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**HYDROLOGIC EFFECTS OF STORM OF  
SEPTEMBER 1-3, 1983 IN  
GOLDEN GATE CITY  
COLLIER COUNTY, FLORIDA**

**FOR**

**BIG CYPRESS BASIN BOARD**

**JOHNSON ENGINEERING, INC.**

**HYDROLOGIC EFFECTS OF STORM OF  
SEPTEMBER 1 - 3, 1983 IN  
GOLDEN GATE CITY  
COLLIER COUNTY, FLORIDA**

Prepared For  
**BIG CYPRESS BASIN BOARD  
SOUTH FLORIDA WATER MANAGEMENT DISTRICT**

**STANLEY W. HOLE, *Chairman, Ex Officio***

**KENDALL C. WISE, *Vice Chairman***

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Prepared By  
**JOHNSON ENGINEERING, INC.**  
Civil Engineers & Land Surveyors  
Fort Myers, Florida

September, 1983

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## 1. INTRODUCTION

The storm event of September 1-2, 1983 in western Collier County, Florida produced flooding in the northern portion of Golden Gate City. At the request of Fred Vidzes, Big Cypress Basin Administrator, the following report was compiled to formally record data collected by Basin personnel, Collier County, the U.S. Geological Survey, Johnson Engineering and others into a concise document.

During the latter part of August 1983, the fringe of tropical storm Barry produced rainfall which raised the groundwater table and the water surface elevations in canals in the Golden Gate City area, especially those in the northerly section. One week later runoff from the rainfall of September 1-2 was superimposed onto canals that were still removing water from the previous rainfall.

This report documents the rainfall, surface water elevations and groundwater table elevations for the western portion of Collier County with special emphasis on the Golden Gate Canal and its tributaries around Golden Gate City. The intent of this report was to document facts. Therefore, no attempt was made to draw conclusions from the data. Data shown outside the area of concern was provided to give a broad based picture and a better understanding of how the peripheral areas may have influenced events in Golden Gate City.

Following collection of field data, meetings were held with Fred Vidzes, Basin Administrator; Charles W. Pemble, Resource Control Department, South Florida Water Management District; and John Boldt, Collier County Water Management Director to insure the proper correlation of data included in this report.

## 2. FIELD RECONNAISSANCE AND DATA ACQUISITION

The key to a valid report was the timely acquisition and correlation of field information to record the immediate response of the area to the storm event. This field data can then be correlated with records from installations established by the Big Cypress Basin in past years to monitor the operational characteristics of the canal system.

Data was obtained from the following sources:

Avatar Utilities	- rainfall records
Collier County Public Works Division	- rainfall records - high water levels - differential stage data
Corkscrew Sanctuary, Audubon Society	- rainfall records
Johnson Engineering, Inc.	- flow measurements - differential stage data
Lee County Mosquito Control	- rainfall records
South Florida Water Management District, Big Cypress Basin	- rainfall records - stage records - groundwater records
U.S. Geological Survey	- stage records

Field reconnaissance and measurements by the Collier County Public Works Division were accomplished throughout the period of August 29 through September 4. Special recognition should go to John Boldt, Water Management Director-Collier County, for data provided by him for this report. The extensive efforts of Collier County to accurately secure surface water elevations were essential to the correlation and verification of data presented herein. The writers of this report express their admiration for Mr. Boldt's professional approach and untiring efforts during the storm event.

Extreme care was taken to present only data that was collected in a technically accurate manner. Estimations and hearsay data were avoided unless specifically acknowledged as such. By using this procedure, it was found that correlation of various sources of data was very good.

Field reconnaissance and data acquisition by Johnson Engineering were accomplished during two specific and key periods. An aerial reconnaissance was performed September 3 between 8:00 and 9:00 a.m. and resulted in most of the high level photographs included in this report. A ground reconnaissance obtaining many of the stage, flow and differential stage measurements was made September 4 between 12:30 p.m. and 6:00 p.m. Ground level photographs included herein were taken during the period between 1:00 p.m. and 5:00 p.m. September 4. Photographs included herein which are not in compliance with the timing outlined above are labeled accordingly. The timeliness of the key reconnaissance efforts over the Labor Day weekend proved critical to this report.

### 3. RAINFALL

Rainfall data collected prior to and including September 1-3, 1983 is given in Table 1 on page 3-3 and the location of gaging stations is shown on page 3-2. The figure on page 3-4 shows the average rainfall for the period from the first of July through mid September.

Avatar Utilities operates the gaging station at their wastewater treatment plant. The remaining stations are collected through efforts of the Big Cypress Basin.

A continuous rainfall strip chart was made available by Collier County Public Works and is given in Table 2 on page 3-5. Total rainfall for September 1 and 2 varied from 3.60 inches at Avatar Utilities Sewage Treatment Plant to 5.80 inches at the Collier County Sewage Treatment Plant.

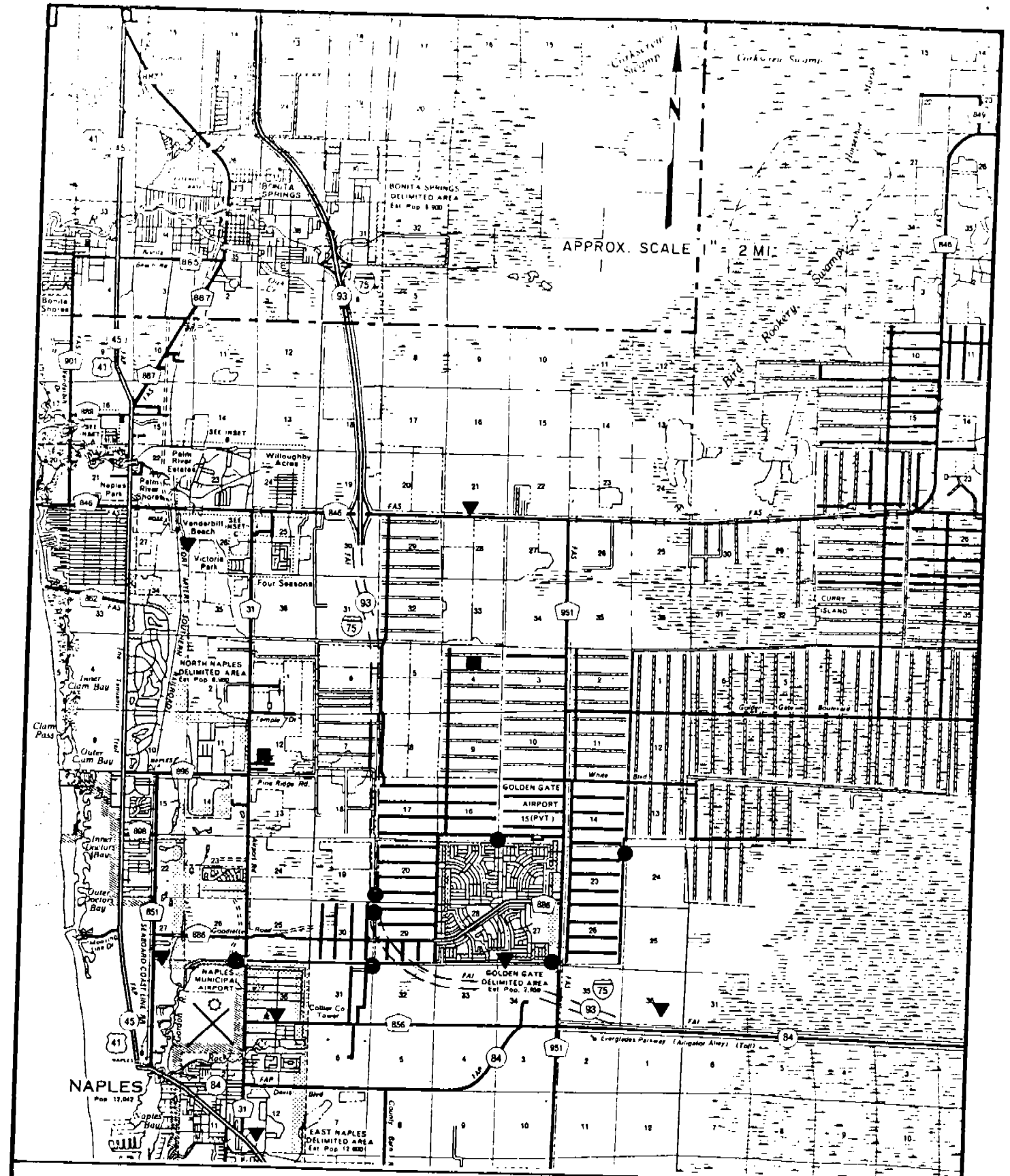


FIGURE 1

JOHNSON ENGINEERING, INC.  
SEPTEMBER, 1983



TABLE 1  
DAILY RAINFALL

	AUGUST			SEPTEMBER			TOTAL 9/1-9/2	
	29	30	31	1	2	3		4
AVATAR Sewage Plant	1.7	0	0.8	0.40	3.20	1.00	0	(3.60)
Bay West Nursery			0.91	4.03	0.75	-		(4.78)
Carribbean Gardens (Jungle Larry's)			0.58	0.97	4.50	0.97		(5.47)
Collier County Courthouse	0.60	0.03	0.52	3.83	1.55	0.05	0.05	(5.38)
Collier County Landfill			0.32	0.69	3.42	1.21		(4.11)
Collier County Sewage Plant			0.38	4.04	1.76	0.07		(5.80)
Naples Fire Tower			0.05	0.05	4.00	1.04		(4.05)

