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PERFORMANCE OF DISTRICT STRUCTURES DURING CRITICAL STORM EVENTS IN WEST MIAMI, AND PROPOSED ALTERNATIVES TO REDUCE FLOODING

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PART I. OPERATIONAL PERFORMANCE EVALUATION

INTRODUCTION

At the November 1981 South Florida Water Management District Governing Board Workshop, the City Engineer for West Miami made a presentation concerning the periodic flooding of that area during recent years (1979-81). The City Engineer felt that the recurring flooding problem in West Miami was due to the raising of the canal stages and, in turn, groundwater stages by the District. He requested that the District prepare a report evaluating the operation of the District's hydraulic structures (S-25B and G-97) in relation to rainfall and groundwater stages in the area. As a result of follow-up discussions, staff initiated a study to analyze the operation of the control structures during critical storm events, and to evaluate alternatives (both regional and local in nature) to alleviate the recurring flooding problem in West Miami.

Typical features of the West Miami area which bear on the flood hazard are moderately high rainfall and low land surface altitude and relief. In this area, flooding results from short periods of heavy rainfall, but the flooding does not necessarily coincide with the years of greatest precipitation. A factor that leads up to flood conditions is a heavy buildup of rainfall over several days, during which the drainage system has insufficient time to normalize groundwater levels. In the past, the area west of West Miami was undeveloped land and storm runoff from the east was discharged before the storm runoff from the west reached the primary canals. However, since the western area has now been highly urbanized, there is no time-lag to allow runoff from the eastern portion to drain first. Runoff water from the western and eastern basins reaches the canals to be discharged simultaneously.

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A related problem in this area is the need to maintain sufficiently high fresh water levels and canal flows to recharge wellfields which deliver more than 250 million gallons of water per day. These wellfields are susceptible to saltwater encroachment, especially during dry months.

It can be clearly seen, based on the above description, that the District must operate the control structures for both flood control and water supply purposes (multi-purpose uses). The objectives of the study will be to: (a) evaluate the operational strategy which has been applied to District control structures in the vicinity of West Miami during past storm events, and (b) evaluate an array of alternatives (both regional and local in nature) to help alleviate recurring flooding problems in West Miami.

DESCRIPTION OF STUDY AREA

The study area (West Miami) is located in east central Dade County. The project area, showing selected hydrologic features is presented in Figure 1. Figure 2 shows major drainage basins and topographic features of Dade County. CLIMATE

The climate in the study area is sub-tropical. Rainfall averages approximately 60 inches per year, about 45 inches of which falls during the months of June through October. This five month period includes both the rainy season and the hurricane season. It is during this five month period that the area has a higher probability of being flooded; however, the area has flooded during dry months also.

SOILS, TOPOGRAPHY, AND LAND USE

The study area is located on the western edge of Coral Gables. A soil map of the area, prepared by the U. S. Department of Agriculture (10) shows the following soil groups in the area: (a) marl glades, (b) rocky pinelands, and (c) sandy prairies.

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Figure 2

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The surface mantle of marl glades soil consists of poorly drained marl that is 2-72 inches thick. This is underlain by oolitic limestone in the east and south, and by either Miami oolite or the Tamiami formation in the west. The rocky pineland forms a belt 4 to 10 miles wide that extends from Coconut Grove southwest to Florida City. Elevations average 9 feet above sea level, but range from 5 to 20 feet. The rocky pinelands are classified as being moderately drained.

Sandy prairies extend south and southwest from the Broward-Dade County line for a distance of about 20 miles. Originally, this land was poorly drained, but extensive drainage operations have lowered the water table of the area to some extent. The topographic elevation of the study area varies from a low of 5 feet NGVD along the western portion to a high of 10 feet NGVD (Figure 2).

Land use changes in the study area started as far back as 1937 with most of the changes being completed before 1955. At the present time, most of the land in this area is in impervious cover. Due to urbanization west of the study area, a large portion of the land surface has been covered by impervious surfaces which inhibit percolation and therefore results in greater peak flows and total volume of storm water. The existing surface water management system now has to handle greater peak flows than in the past.

