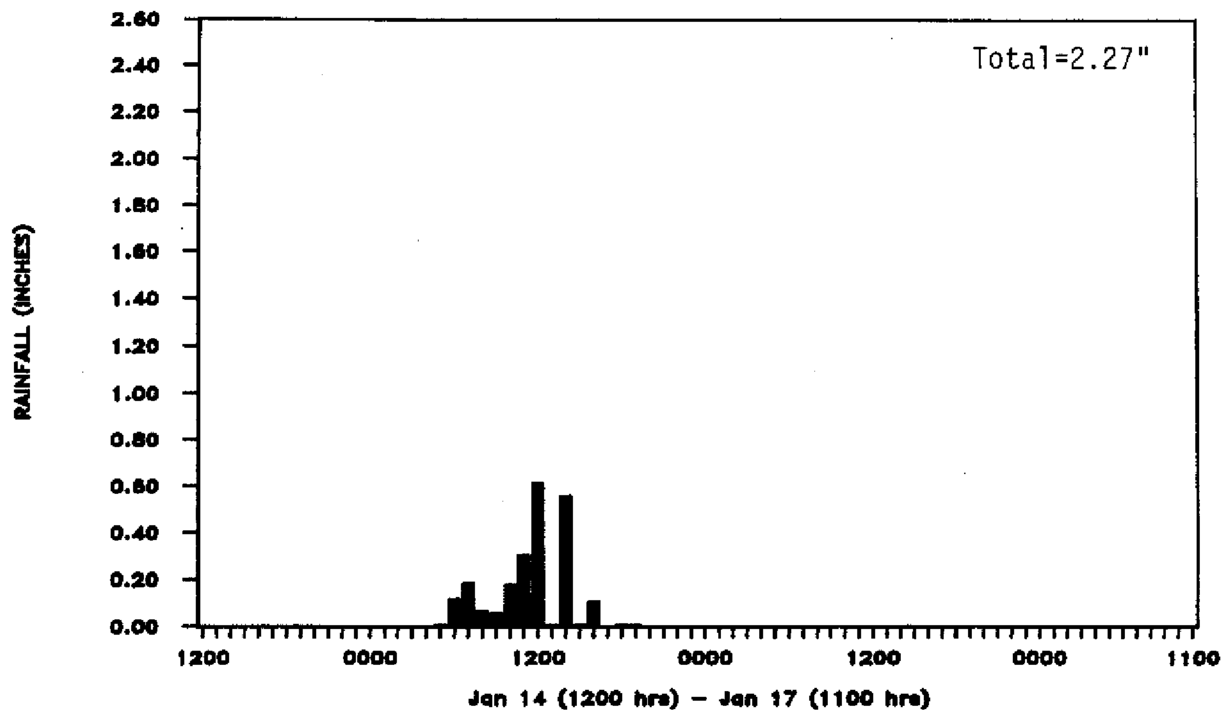


Figure B-16. Hourly Rainfall Distribution in Dade County at Station MRF 401

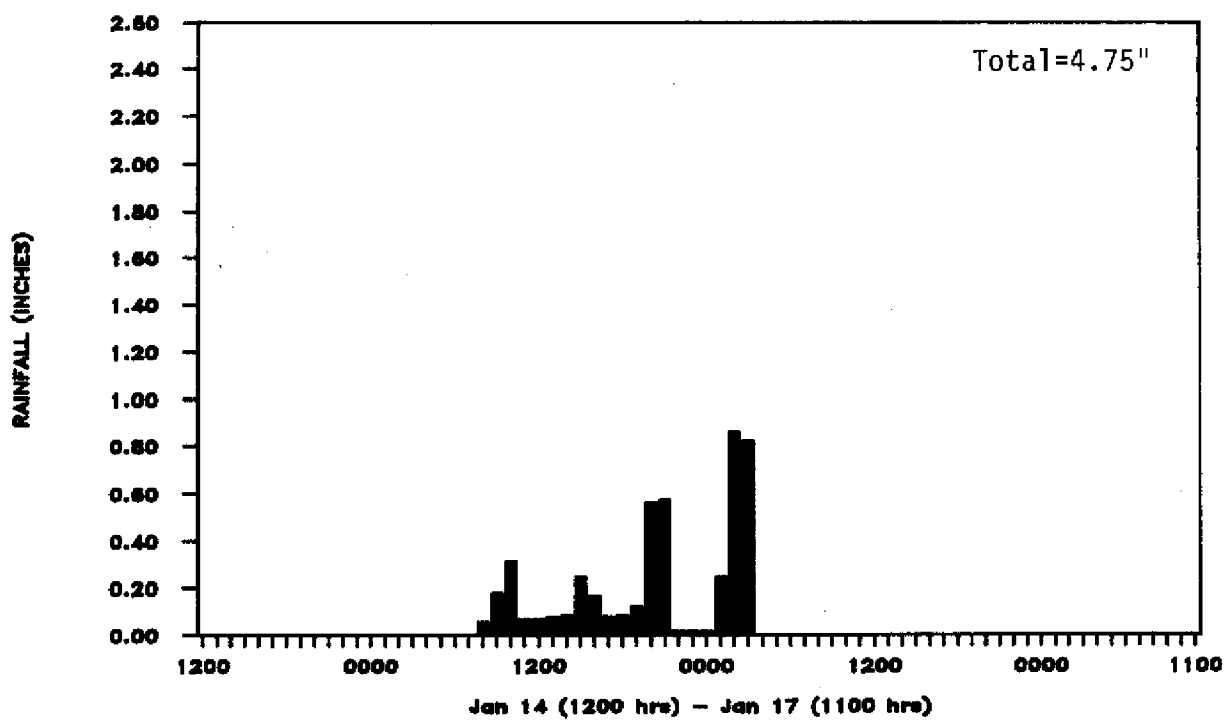


Figure B-17. Hourly Rainfall Distribution in C-159 Basin at MRF 182

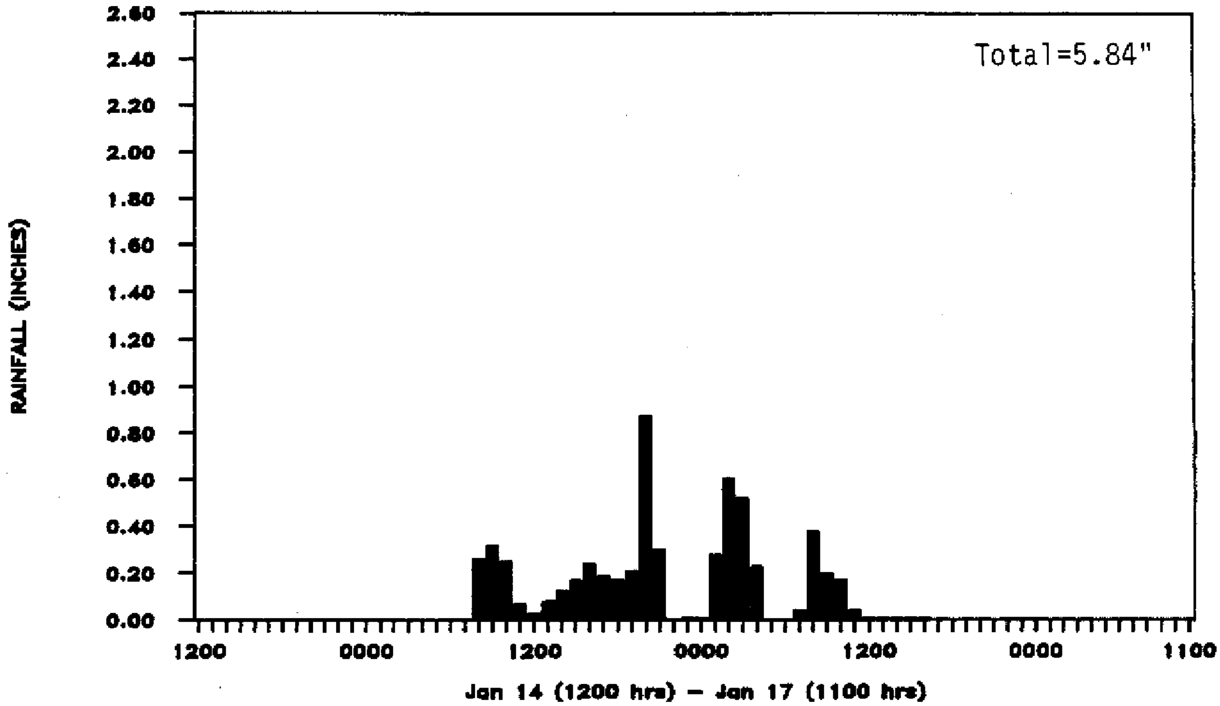


Figure B-18. Hourly Rainfall Distribution in C-159 Basin at Station MRF 379

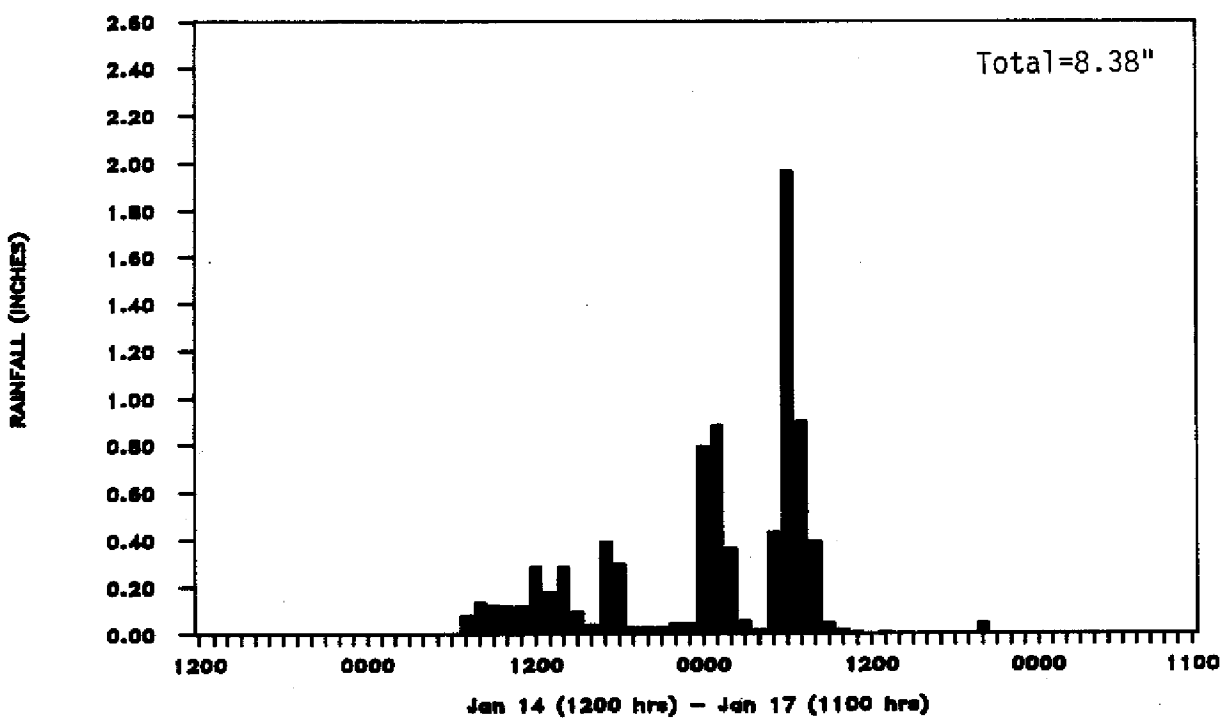