AVATAR SEWAGE TREATMENT PLANT

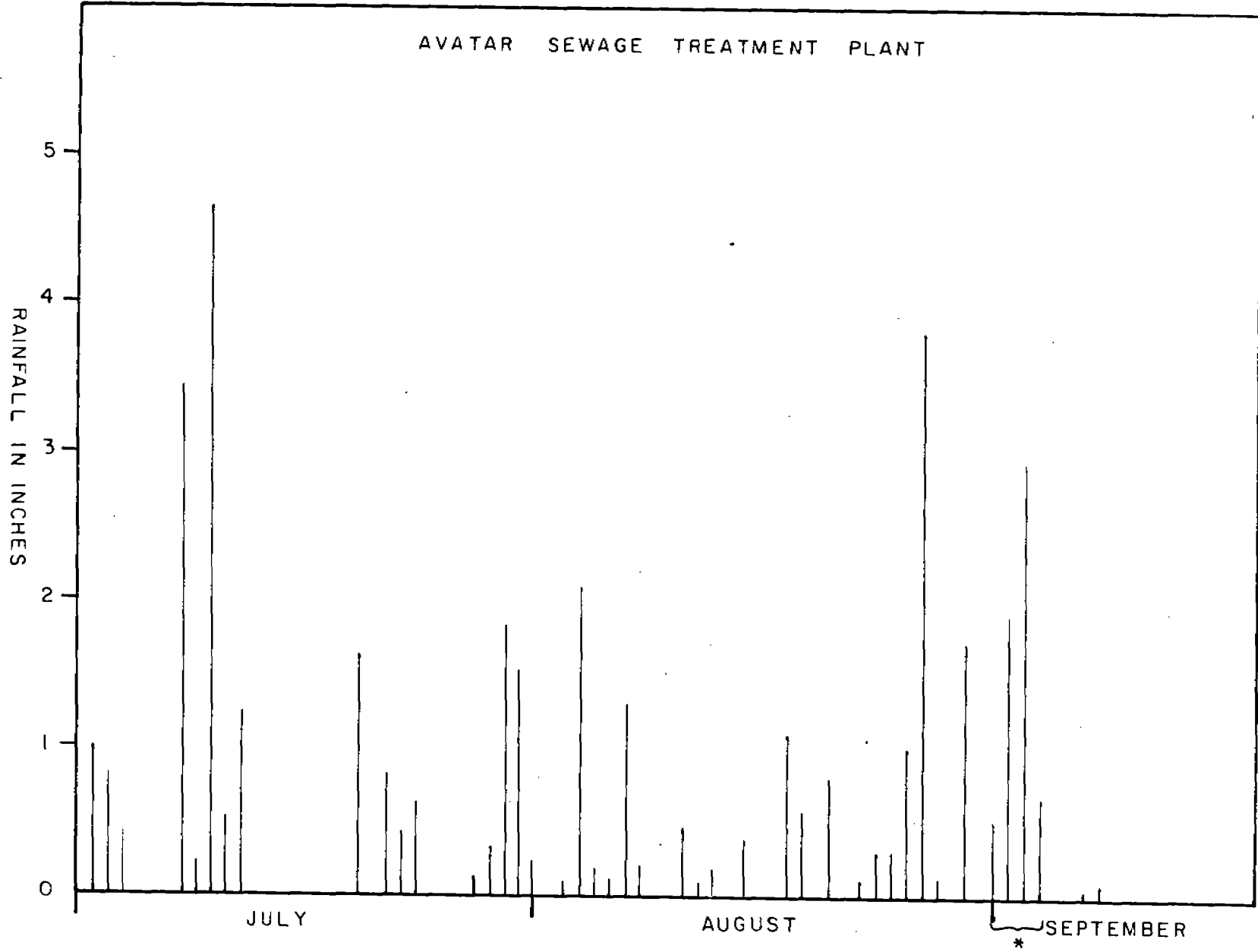


FIGURE 2

3-4

\* RAINFALL SHOWN FOR AUGUST 31 THROUGH SEPTEMBER 3 IS AN AVERAGE OF 7 LOCALIZED COLLIER CO. RAINFALL STATIONS

DAILY RAINFALL \*  
JOHNSON ENGINEERING, INC.  
SEPTEMBER 1984

TABLE 2  
 HOURLY RAINFALL FOR THE COLLIER COUNTY COURTHOUSE  
 AUGUST 31 - SEPTEMBER 3, 1983  
 Rainfall, in Inches  
 Time in hours

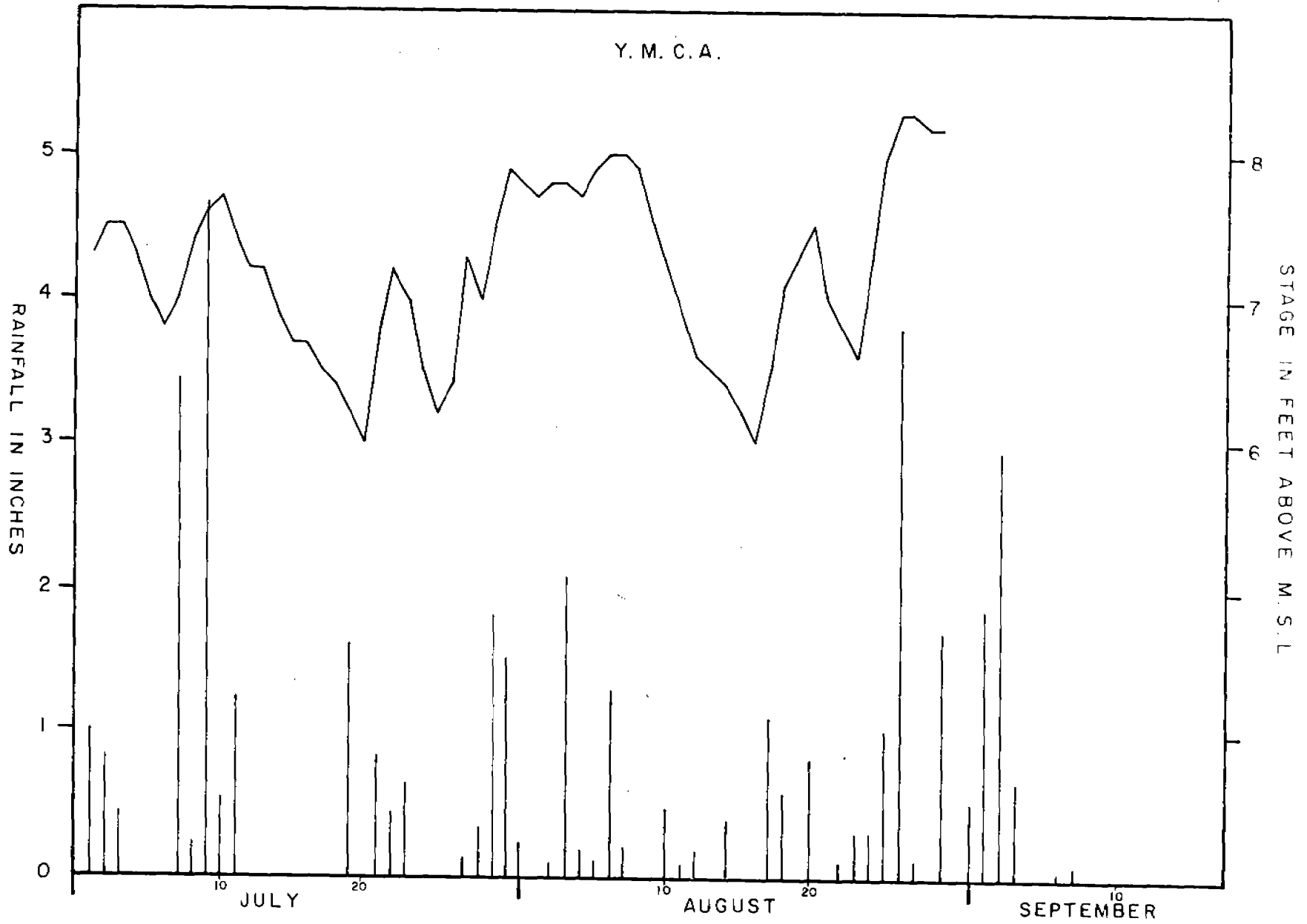
TIME	8-31	9-1	9-2	9-3
Midnight - 1:00 a.m.	0.00	0.00	0.00	0.00
1:00 - 2:00 a.m.	0.00	0.00	0.00	0.00
2:00 - 3:00 a.m.	0.00	0.00	0.05	0.00
3:00 - 4:00 a.m.	0.00	0.00	0.05	0.00
4:00 - 5:00 a.m.	0.00	0.00	0.15	0.00
5:00 - 6:00 a.m.	0.00	0.00	0.30	0.05
6:00 - 7:00 a.m.	0.00	0.10	0.60	0.00
7:00 - 8:00 a.m.	0.00	0.00	0.00	0.00
8:00 - 9:00 a.m.	0.215	0.40	0.00	0.00
9:00 - 10:00 a.m.	0.11	0.00	0.00	0.00
10:00 - 11:00 a.m.	0.00	0.00	0.00	0.00
11:00 - Noon	0.00	0.15	0.00	0.00
Noon - 1:00 p.m.	0.10	0.20	0.00	0.00
1:00 - 2:00 p.m.	0.10	0.45	0.20	0.00
2:00 - 3:00 p.m.	0.00	0.35	0.20	0.00
3:00 - 4:00 p.m.	0.00	0.075	0.00	0.00
4:00 - 5:00 p.m.	0.00	0.05	0.00	0.00
5:00 - 6:00 p.m.	0.00	0.10	0.00	0.00
6:00 - 7:00 p.m.	0.00	0.00	0.00	0.00
7:00 - 8:00 p.m.	0.00	0.15	0.00	0.00
8:00 - 9:00 p.m.	0.00	0.05	0.00	0.00
9:00 - 10:00 p.m.	0.00	0.45	0.00	0.00
10:00 - 11:00 p.m.	0.00	0.05	0.00	0.00
11:00 - Midnight	0.00	1.25	0.00	0.00
	0.525	3.825	1.550	0.050

## 4. GROUNDWATER LEVELS

The groundwater table elevation for the two locations shown on page 3-2 were supplied by Big Cypress Basin. Records show a typical lagging of rise in the groundwater following a rainfall event. Figures on pages 4-2 and 4-3 show the recorded elevations with an overlay of the rainfall data (shown previously on page 3-4). Although these groundwater recorders are outside Golden Gate City, they indicate how the earlier rainfall events affected the outcome of following storms. This was evidenced by the rainfall of September 1-2, 1983 following the rainfall of August 25-26, 1983.

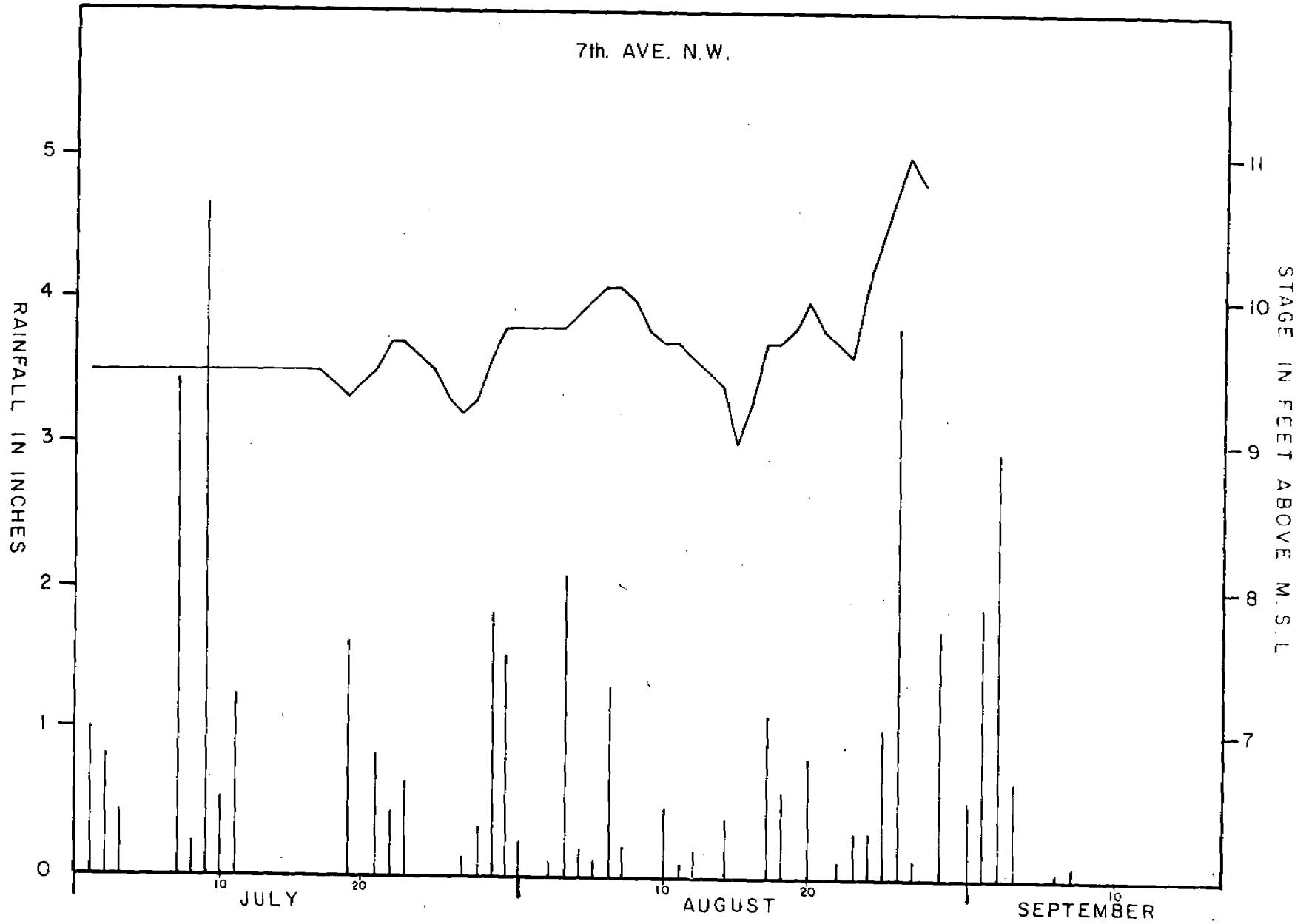
Both the groundwater table and the surface water elevations in the northern area of Golden Gate City were elevated from rainfall produced in late August by the fringes of tropical storm Barry. Recovery from the runoff of the rainfall event was still occurring in both the canals and the ground when the rainfall event of September 1-2, 1983 occurred. The lack of ground storage increased the volume of runoff created by the rainfall event.

4 - 2  
FIGURE 4



GROUND WATER LEVELS AND DAILY RAINFALL  
JOHNSON ENGINEERING, INC.  
SEPTEMBER, 1983

FIGURE 4



GROUND WATER LEVELS AND DAILY RAINFALL  
JOHNSON ENGINEERING, INC.  
SEPTEMBER, 1983

## 5. SURFACE WATER STAGES AND FLOWS

The network of surface water recording gages is shown on the map on page 3-2. These gages continuously record the water levels in canals. The records of these continuous water levels were correlated for the period of the storm event with rainfall, spot water level measurements, and stage differential measurements. The continuous recorders gave a valid data base for verification of other field measurements and also gave a historical background for comparison of the September 1983 storm event.

Figure 5 on page 5-3 shows water surface elevations measured on given dates. Figure 6 on page 5-4 shows the area in Golden Gate City affected by high surface water elevations. The U.S. Geological Survey has operated the stage recorder on the Golden Gate Canal at Airport Road (SR-31) since 1964. The remainder of the recorders were installed in the spring of 1981 and operated by the Big Cypress Basin with the maintenance currently done by the Audubon Society employees at Corkscrew Sanctuary. The recorder information is plotted with an overlay of the rainfall from page 3-4 on figures shown on pages A-2 through A-7 in the Appendix. Table 4 (page A-8 in the Appendix) gives high water elevations with location and date for Golden Gate City and nearby areas.

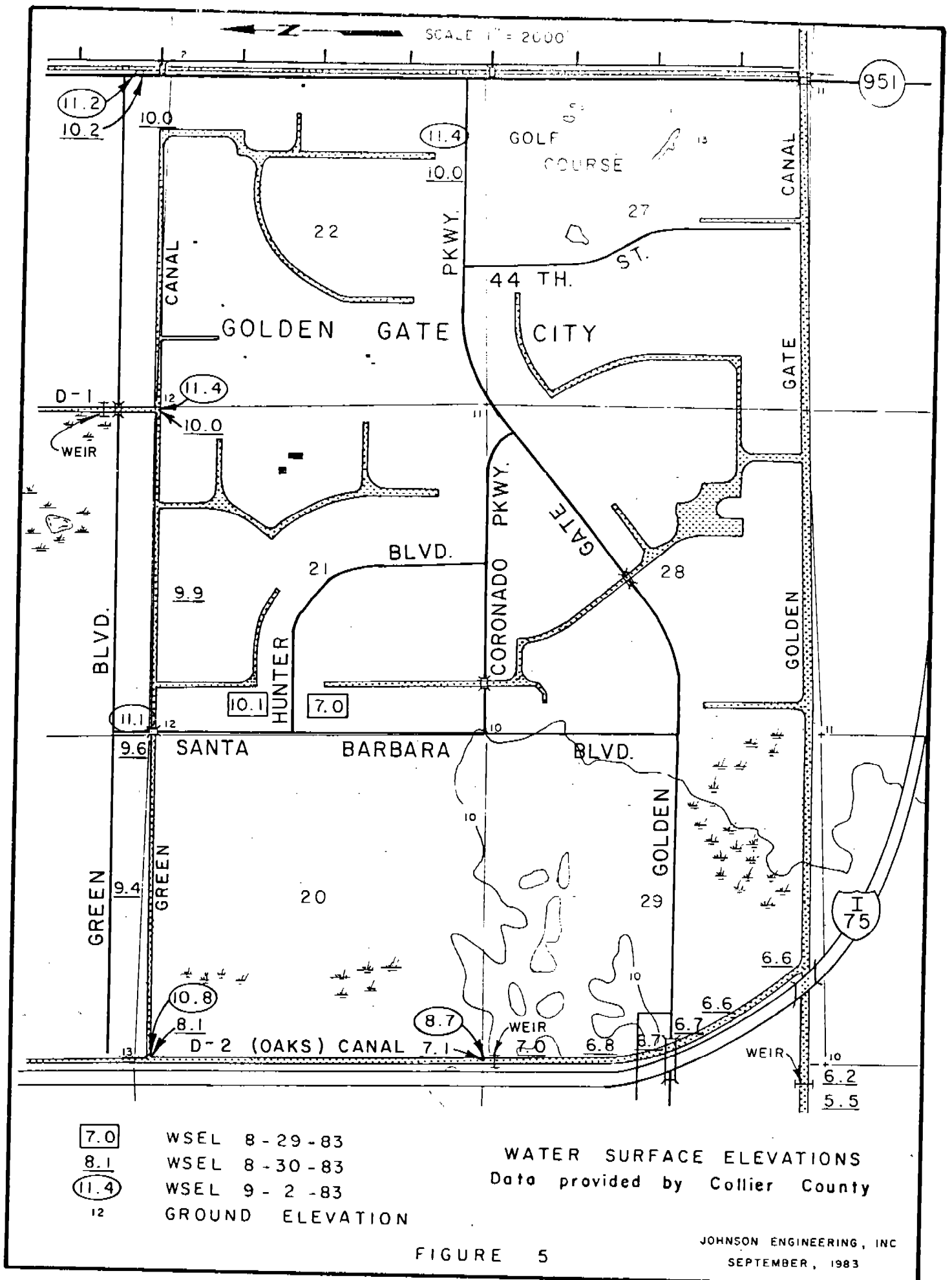
One flow measurement was made during the rainfall event which caused high surface water levels in the northern part of Golden Gate City. The measurement was made in the late afternoon of September 4, 1983 at Airport Road (SR-31) bridge including an estimated flow of 150 cfs discharging from the northeasterly ditch along Airport Road. The measured flow was 1,680 cfs

with the location shown in Appendix page A-9. The work was accomplished using a cable suspended "Price Current Meter". The velocity profile was checked to verify a near logarithmic shape near the center of the channel with the remainder of the vertical profiles measured only for the mean velocity. The flow was measured by summation of the product of the mean velocity and area of each channel cross section segment.

With the exception of the 150 cfs entering the canal at Airport Road there is very little change in the canal discharge upstream until the intersection of the D-2 (Oaks Blvd.) Canal is reached. Using the upstream and downstream water surface elevations and a correction factor for discharge over a submerged weir, the flow at Golden Gate #2 weir was calculated to be 1,430 cfs.

Photographs of conditions in the Golden Gate area are shown on pages 5-5 through 5-10. All aerial photographs in Section 5 were taken Saturday, September 3, and all ground photographs in this section were taken on Sunday, September 4 at times outlined on page 2-2 of this report.