Figure B-19. Hourly Rainfall Distribution in West Collier at Station MRF 311

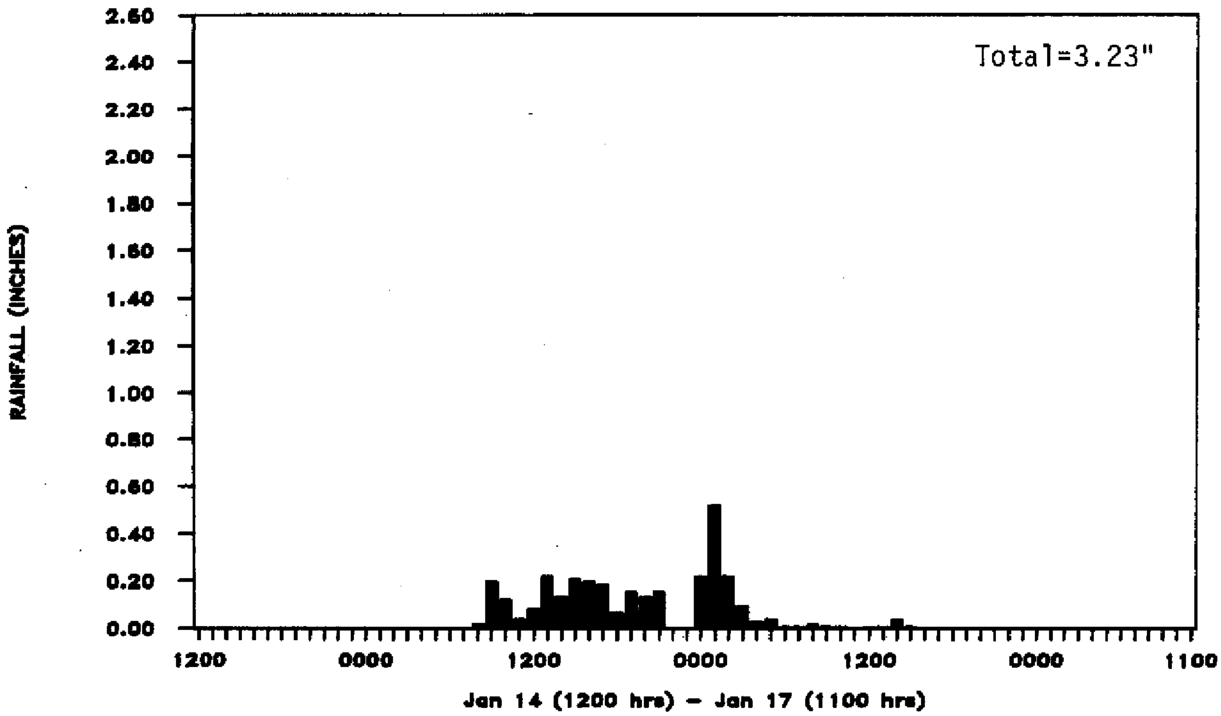


Figure B-20. Hourly Rainfall Distribution in S-131 Basin at Station MRF 52

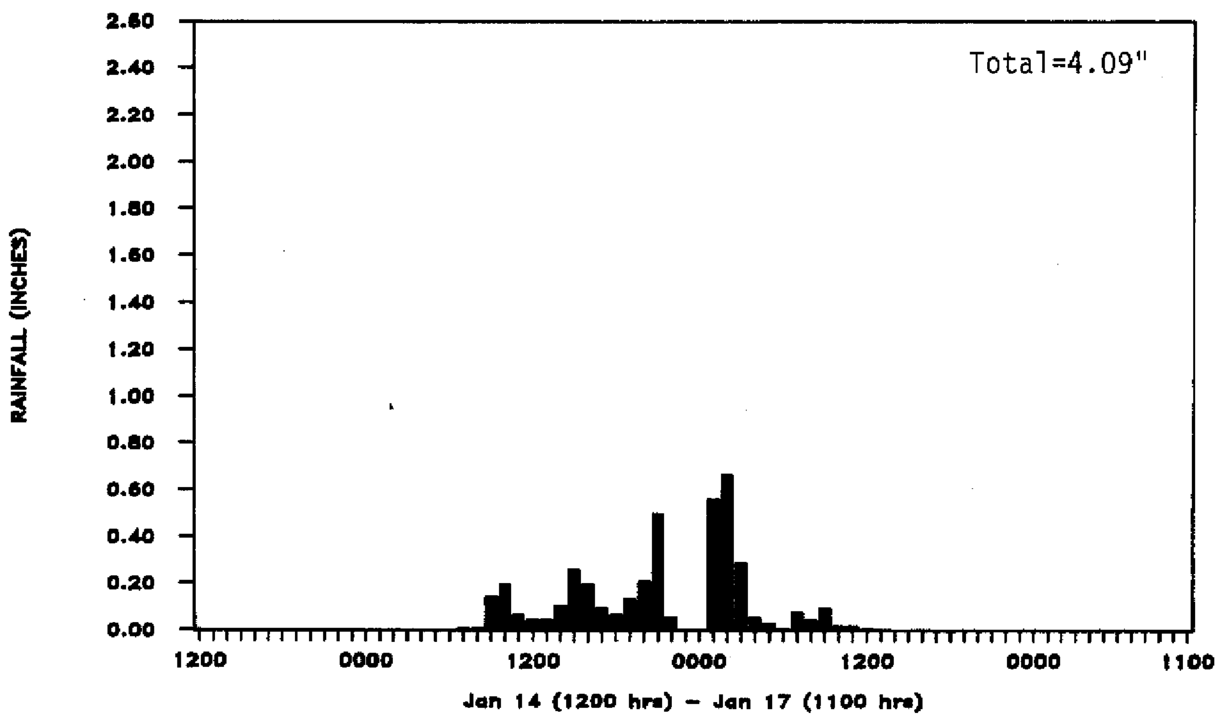


Figure B-21. Hourly Rainfall Distribution in S-236 Basin at Station MRF 68C

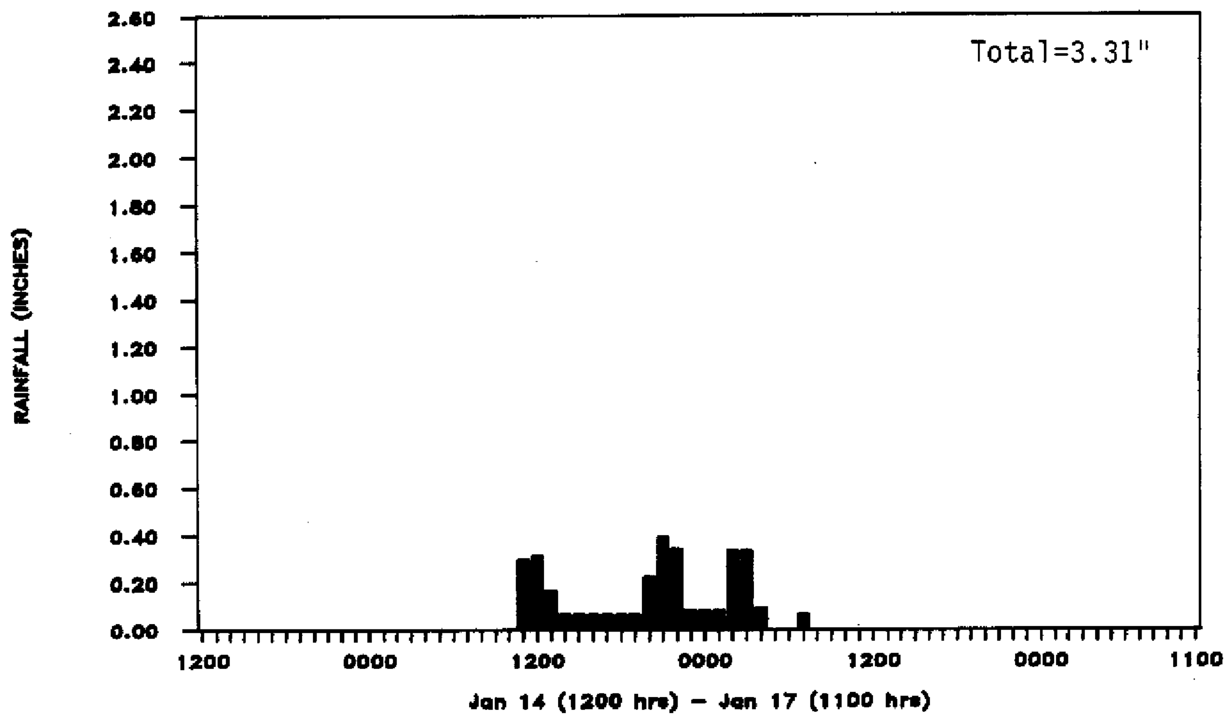


Figure B-22. Hourly Rainfall Distribution in S-65D Basin at Station MRF 43

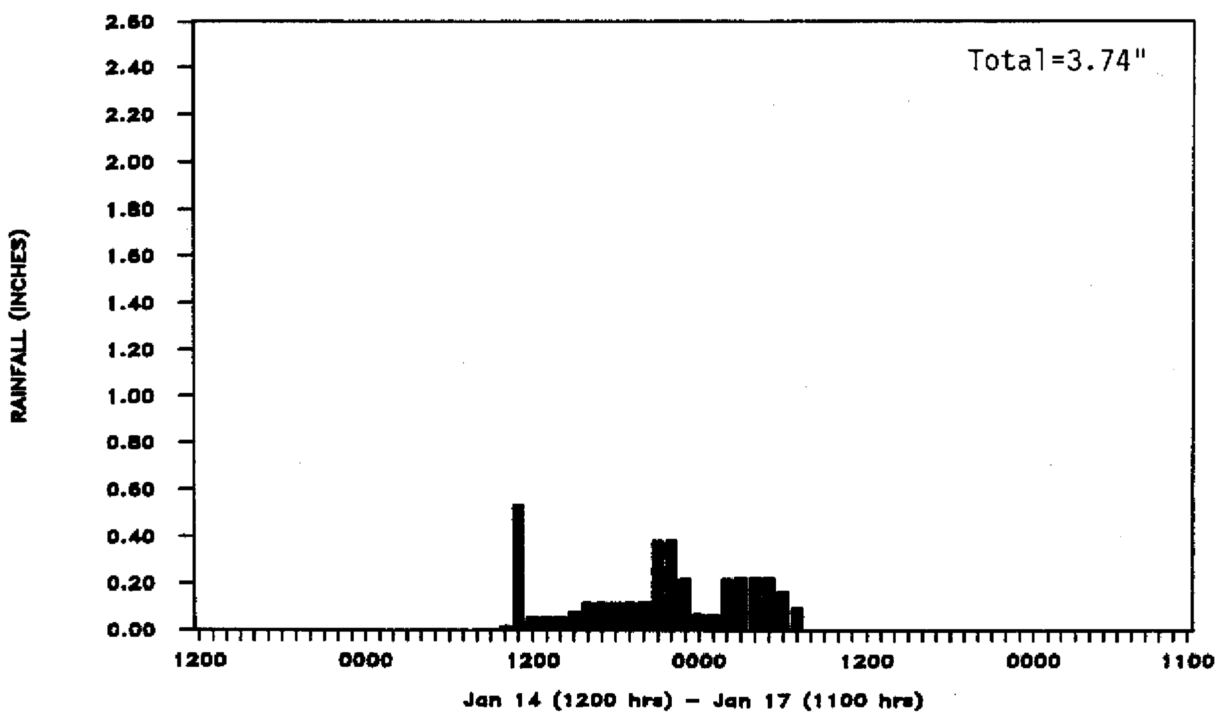


Figure B-23. Hourly Rainfall Distribution in C-41 Basin at Station MRF 48

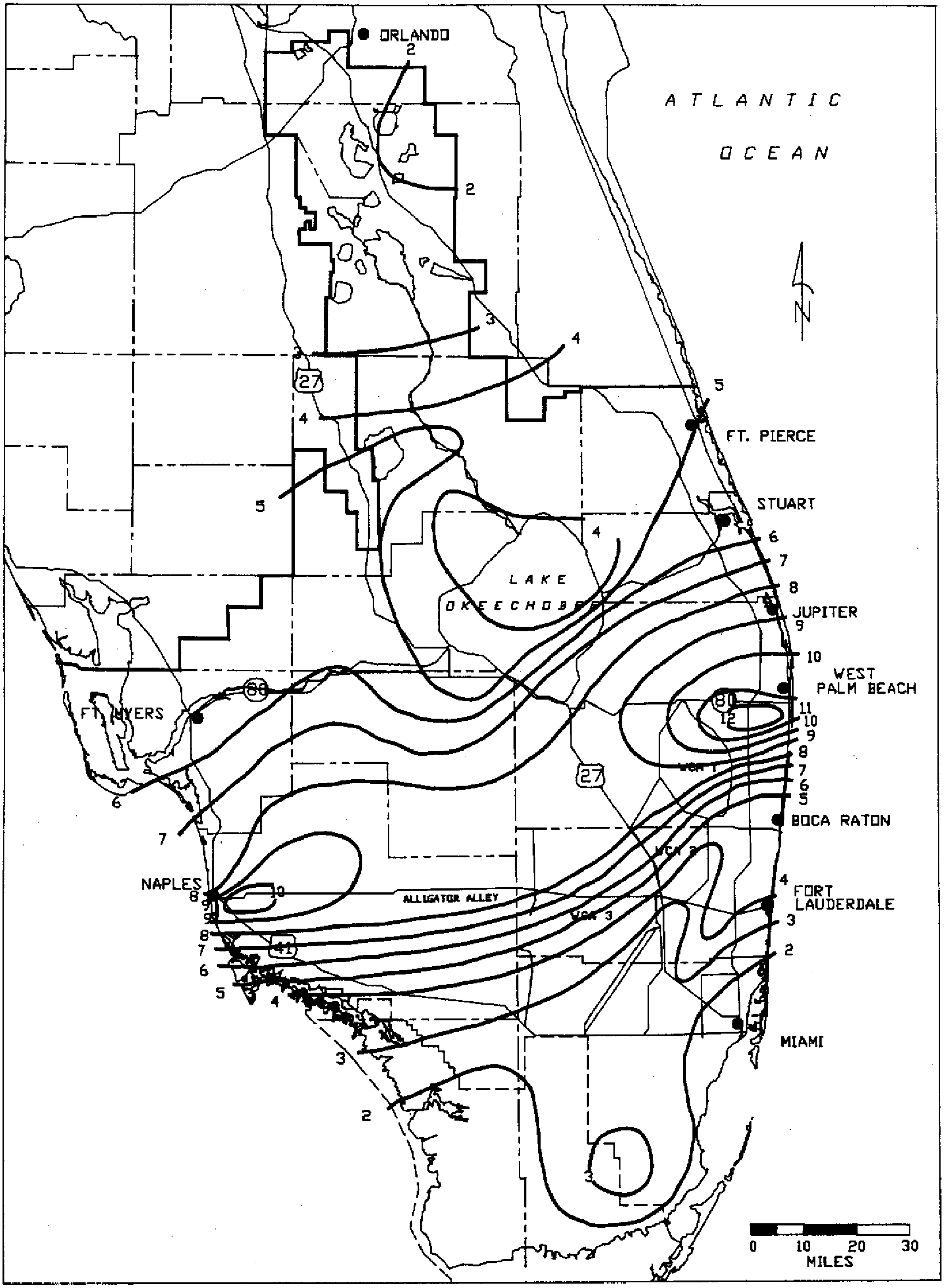


Figure B-24. Isohyetal Map of Total Rainfall (January, 1991)

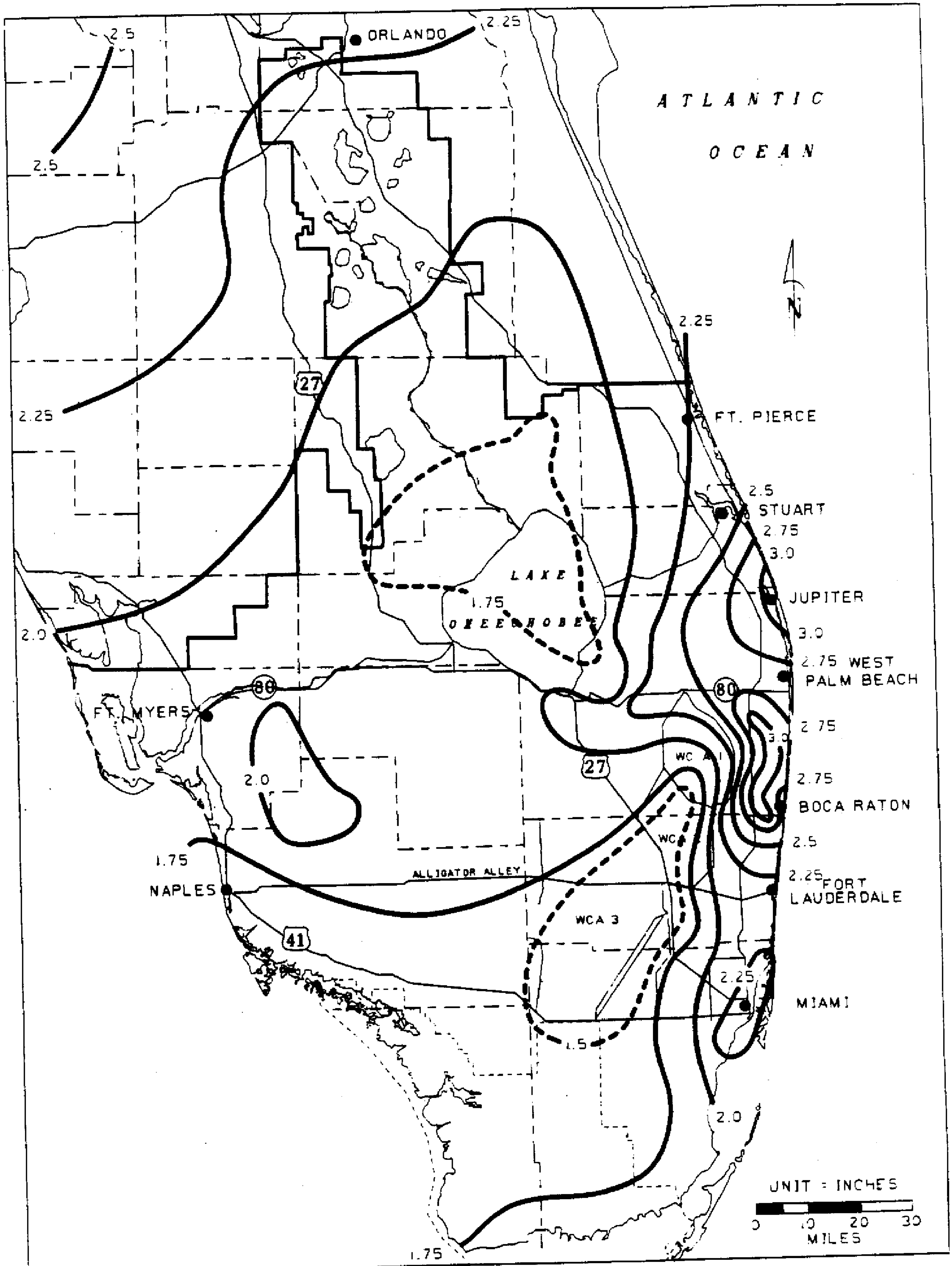


Figure B-25. Isohyetal Map of Normal Rainfall (January)