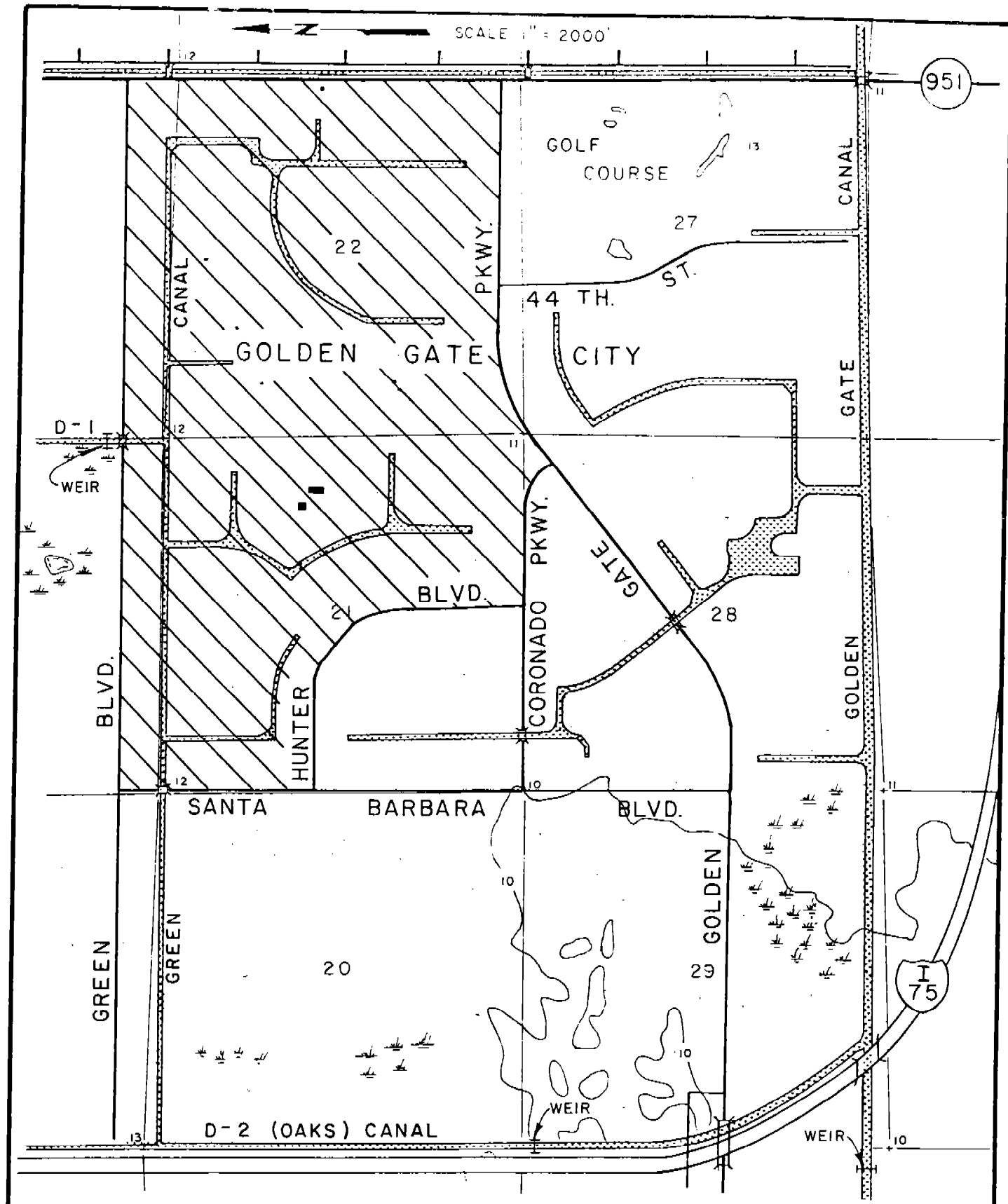


- 7.0 WSEL 8-29-83
- 8.1 WSEL 8-30-83
- 11.4 WSEL 9-2-83
- 12 GROUND ELEVATION

**WATER SURFACE ELEVATIONS**  
Data provided by Collier County

JOHNSON ENGINEERING, INC  
SEPTEMBER, 1983

FIGURE 5



CROSS HATCHED AREA IS PORTION OF GOLDEN GATE CITY  
AFFECTED BY HIGH WATER

FIGURE 6

JOHNSON ENGINEERING, INC  
SEPTEMBER, 1983



Look north at Golden Gate Canal Weir No. 1.  
Note canal level is within banks as evidenced by  
dry condition of street in foreground.



Closeup of above weir. Note weir freeboard at arrow.



Look north at Golden Gate Weir No. 2 (at arrow).  
I-75 is at top right.



Look south across Golden Gate Weir No. 2.



Look north at Golden Gate City.  
Golden Gate Parkway is denoted by dots.  
Note area south of Parkway is not subject to flooding.



Look west at Golden Gate City.



Look south at Golden Gate City.  
Parkway is located by dots.



Look east at Golden Gate City with CR-951 near top of photo.



Look north at intersection of I-75 with Golden Gate Parkway.



Look north with the repositioned D-2 (Oaks) Canal  
in the upper left corner.



Look east up Golden Gate Canal at temporary crossing.  
Photo taken from permanent I-75 bridge crossing  
(reinforcing steel for guardrail is in foreground of photo).



Photo taken from same location as above.  
Look northeast at emergency bypass channel.



6. HISTORICAL CORRELATIONS

Rainfall

Using data collected at the Collier County Courthouse, the following are maximum amounts of rainfall for various time periods.

<u>Duration</u>	<u>Maximum Amount of Rainfall (in.) Collier Co. Courthouse</u>
1 hour	1.25
6 hours	1.95
1 day	3.83
2 days	5.38

The above rainfall data was plotted on the depth-duration-frequency curves on page 6-3. These curves were derived from the values in Table 3 on page 6-6 and based on rainfall distribution given in the South Florida Water Management District Manual IV.

The maximum one-hour rainfall recorded at the Courthouse only slightly exceeded an annual occurrence. The six-hour amount was less than a two-year event. The one and two-day rainfalls were slightly rarer than the one and six hour events but nothing exceeding the three-year event. This rainfall followed one week after a similar rainfall event from the fringes of tropical storm Barry.

Stage and Flow

The figure on page 6-4 is a comparison of measured water surface profiles in 1981 and 1983 with the 1983 discharge at Golden Gate #2 weir almost twice as much as the 1981 discharge. Also, gages in the main canal at the 17th Avenue Weir recorded much lower stages upstream of CR-951 in 1983 than

in 1981. This is conclusively illustrated by the photographs on page 6-10.

The measured flow of 1,680 cubic feet per second on September 4, 1983 is plotted on Figure 8 on page 6-5 taken from U.S. Geological Survey "Water-Resources Investigations 57-75" indicating a two-year recurrence interval. The stage was a similar event approximately equal to a three-year event.

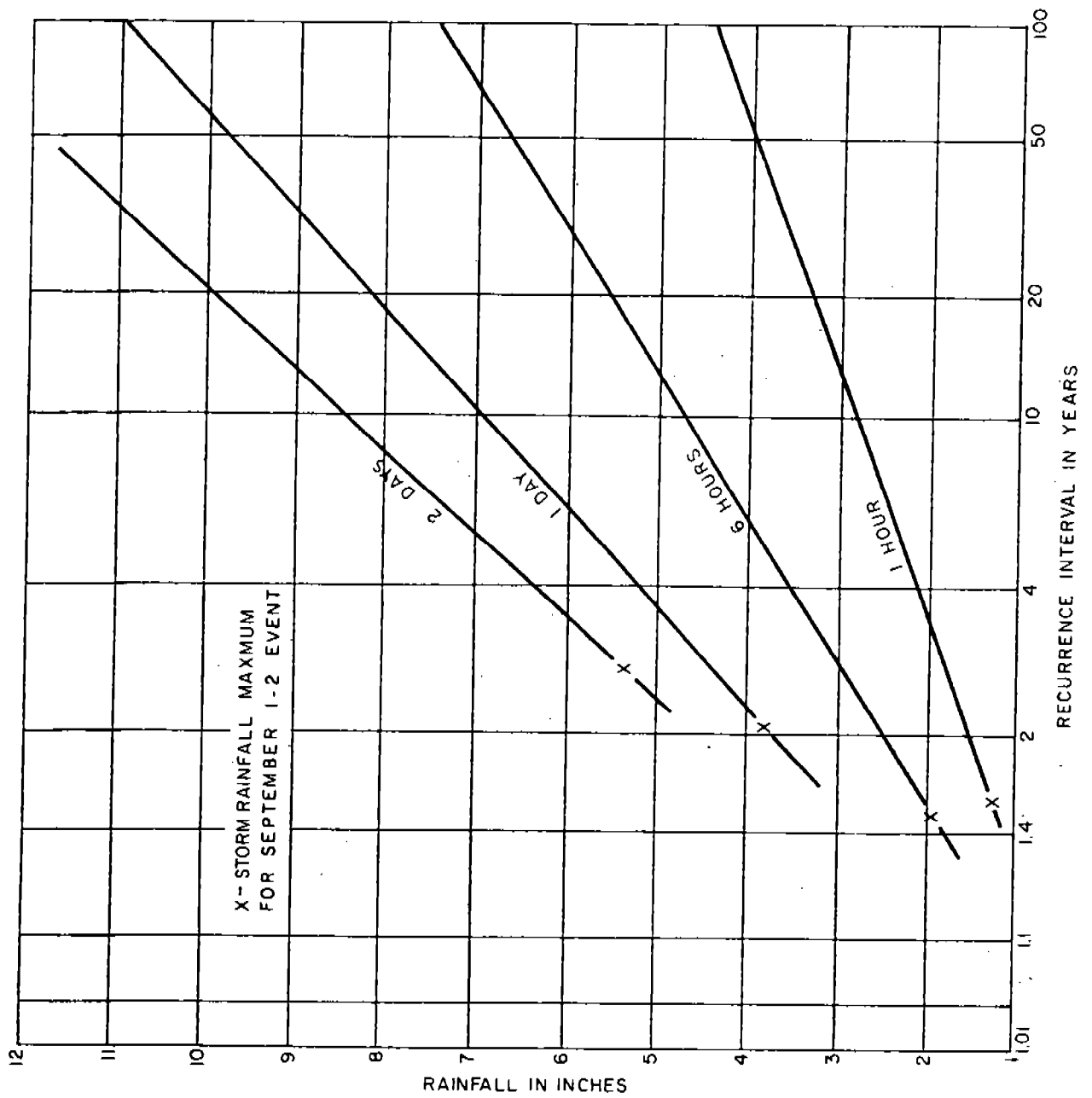
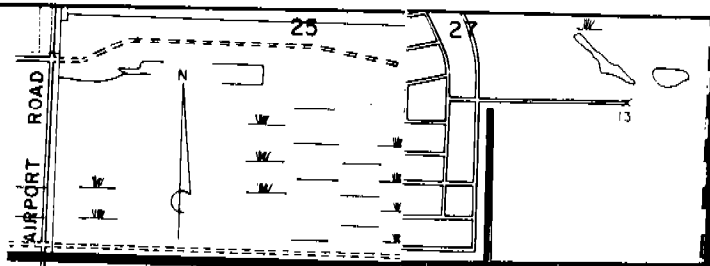


FIGURE 7. - RAINFALL DEPTH-FREQUENCY-DURATION CURVES FOR AREA OF GOLDEN GATE CITY.



COMPARISON OF MEASURED SURFACE  
WATER PROFILES  
GOLDEN GATE CANAL - MAIN STEM  
SCALE = 1" = 2000' HORIZ. 1" = 10' VERT.