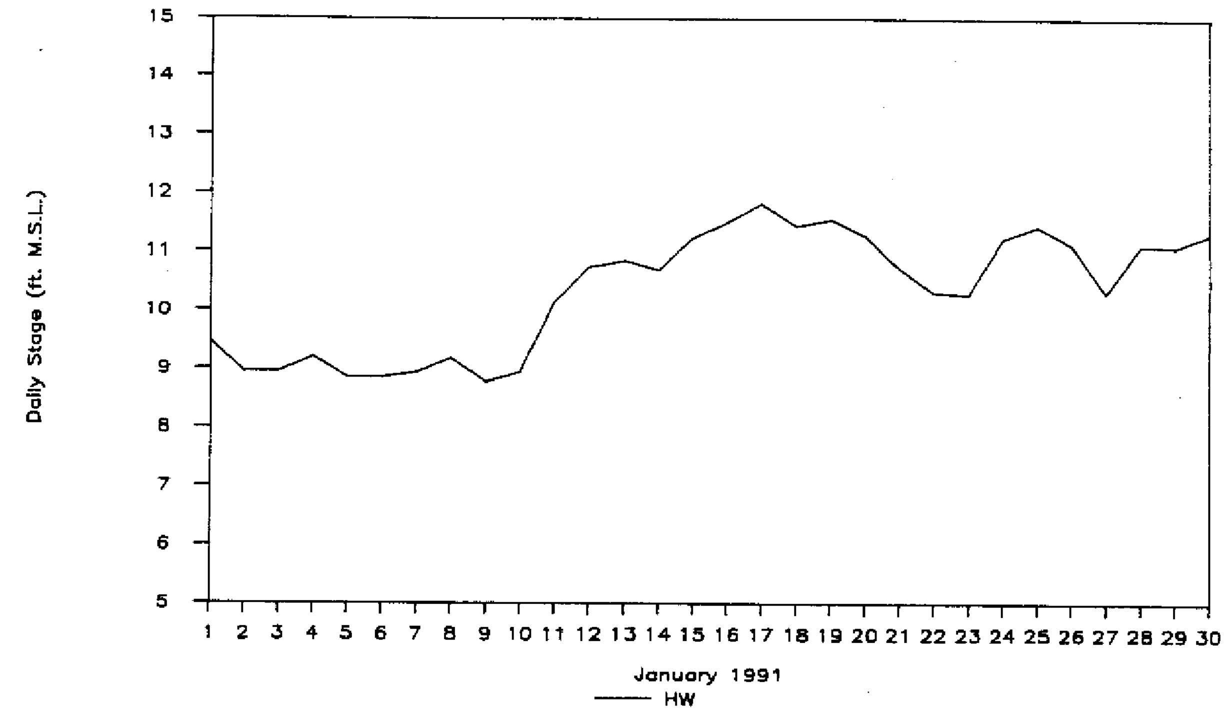


Figure B-26. Daily Stages in Miami Canal 15 Miles Below Lake Harbor

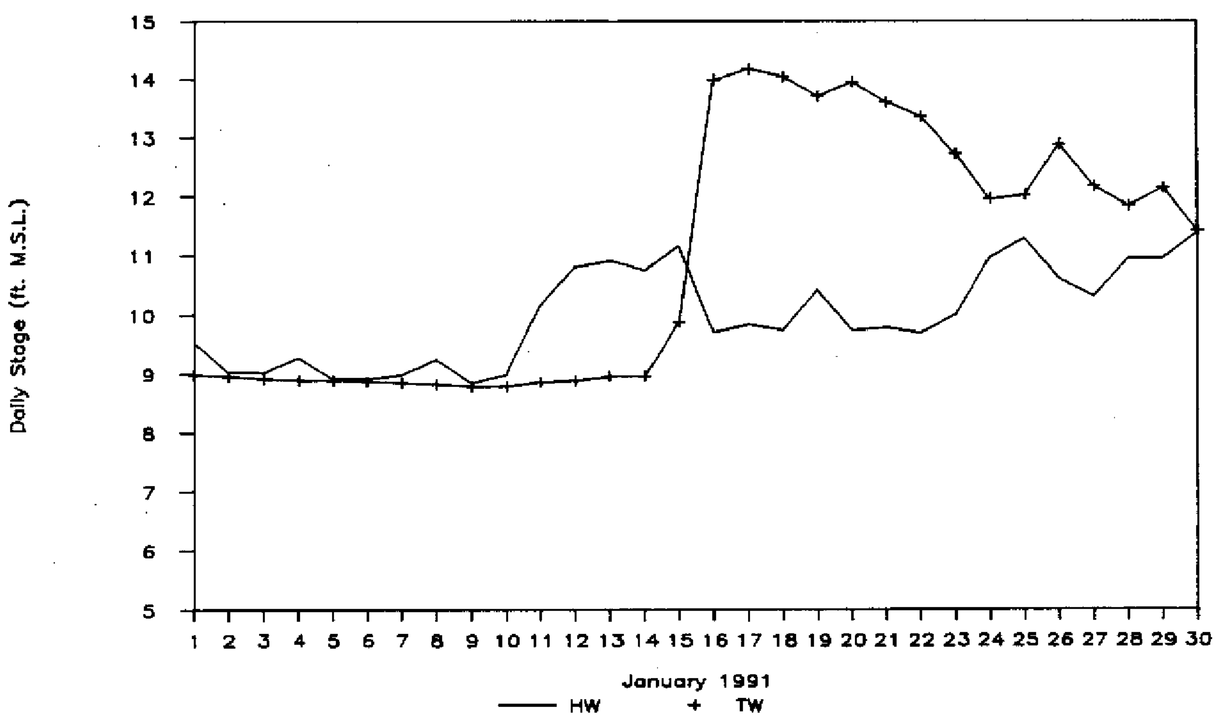


Figure B-27. Daily Stages in Miami Canal at S-8

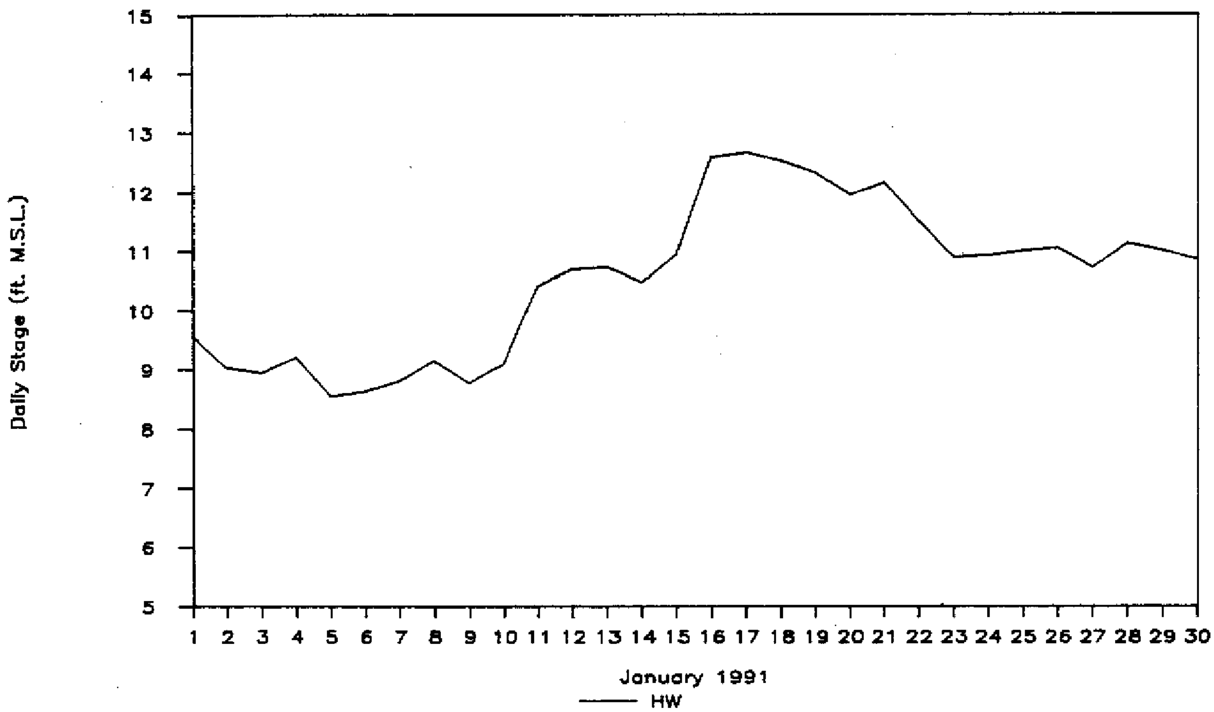


Figure B-28. Daily Stages in North New River Canal at South Florida Sugar

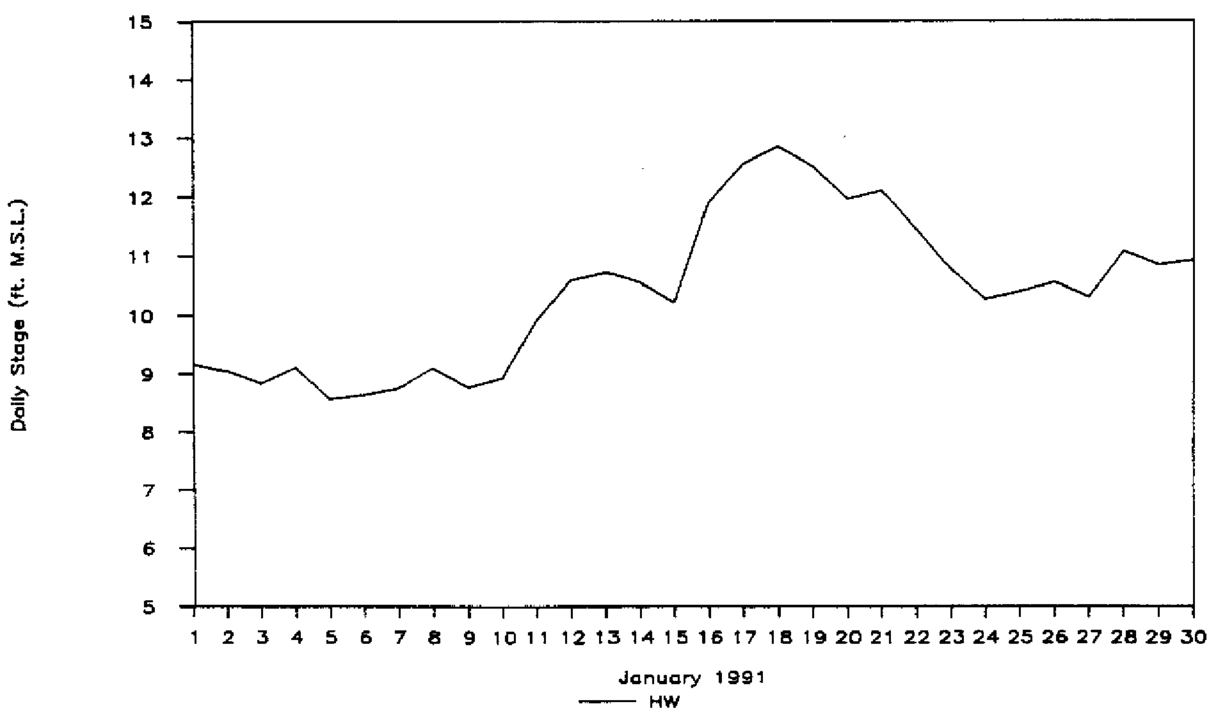


Figure B-29. Daily Stages in Hillsboro Canal at Six Mile Bend

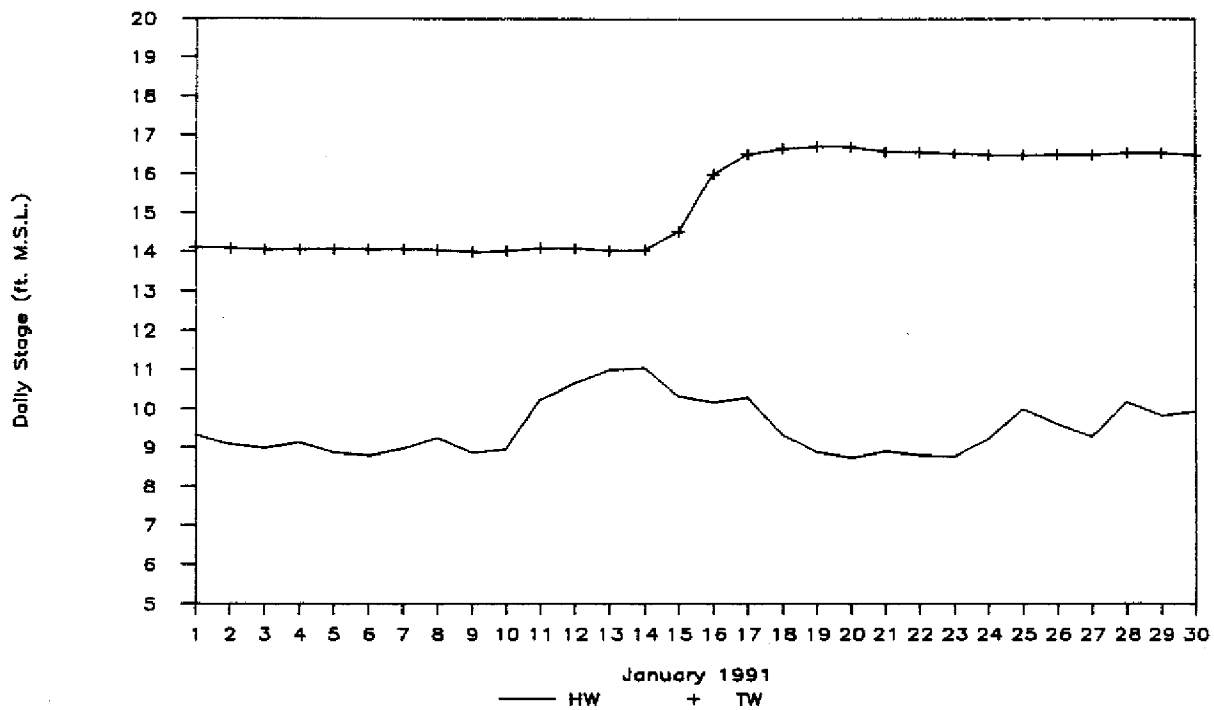


Figure B-30. Daily Stages in West Palm Beach Canal at S-5A

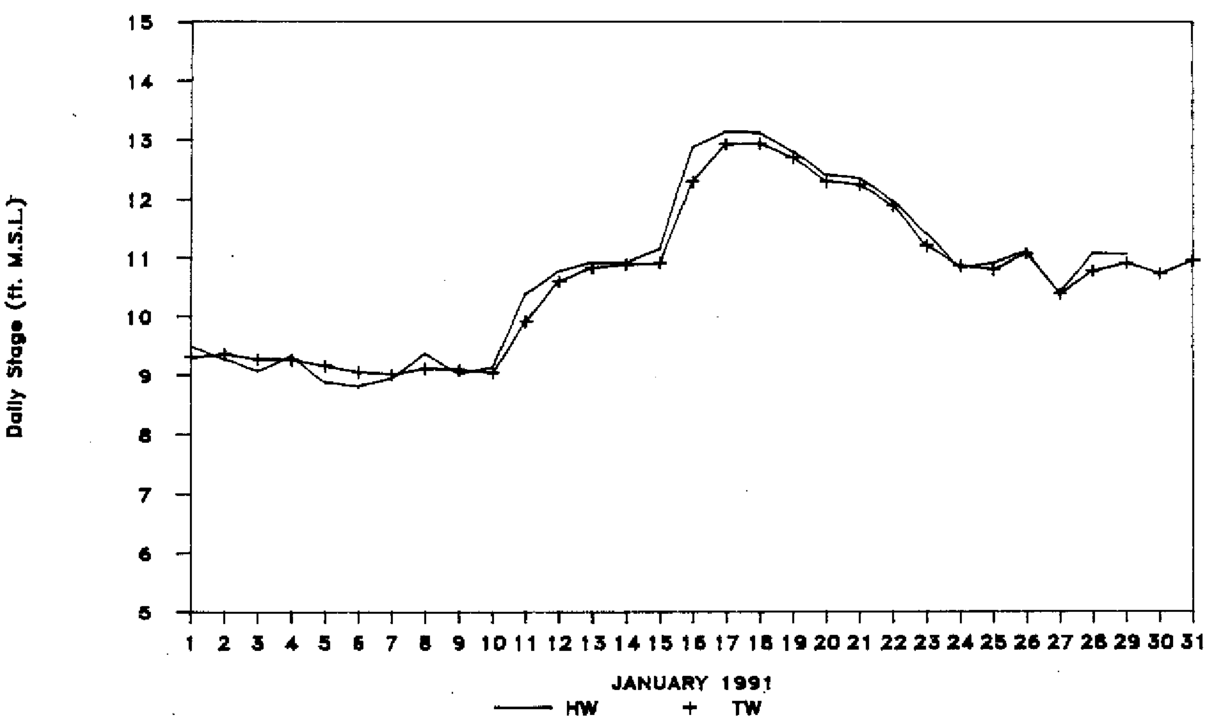


Figure B-31. Daily Stages in Ocean Canal at S-5A(X)

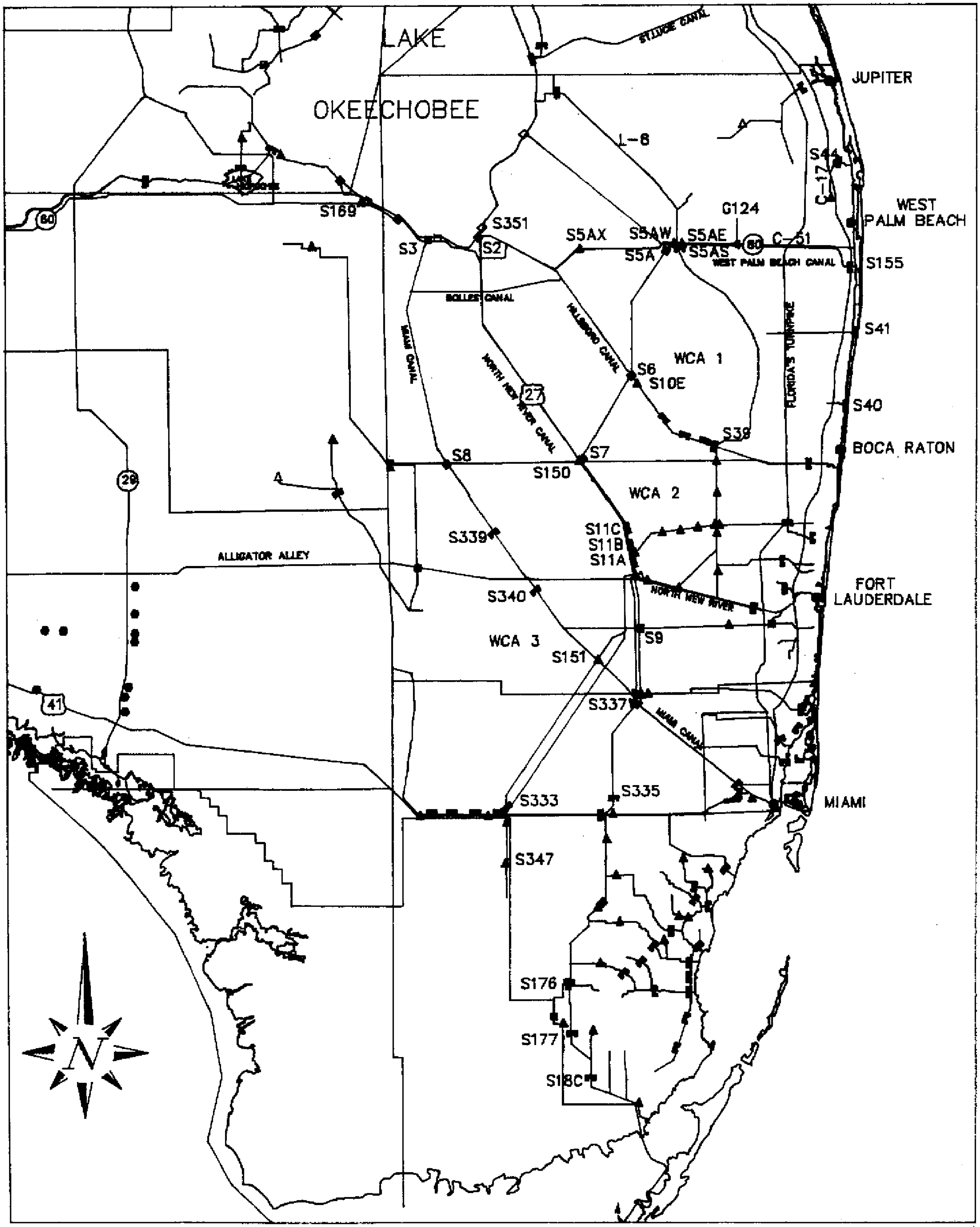
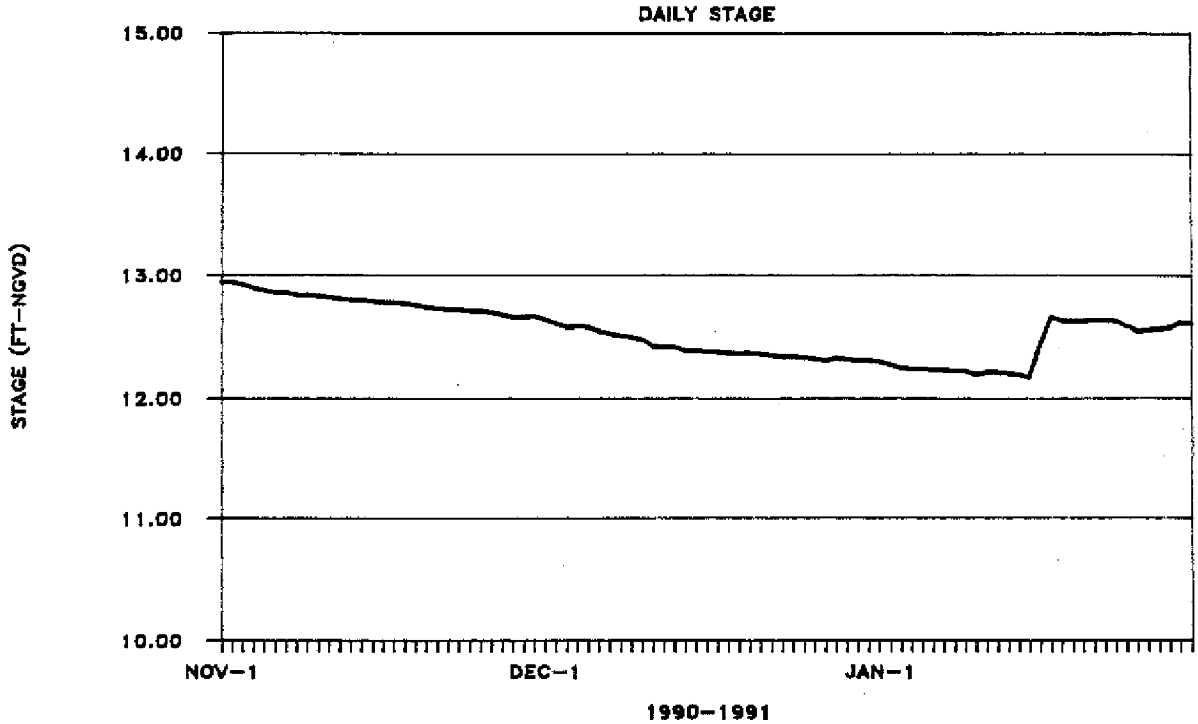