**PLAN**

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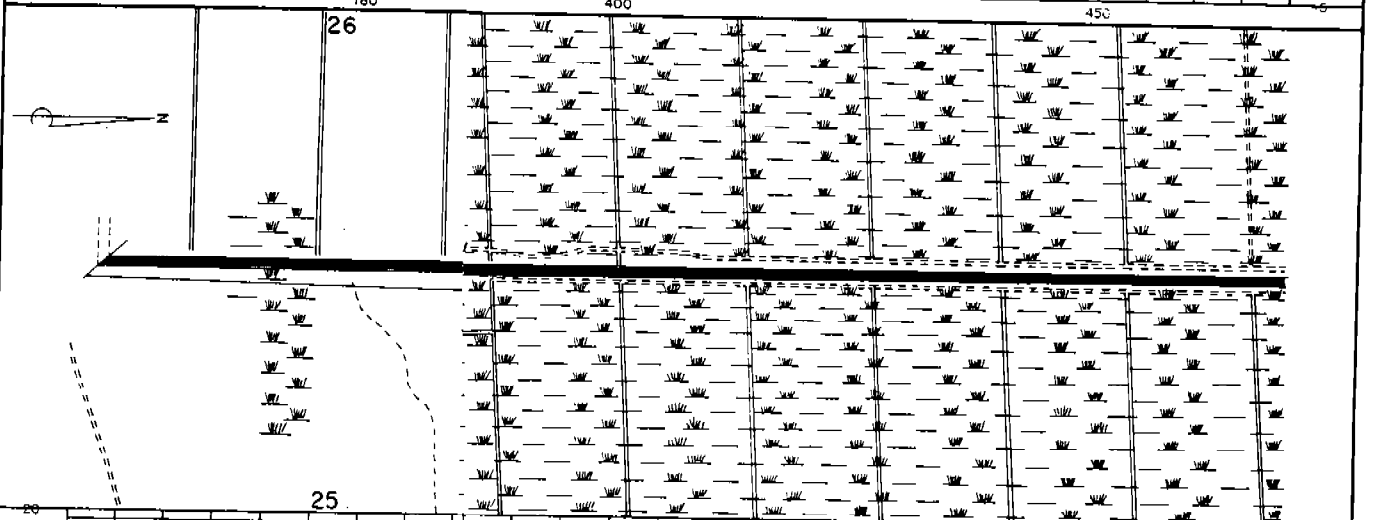
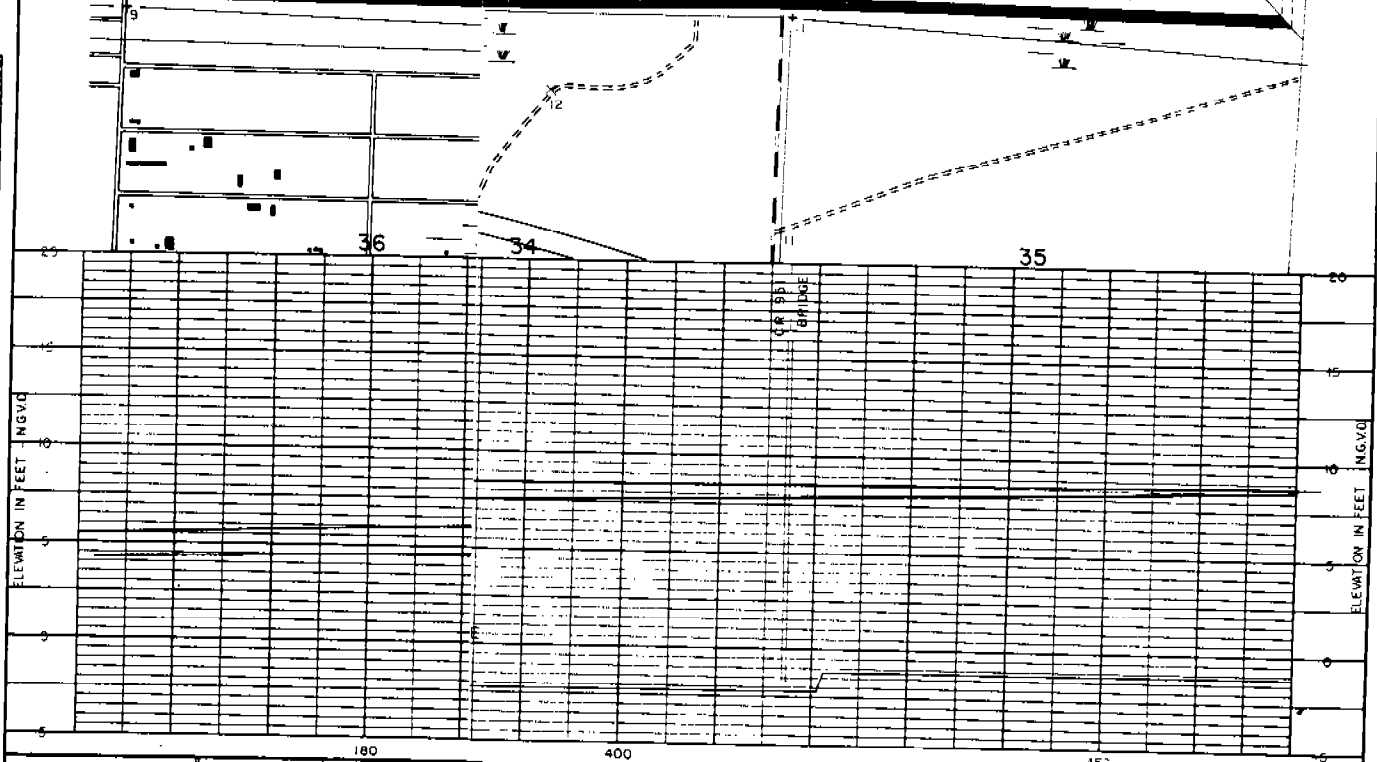
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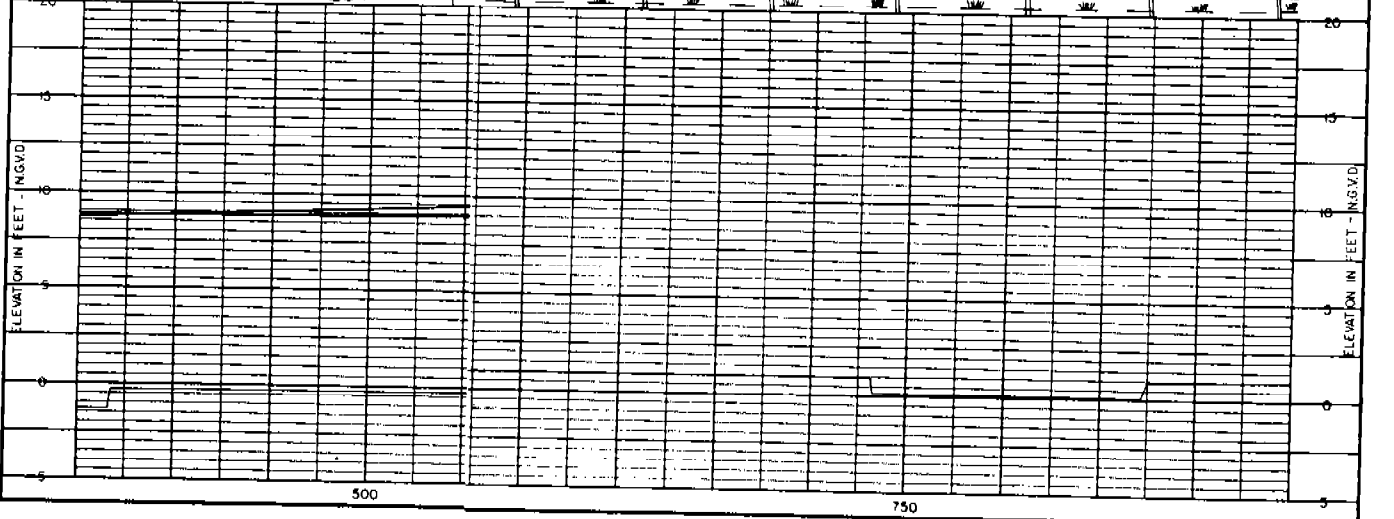
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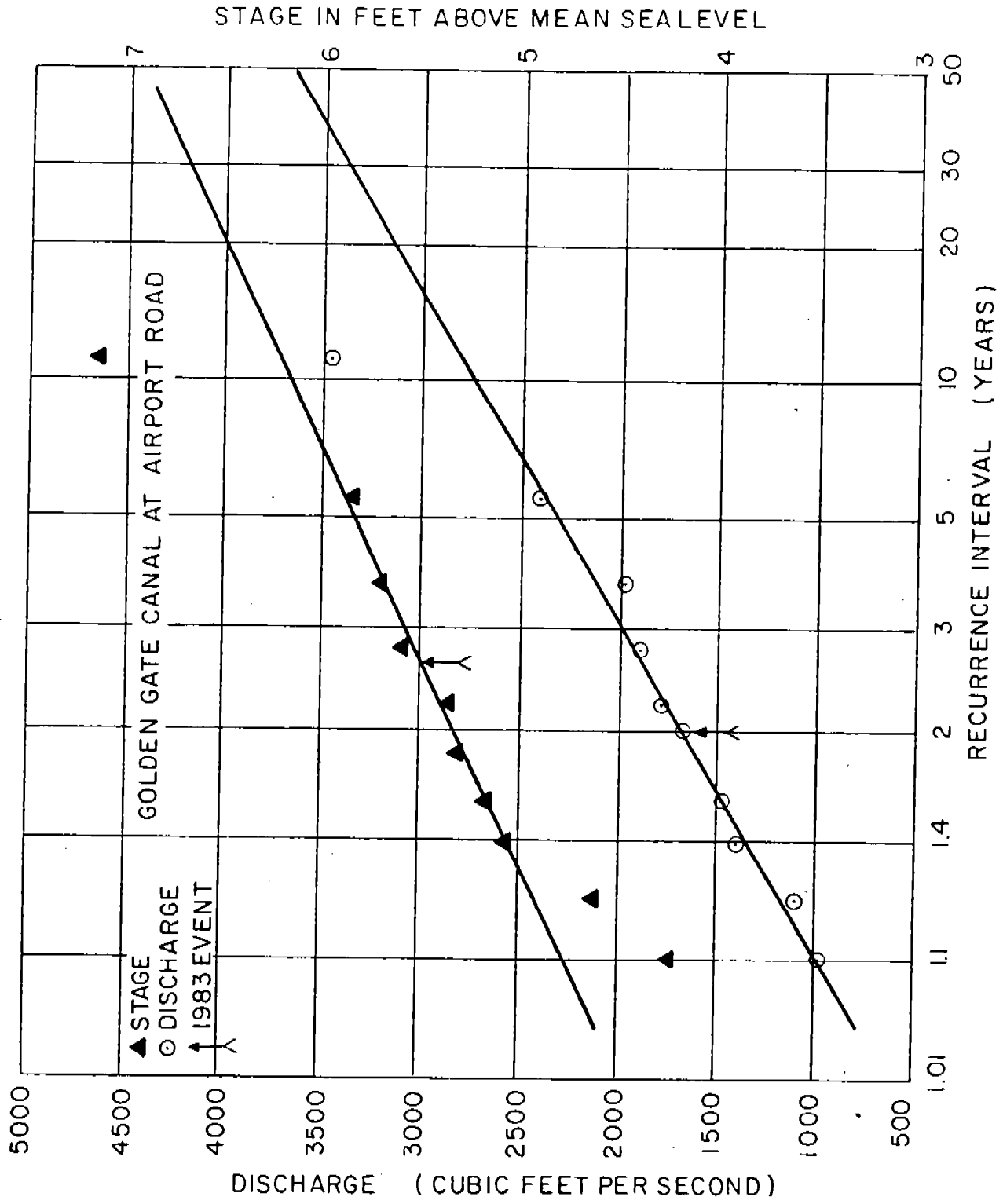
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DISCHARGE AND STAGE FREQUENCY CURVES

FIGURE 8

TABLE 3  
 RAINFALL<sup>1</sup> FOR VARIOUS DURATIONS AND  
 RETURN PERIODS FOR GOLDEN GATE CITY

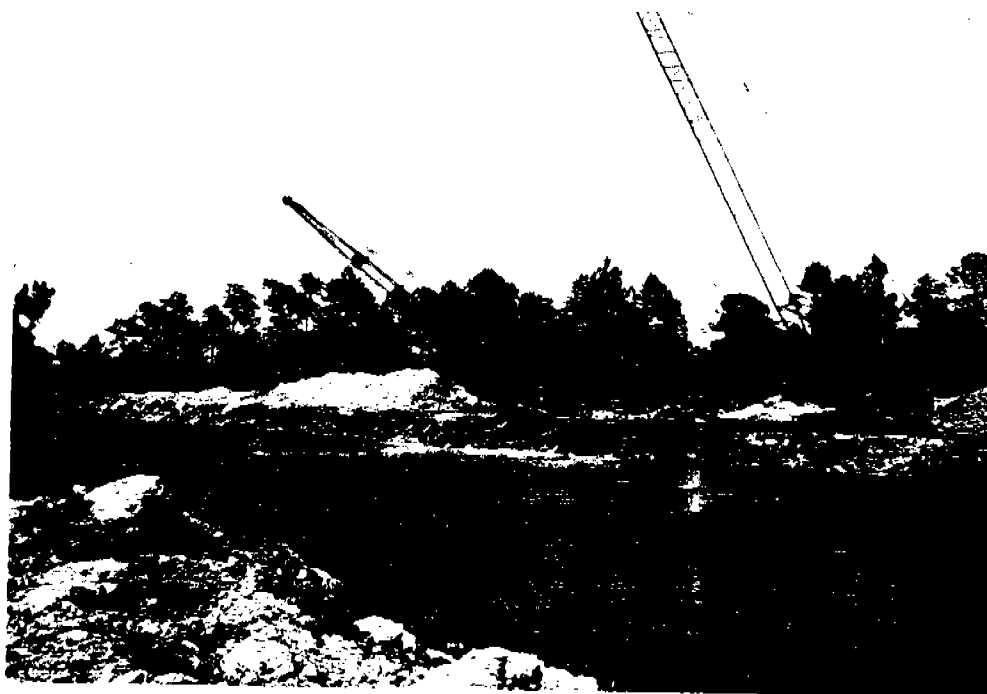
Rainfall in Inches

Return Period (year)	Duration			
	1 hour	6 hours	1 day	2 days
3	1.9	3.1	4.6	5.6
5	2.3	3.8	5.6	6.8
10	2.9	4.8	7.0	8.5
25	3.5	5.9	8.6	10.4
50	4.0	6.7	9.8	11.9
100	4.5	7.5	11.0	13.3

<sup>1</sup>Calculated from information in South Florida Water Management District, Manual IV (1983).



Blockage in Golden Gate Canal south of  
17th Avenue Weir - January 3, 1983.  
Stage recorder at arrow is same one shown in photos on page 6-10.



Removal of silt and rock constriction shown above - May 24, 1983.



Look north up canal at excavation nearing completion.



Look north up Golden Gate Canal at completed project.





Look southwest across Golden Gate Canal - Sept. 3, 1983  
17th Avenue recorder is at arrow (see next page for ground  
shots of weir). Note well drained condition of roads in section  
of Golden Gate Estates east of CR-951. Golden Gate City is in  
background at upper right.



Look north across 17th Avenue Weir - August 26, 1981.  
Stage recorders at arrows.



Same view as above -- September 4, 1983.  
Note decrease in water stage by comparing 1981 and 1983  
levels at nearest recorder (shown in both photos).

## 7. SUMMARY

Data utilized in this report was collected from several sources as earlier noted. Care was taken to use only data that could be clearly substantiated. High water marks that are included are from continuous recorders, stakes set in the field or reference marks on bridges. The elevations from the last two sources were obtained a few days after the storm event.

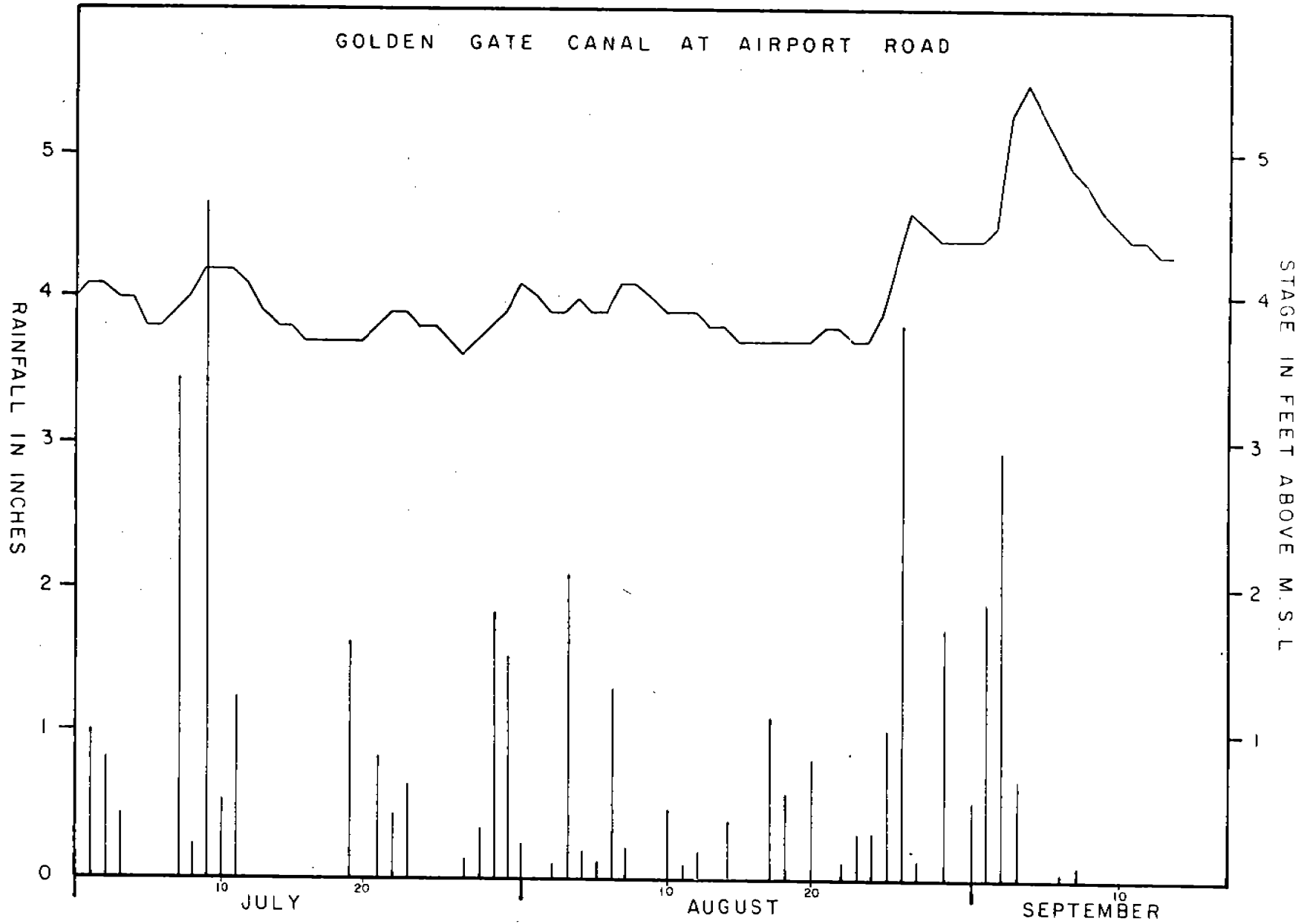
Reconnaissance efforts over the key Labor Day weekend period proved critical to this report. Photographs included herein are documented as to location and time.

Extreme care was taken to present collected data in a form such that logical evaluation would not easily result in illogical interpretations. The lack of flow data in the tributaries to the main canal may preclude any conclusive quantitative analysis. A qualitative review of data correlation can be accomplished using the rainfall data, stage recorder data, stage differential data and documentary photographs.

APPENDIX

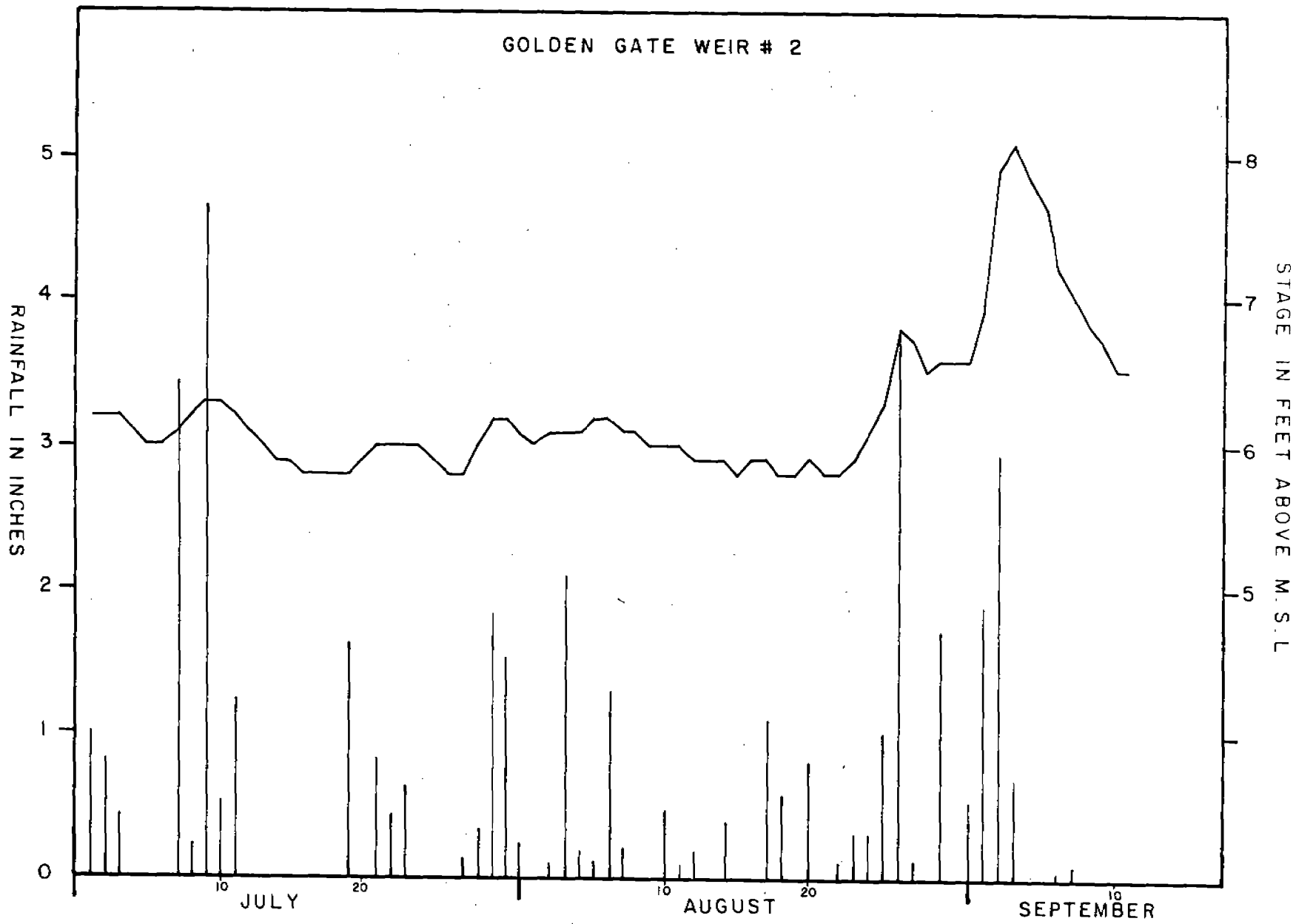
<u>DESCRIPTION</u>	<u>PAGE</u>
SURFACE WATER LEVELS	A-2
HIGH WATER ELEVATIONS	A-8
WATER SURFACE ELEVATIONS AND FLOWS	A-9