Figure B-32. Canal and Structure Location Map for the East Coast



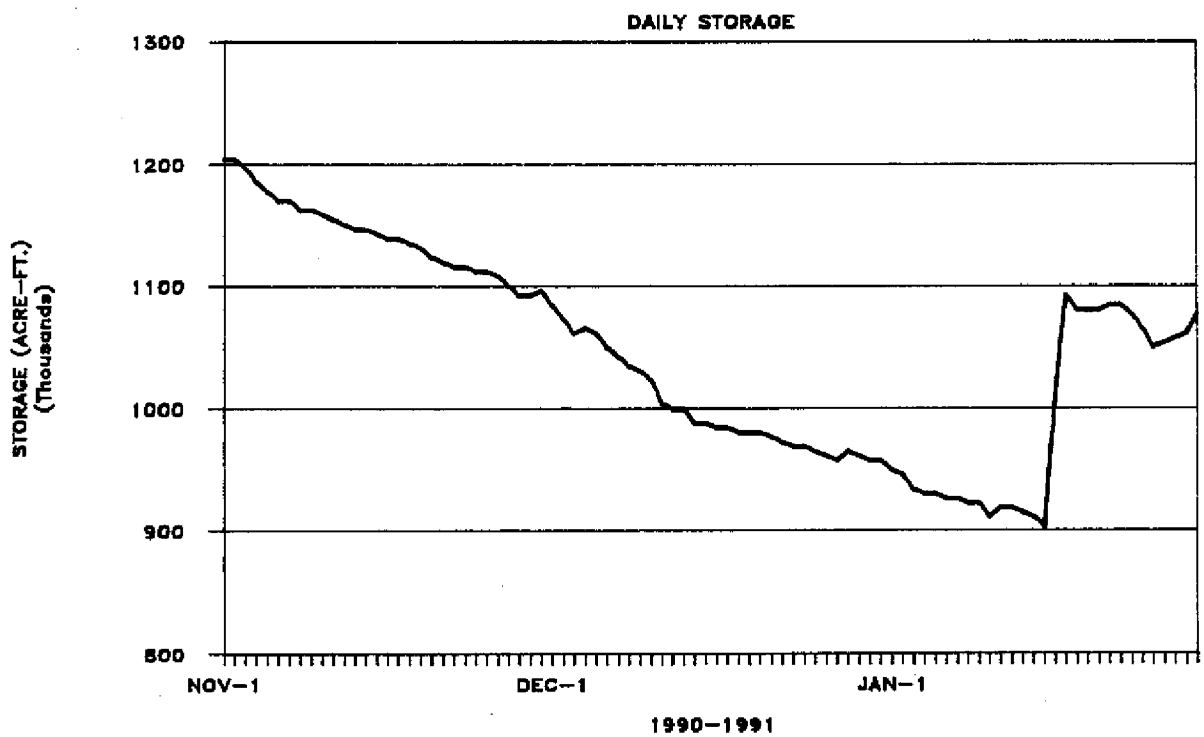
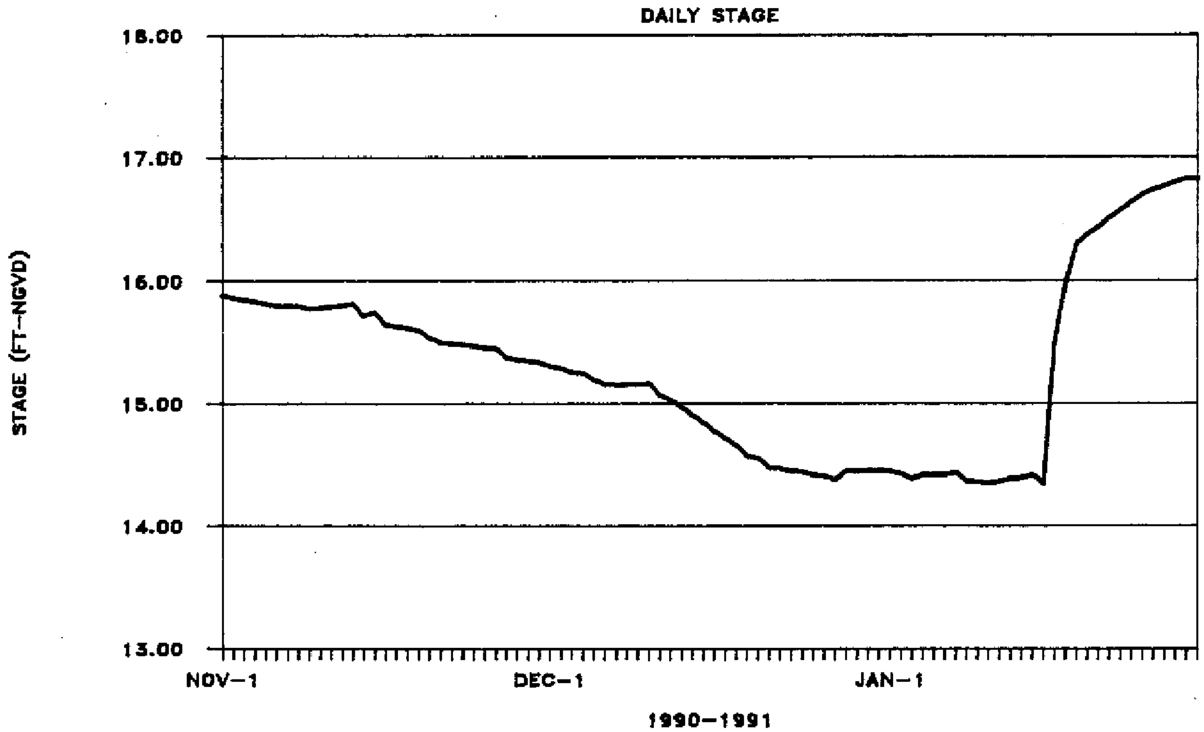


Figure B-33. Daily Stage and Available Storage for Lake Okeechobee



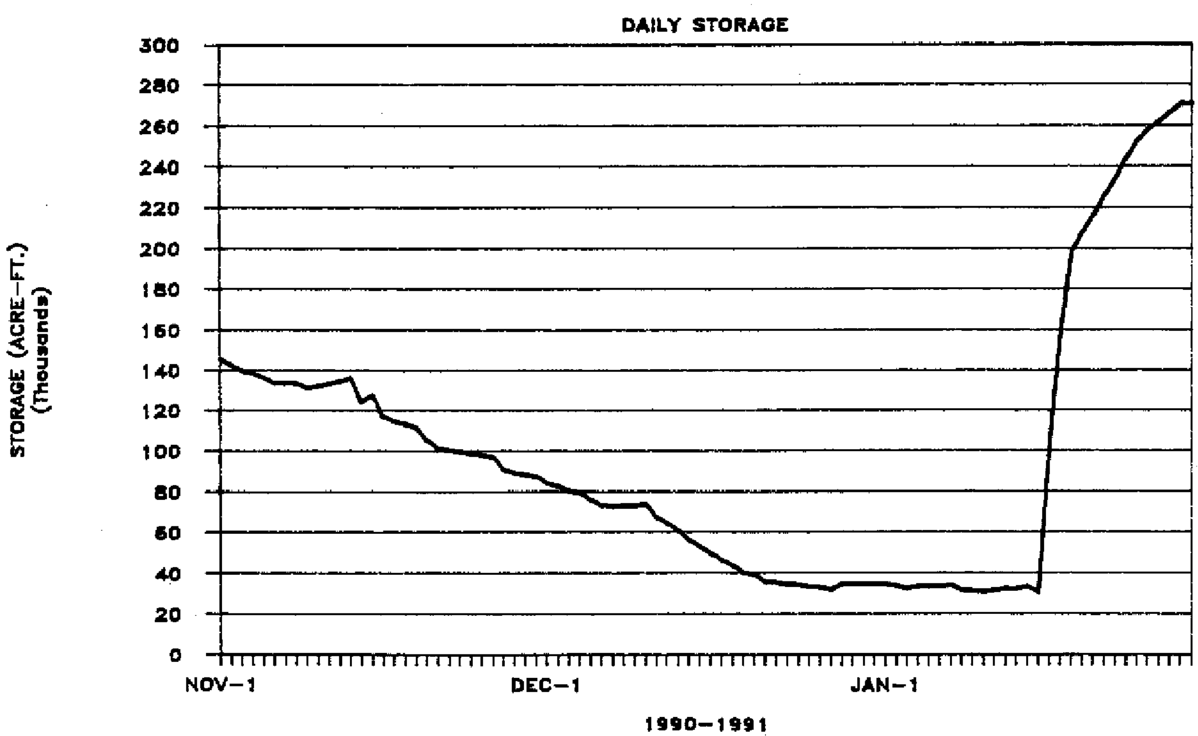
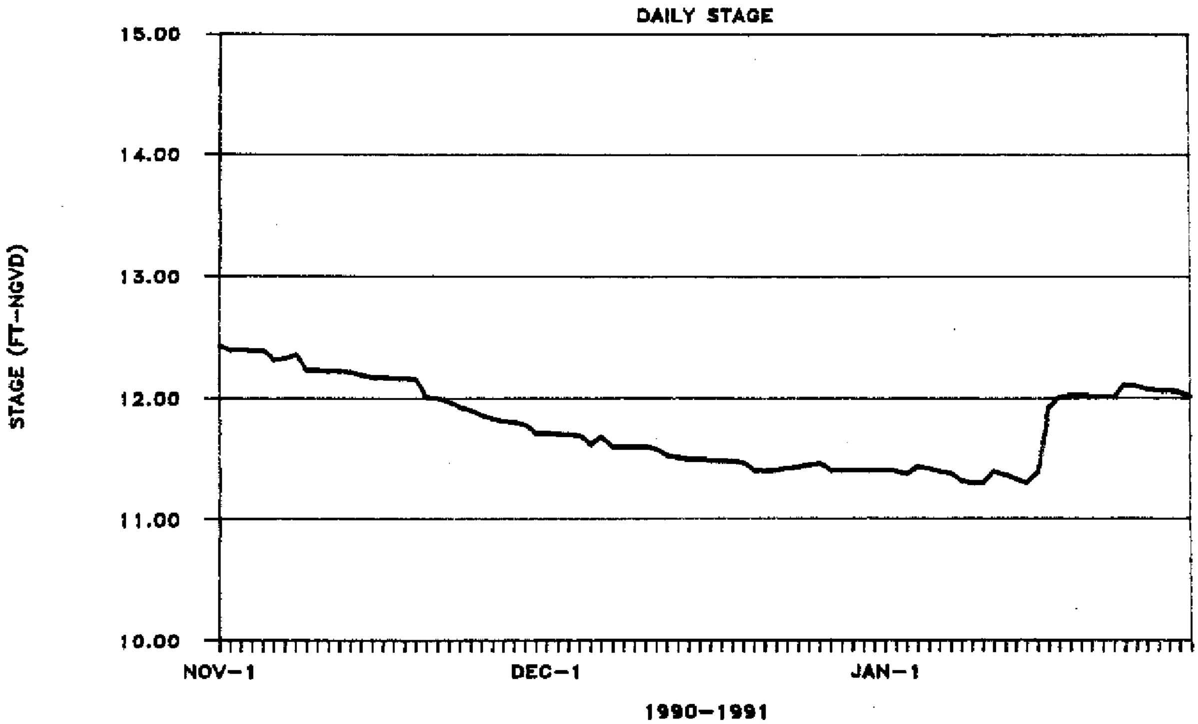