A-2



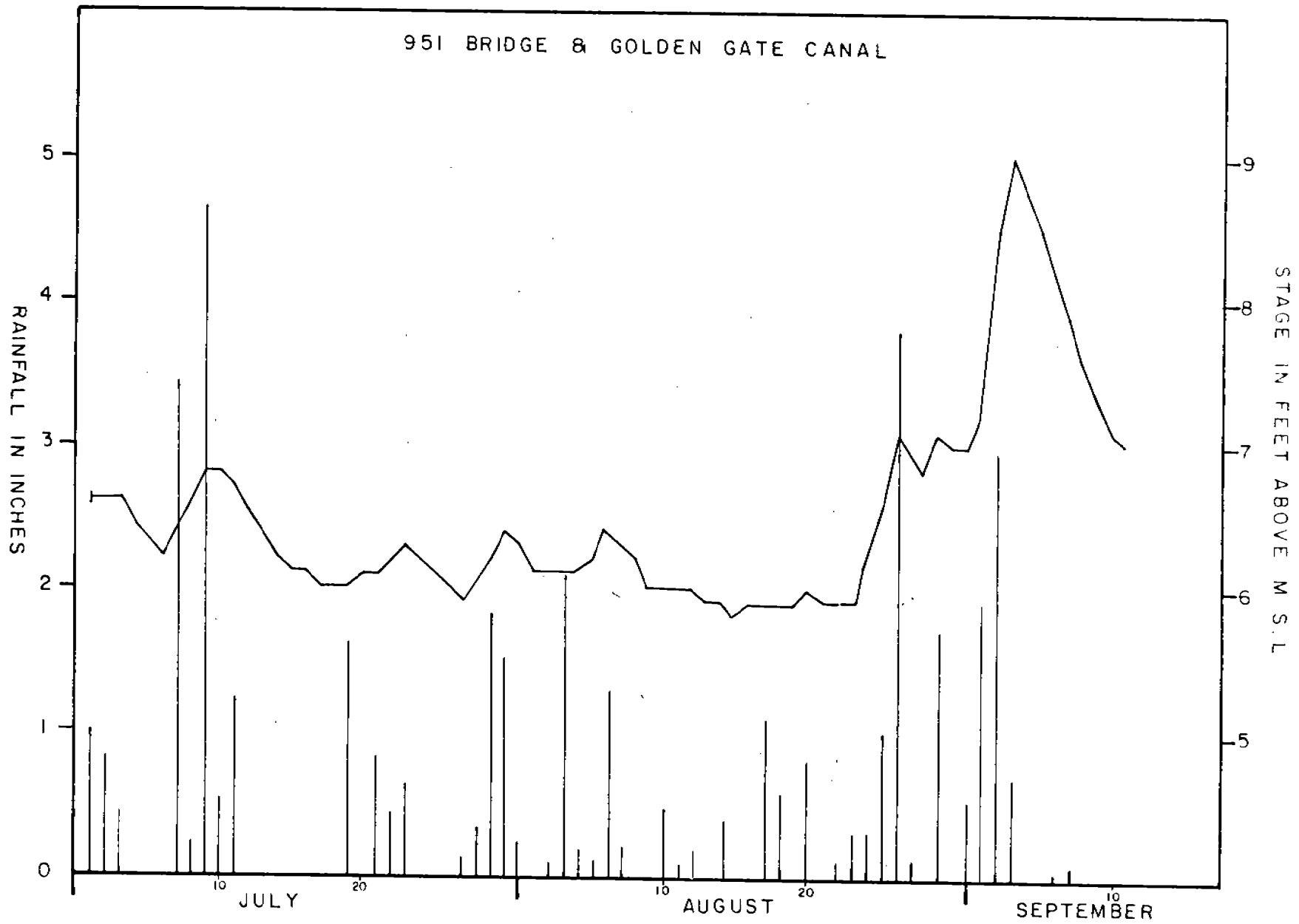
SURFACE WATER LEVELS AND DAILY RAINFALL  
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A-3



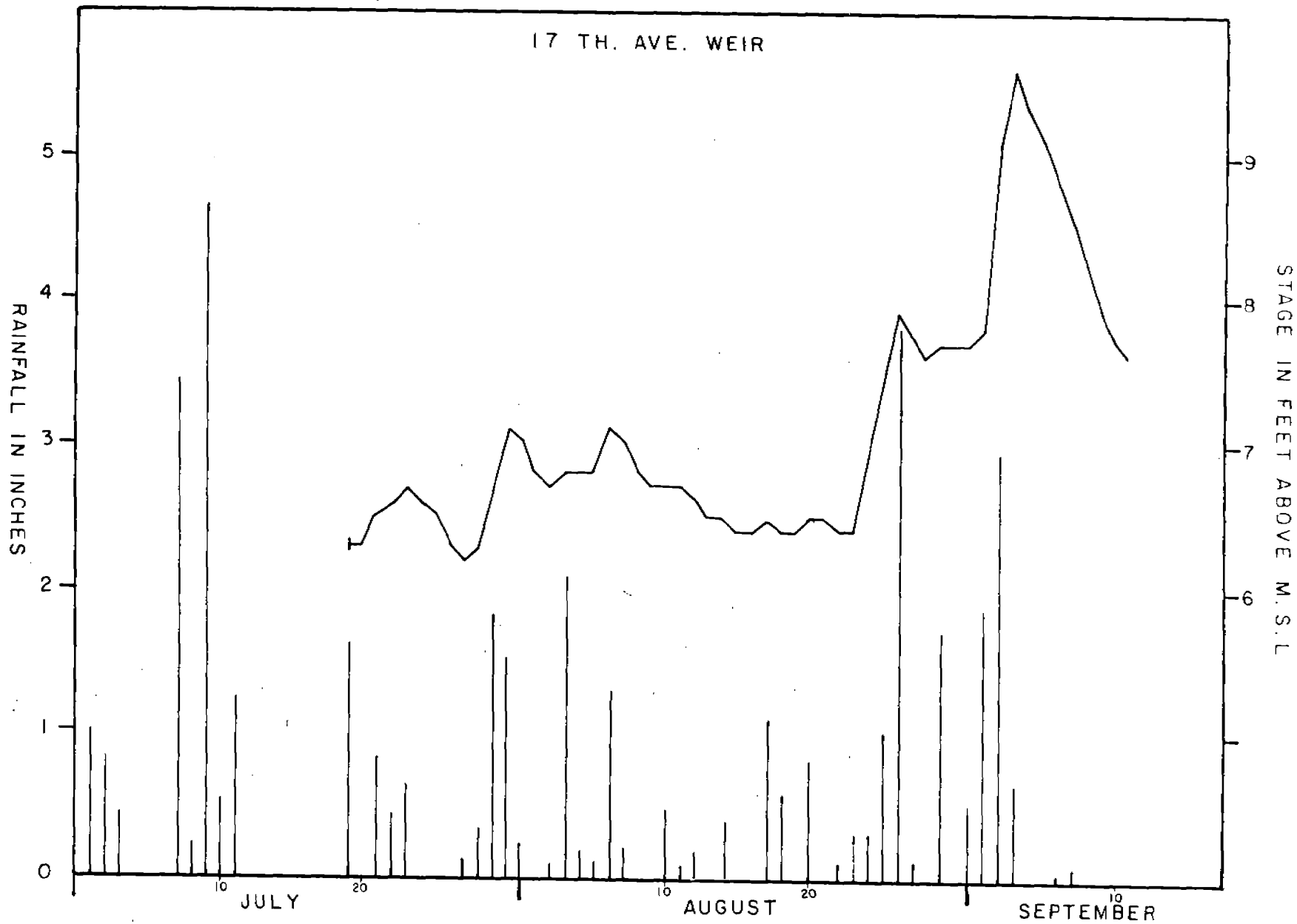
SURFACE WATER LEVELS AND DAILY RAINFALL  
JOHNSON ENGINEERING, INC.  
SEPTEMBER, 1983