Figure B-34. Daily Stage and Available Storage for Water Conservation Area 1



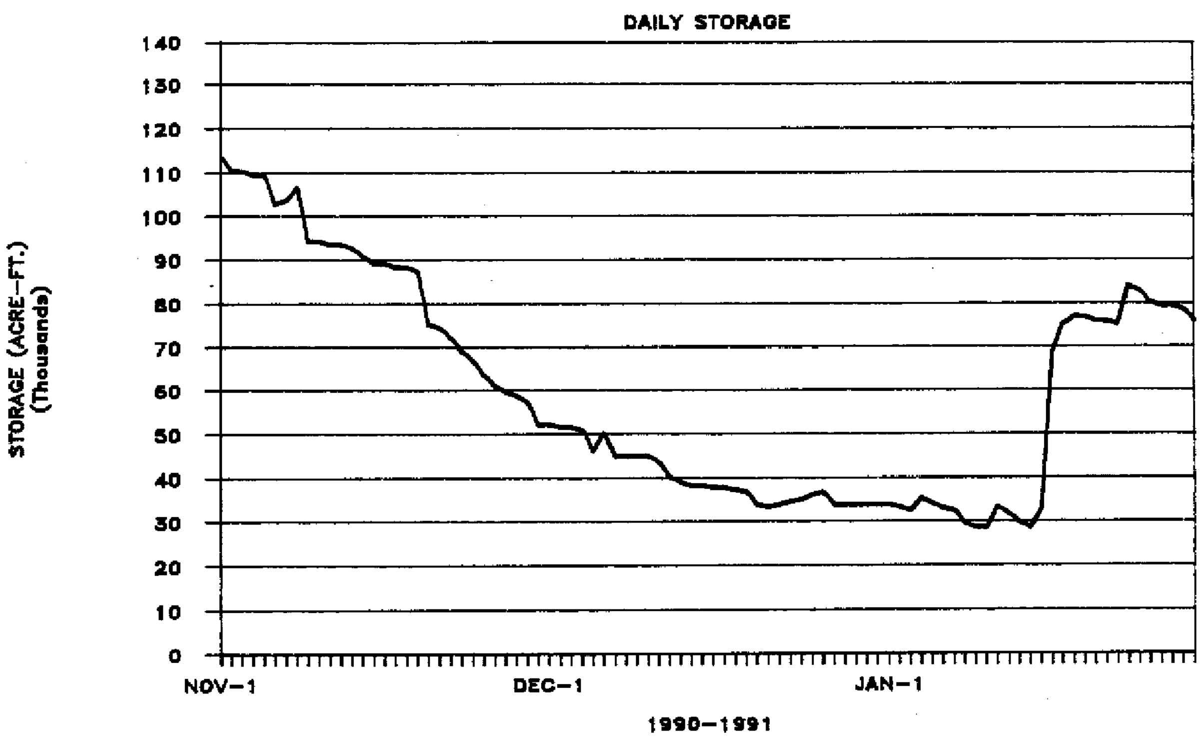
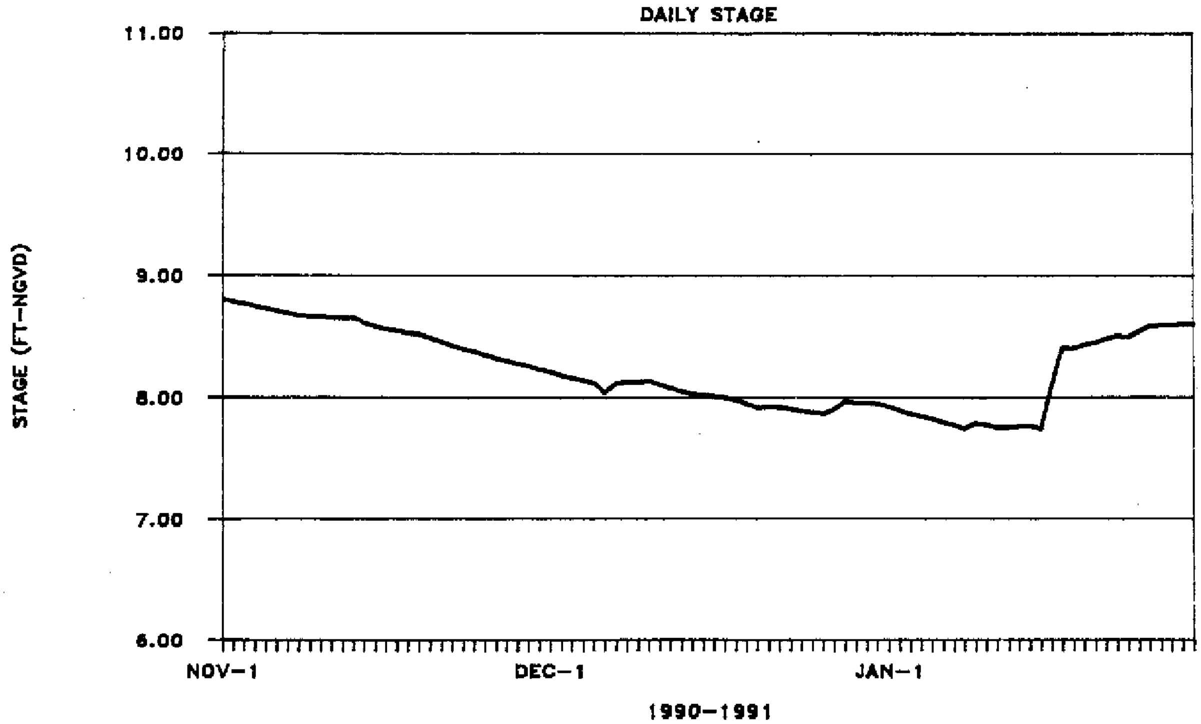


Figure B-35. Daily Stage and Available Storage for Water Conservation Area 2



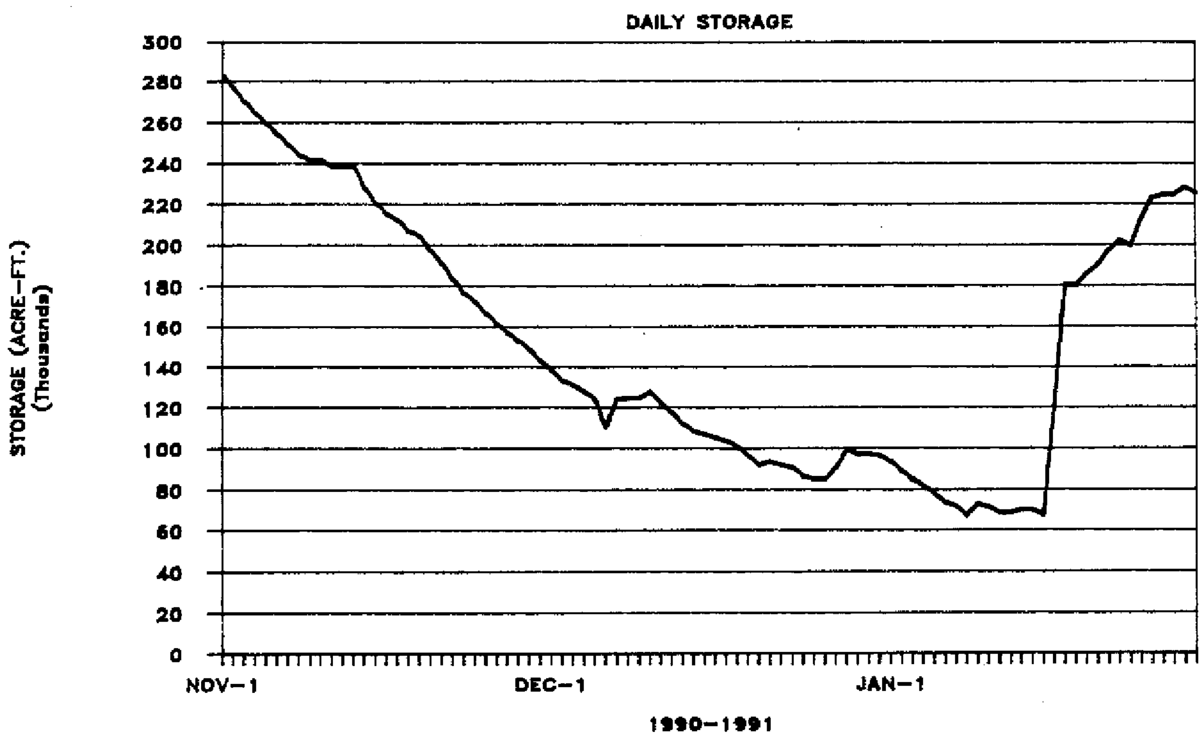


Figure B-36. Daily Stage and Available Storage for Water Conservation Area 3

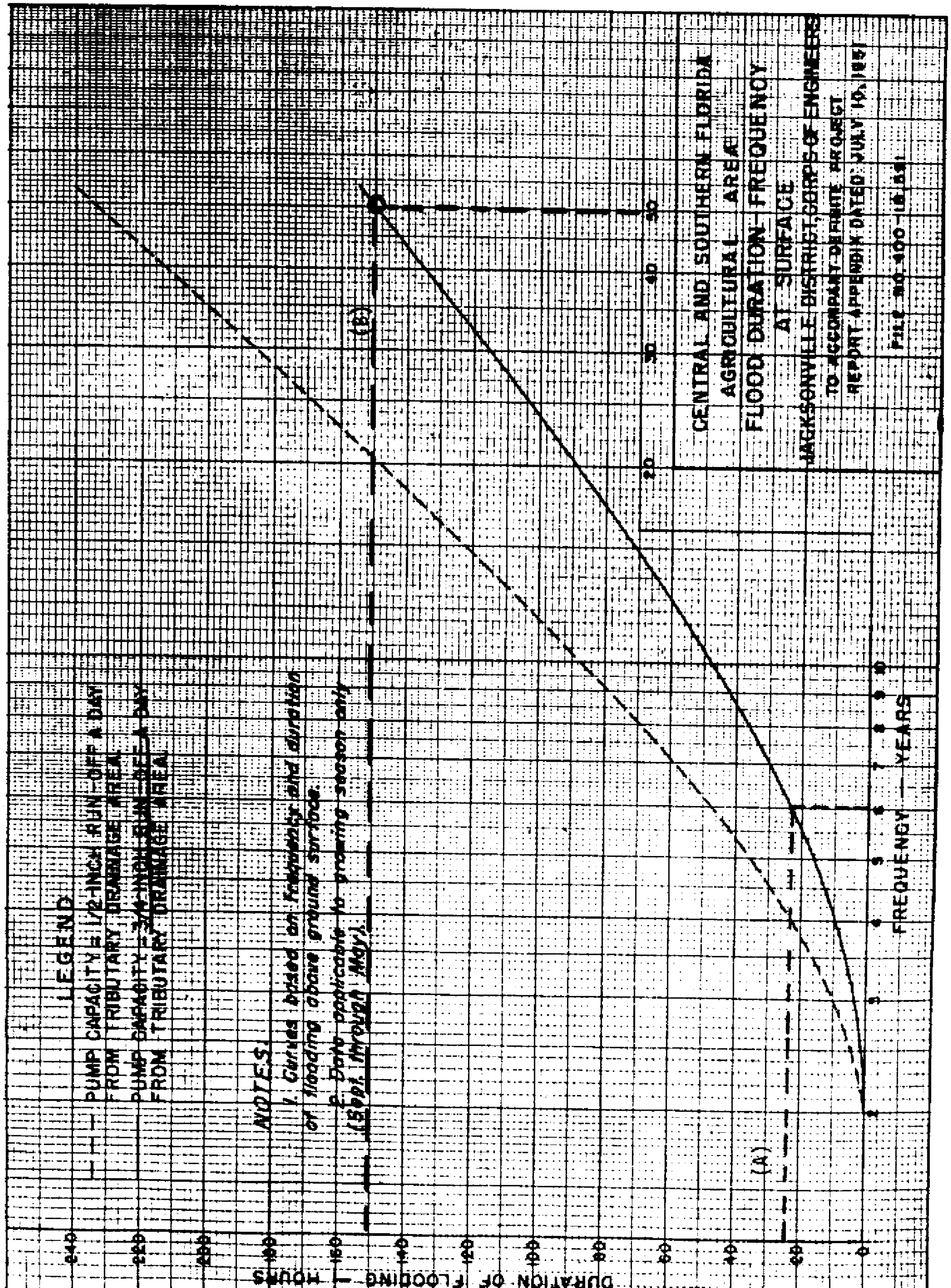


Figure B-37. EAA Flood Duration-Frequency

APPENDIX C

Summary of Total Phosphorus in the EAA During the Period of January 16-29, 1991

Appendix C. Summary of Total Phosphorus in the EAA During the Period of January 16-29, 1991

Site	Mean Total P (mg/L)	Number of Samples	Minimum Total P (mg/L)	Maximum Total P (mg/L)
WP18.4TS	1.401	3	1.176	1.632
NR07.8TE	1.237	3	0.092	2.006
NR12.5TW	0.948	3	0.355	1.706
OC07.6TS	0.839	3	0.617	0.990
WP06.7TN	0.836	4	0.313	1.813
HC10.6TN	0.799	3	0.308	1.127
NR11.4TE	0.786	5	0.499	1.416
NR06.6TE	0.761	4	0.087	2.390
NR26.4TE	0.755	2	0.495	1.015
OC04.5TN	0.683	2	0.446	0.921
NR19.7TE	0.673	4	0.440	1.195
OC00.6TS	0.657	2	0.315	0.999
WP16.8TS	0.646	5	0.464	0.791
HC11.8TS	0.614	4	0.319	0.741
WP10.6TS	0.555	4	0.286	0.888
NR25.2TW	0.547	2	0.124	0.971
NR16.9TE	0.542	2	0.266	0.818
MC19.9TW	0.537	2	0.469	0.606
OC01.1TS	0.522	3	0.371	0.764
NR05.4TE	0.503	4	0.064	1.014
HC19.7TN	0.493	3	0.415	0.557
HC08.8TS	0.480	3	0.186	0.745
HC13.3TS	0.475	3	0.257	0.879
OC11.8TS	0.473	3	0.178	0.876
NR14.2TE	0.466	2	0.243	0.689
HC00.7TS	0.454	5	0.110	0.901
WP19.5TS	0.440	1	0.440	0.440
NR26.7TW	0.437	5	0.205	0.886
WP10.1TN	0.423	3	0.320	0.529
MC16.8TE	0.418	3	0.326	0.583
MC21.5TW	0.398	2	0.236	0.559
OC04.1TS	0.393	4	0.323	0.437
NR03.0TW	0.381	7	0.064	0.713
HC10.0TN	0.381	2	0.165	0.596
HC19.6TS	0.377	3	0.311	0.429
MC12.2TW	0.363	2	0.120	0.606
WP14.1TN	0.342	2	0.131	0.553
NR13.0TW	0.334	2	0.041	0.626
WP00.7TN	0.329	6	0.094	0.925

Appendix C. Summary of Total Phosphorus in the EAA During the Period of January 16-29, 1991

Site	Mean Total P (mg/L)	Number of Samples	MInimum Total P (mg/L)	Maximum Total P (mg/L)
WP07.4TS	0.328	4	0.156	0.512
WP19.3TN	0.324	4	0.203	0.388
OC02.6TS	0.317	3	0.265	0.367
MC10.7TW	0.316	2	0.152	0.480
OC11.1TN	0.311	1	0.311	0.311
NR09.0TE	0.293	6	0.057	0.612
NR20.2TW	0.291	4	0.199	0.402
L824.6TS	0.291	1	0.291	0.291
HC11.8TN	0.290	4	0.118	0.428
HC04.5TN	0.289	5	0.066	0.708
WP15.4TN	0.286	2	0.207	0.365
HC02.7TS	0.282	5	0.077	0.623
NR15.4TW	0.278	5	0.125	0.476
WP04.5TS	0.271	4	0.136	0.625
WP12.0TN	0.270	2	0.240	0.300
HC10.7TS	0.264	5	0.113	0.625
OC06.6TN	0.264	1	0.264	0.264
NR10.3TW	0.264	5	0.140	0.341
NR18.2TW	0.263	3	0.106	0.574
HC22.5TN	0.261	3	0.212	0.329
HC14.9TN	0.261	5	0.122	0.478
WP13.7TN	0.249	5	0.161	0.332
WP16.0TN	0.245	2	0.098	0.392
NR10.3TE	0.241	4	0.082	0.517
NR14.7TE	0.241	4	0.129	0.359
HC09.4TN	0.241	3	0.201	0.280
NR02.7TW	0.237	5	0.070	0.514
L823.3TN	0.236	2	0.134	0.337
WP15.3TS	0.233	4	0.193	0.268
OC10.3TS	0.232	3	0.165	0.278
WP12.1TS	0.230	3	0.163	0.362
HC15.5TS	0.227	4	0.176	0.328
NR23.7TE	0.225	5	0.059	0.348
NR22.2TW	0.224	5	0.109	0.334
MC23.3TW	0.217	1	0.217	0.217
MC19.9TE	0.217	2	0.171	0.262
WP17.9TN	0.215	4	0.133	0.271
HC13.6TN	0.214	3	0.178	0.271
NR04.2TW	0.212	5	0.082	0.359

Appendix C. Summary of Total Phosphorus in the EAA During the Period of January 16-29, 1991

Site	Mean Total P (mg/L)	Number of Samples	Minimum Total P (mg/L)	Maximum Total P (mg/L)
NR18.7TE	0.207	3	0.089	0.278
HC16.8TN	0.206	1	0.206	0.206
HC13.8TS	0.205	3	0.190	0.214
WP07.5TN	0.199	3	0.149	0.298
NR12.5TE	0.196	4	0.107	0.295
HC12.5TN	0.196	1	0.196	0.196
MC16.8TW	0.194	3	0.136	0.264
HC03.9TS	0.194	2	0.161	0.227
HC17.4TN	0.193	1	0.193	0.193
OC06.0TN	0.191	1	0.191	0.191
HC05.2TS	0.189	5	0.075	0.422
NR06.6TW	0.189	6	0.044	0.384
NR24.6TW	0.186	3	0.090	0.349
WP08.7TS	0.185	5	0.112	0.280
HC17.9TS	0.181	4	0.161	0.215
OC10.3TN	0.179	1	0.179	0.179
HC19.1TN	0.176	2	0.130	0.223
WP00.8TN	0.175	2	0.165	0.186
L824.2TN	0.174	1	0.174	0.174
HC13.0TN	0.173	1	0.173	0.173
OC02.0TN	0.171	3	0.121	0.267
WP10.8TN	0.169	1	0.169	0.169
NR04.1TE	0.168	3	0.120	0.207
L823.8TN	0.168	2	0.147	0.189
NR01.8TE	0.167	5	0.030	0.377
WP03.6TN	0.160	5	0.097	0.227
NR19.2TE	0.159	3	0.069	0.240
WP09.1TN	0.159	3	0.101	0.208
HC15.2TN	0.159	4	0.129	0.197
L823.9TN	0.158	1	0.158	0.158
MC24.1TW	0.158	2	0.124	0.192
MC09.1TE	0.155	3	0.096	0.195
NR27.6TW	0.150	1	0.150	0.150
WP04.8TN	0.149	2	0.129	0.168
MC23.0TW	0.148	1	0.148	0.148
WP09.9TS	0.145	6	0.087	0.180
NR20.7TE	0.144	4	0.085	0.202
MC24.1TE	0.142	1	0.142	0.142
MC10.7TE	0.141	3	0.057	0.193

Appendix C. Summary of Total Phosphorus in the EAA During the Period of January 16-29, 1991

Site	Mean Total P (mg/L)	Number of Samples	Minimum Total P (mg/L)	Maximum Total P (mg/L)
NR22.7TE	0.140	3	0.105	0.160
MC00.1TW	0.132	1	0.132	0.132
MC13.7TE	0.129	3	0.077	0.196
OC09.2TN	0.127	1	0.127	0.127
L8-C10A	0.122	3	0.077	0.160
OC01.3TS	0.121	3	0.069	0.178
HC08.1TN	0.120	4	0.059	0.170
NR28.2TW	0.119	2	0.113	0.126
HC02.8TN	0.113	5	0.011	0.255
NR24.2TW	0.106	3	0.047	0.202
HC09.5TS	0.104	5	0.058	0.201
MC18.8TE	0.097	3	0.067	0.132
MC23.0TE	0.092	3	0.061	0.134
HC14.7TN	0.087	1	0.087	0.087
NR03.0TE	0.084	6	0.025	0.191
NR23.2TE	0.077	3	0.035	0.152
L8S76	0.047	3	0.035	0.059
NR13.6TW	0.046	3	0.034	0.055
MC08.6TW	0.030	2	0.029	0.032
MC08.6TE	0.029	3	0.023	0.036