A-4



SURFACE WATER LEVELS AND DAILY RAINFALL  
JOHNSON ENGINEERING, INC.  
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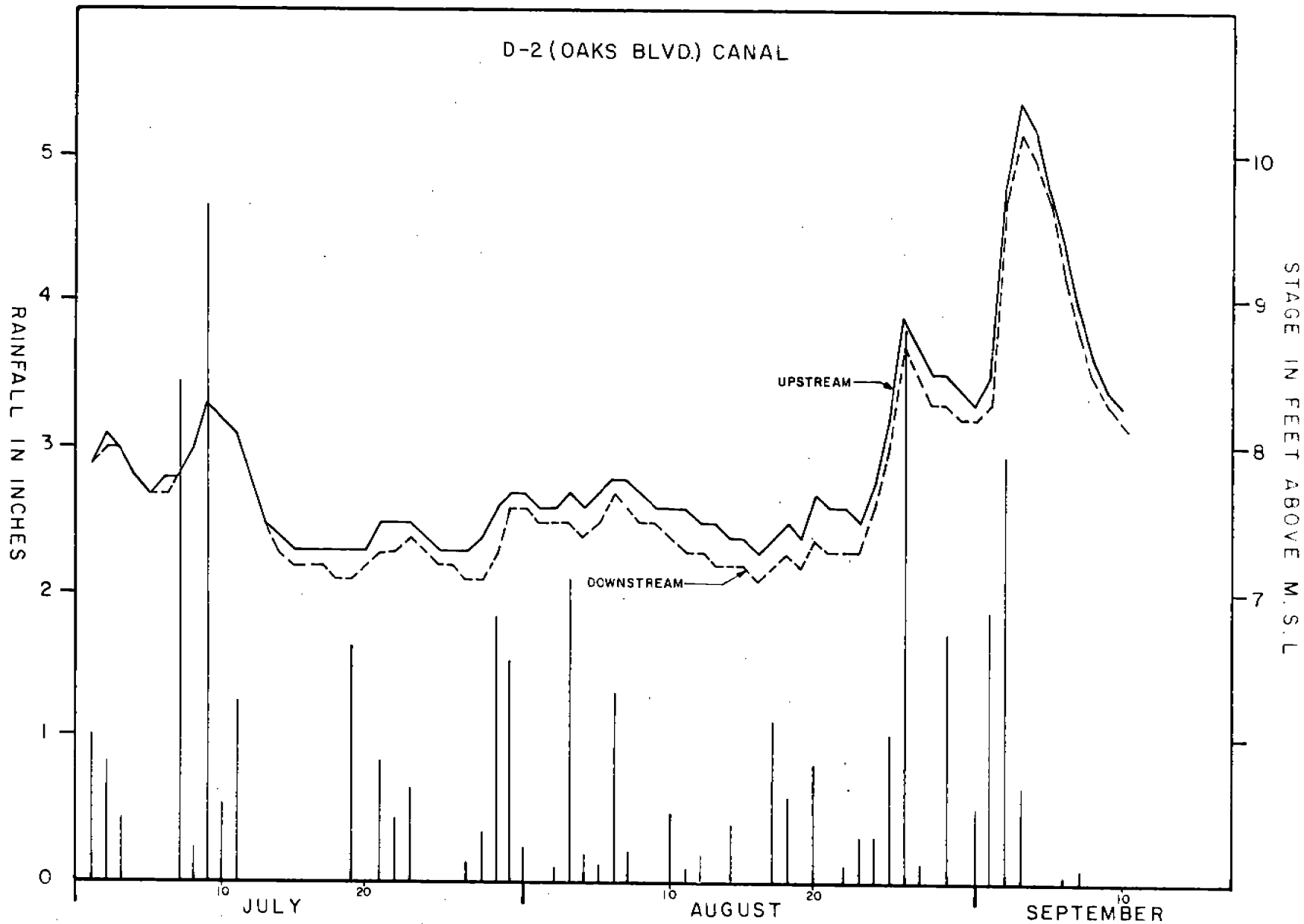
A-5



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A-6

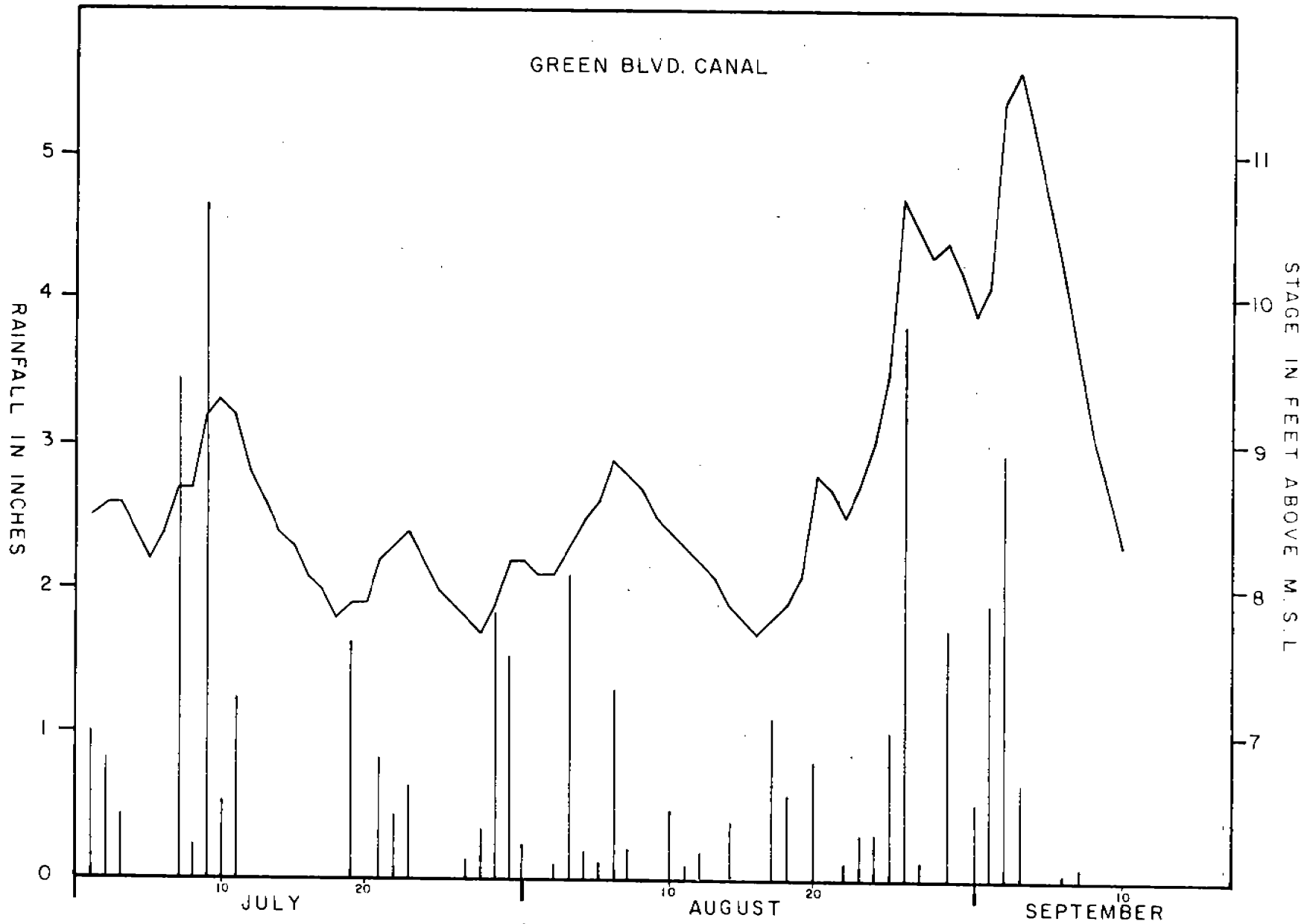


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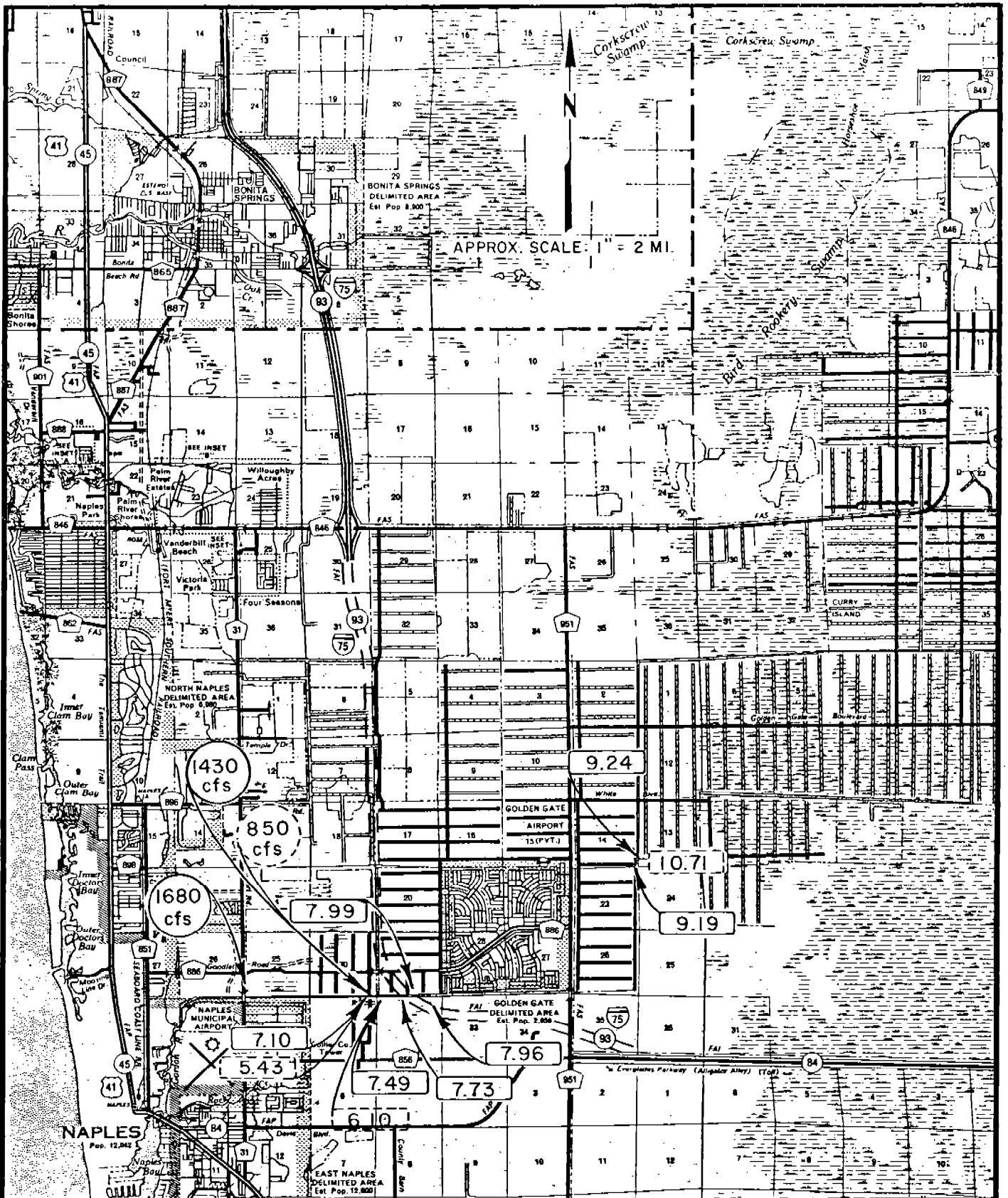


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TABLE 4  
HIGH WATER ELEVATIONS

<u>LOCATION/DESCRIPTION</u>	<u>ELEVATION</u>	<u>DATE</u>
Airport Road	5.49	9-2-83
Golden Gate #2 Weir Upstream	8.11	9-2-83
951 Bridge	9.01	9-3-83
17th Avenue Weir Downstream	9.65	9-3-83
D-2 (Oaks) Canal Weir Downstream	10.22	9-3-83
Upstream	10.41	9-3-83
Green Blvd. - D-1	11.72	9-3-83
South end of canal east of Hunter Blvd. <sup>1</sup>	11.6	9-3-83

<sup>1</sup>Information provided by Collier County



APPROX. SCALE: 1" = 2 MI.

- 10.71 WSEL 8-26-81      cfs = CUBIC FEET PER SECOND
- 9.24 WSEL 9-4-83
- 1430  
cfs DISCHARGE 9-4-83
- 850  
cfs DISCHARGE 8-26-81

## WATER SURFACE ELEVATIONS

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SEPTEMBER, 1983