HYDROGEOLOGY

The study area is underlain by the Biscayne aquifer. This aquifer is composed of highly permeable limestones, sandstones, and sand. Within this area the aquifer thicknesss varies from 85 feet in the western portion to about 120 feet along the coast. The Biscayne aquifer is the source of water for the Hialeah/Preston, Miami Springs, and Alexander Orr wellfields for metropolitan Miami. These wellfields all receive recharge water from the surface water canals in the area, especially during dry months when rainfall is low. -5-

Water Supply Withdrawals

Presently, 272 million gallons of water is being withdrawn from this area. The District permits the Miami-Dade Water and Sewer Authority to withdraw up to 146 million gallons of water from the Hialeah/Preston and Miami Springs wellfields. Alexander Orr has a permitted withdrawal of 126 million gallons per day. It is estimated that as much as 378 million gallons of water will be needed by the year 2000, on a daily basis, to meet metropolitan Dade County's potable water requirements (9)). Sherwood and Leach (7) determined that as much as 50% of the water coming from the wellfields during dry months is canal water. In addition, approximately 53 cfs must be released to maintain a minimum canal stage of 2.8 ft. NGVD for saltwater intrusion. During the period of their study, the total withdrawal from the area's wellfields was approximately 130 mgd. Assuming the above recharge percentage (50%) to be still holding, as much as 210 cfs of water must be released to the canal to replenish the 272 mgd withdrawn from the wellfields, especially during dry months.

The Biscayne aquifer is subject to saltwater intrusion during critical low rainfall periods. Figures 3, 4, and 5 depict the extent of the saltwater encroachment before and after the District structures were put into operation.

Due to a constant threat of saltwater intrusion in the present wellfields, the Miami-Dade Water and Sewer Authority is developing two new wellfields; (1) the Northwest wellfield, and (2) the East Everglades wellfield. The Northwest wellfield, which is also known as the Three Square Mile wellfield, is located west of the present wellfield and is currently being tested. As much as 150 mgd may be withdrawn from this wellfield. The rest will be withdrawn from the East Everglades wellfield.

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Figure 3





PRIMARY DRAINAGE FACILITIES

Primary drainage through the study area is through the Tamiami and Coral Gables Canals. Flow in these canals is regulated by the operation of District control structures (sheet pile barrier dam (G-97) on the Coral Gables Canal and a reinforced concrete gated spillway (S-25B) on the Tamiami Canal).

Structure Operations

District control structures are operated for multi-purpose uses. Kohout and Hartwell (4) have determined that a minimal canal stage of 2.7 ft. above msl is needed near the control structures to prevent saltwater encroachment in the Biscayne aquifer in Dade County.

District structure G-97 on Coral Gables Canal (C-3), together with S-25B on the Tamiami Canal (C-4), are operated to maintain a headwater elevation of 2.8 ft. above msl. G-97 is a sheet pile barrier and, during storm events, these sheet piles are difficult to operate (requires pulling sections out); therefore, required releases are normally made by S-25B. Presently, a dialogue has started between the Corps of Engineers and the District to replace G-97 with a more efficient control structure. The design discharge rate of G-97 is 640 cfs (40% SPF) and the design rate of S-25B is 2000 cfs (100% SPF). The design discharge rate of these two control structures should be able to maintain optimal groundwater stages in the West Miami area.

Operation of the gates at S-25B is automatically controlled. This structure is located in the City of Miami and is immediately downstream of the LeJuene Road crossing of the Tamiami Canal. The main gates at S-25B operate to maintain the upstream water surface elevation as follows:

 When the headwater elevation rises to 3.0 ft., the gates will open at the rate of six inches per minute.

- 2. When the headwater elevation rises or falls to 2.9 ft., the gates will become stationary.
- 3. When the headwater elevation falls to 2.5 ft., the gates will close at the rate of six inches per minute.

Kohout and Hartwell (4) have compared the groundwater levels of the study area prior to inception of the Flood Control Project with those after the structures were placed in operation. They state that groundwater levels over most of the area prior to the Project were 9 to 10 feet above msl, or about 3 to 5 feet above land surface. After completion of the Project work, water levels in the study area ranged 5 to 8 feet above msl, or 2 to 4 feet lower than those before the completion of the Project.

SECONDARY DRAINAGE FACILITIES

Presently, there is no positive outfall from the study area to the regional drainage system. The internal drainage system of the area consists of french drains. Installation of the french drain system of storm water removal started some 30 years ago, but some improvements were made 4 or 5 years ago. According to the Land Use Comprehensive Plan for the area, the french drain method has proven to be a very cost effective means of drainage. French drains are supported by ballast rock and are used where the soils are not capable of supporting an open trench structure. Most french drain systems use 15 inch pipe. Larger pipes are necessary only in areas where excessive amounts of stormwater are expected.

Under present conditions, storm rainfall will first infiltrate vertically downward. Once it reaches the water table, it begins to move horizontally towards the primary drainage canals, depending on the hydraulic gradient (difference between the canal and groundwater stages). However, as groundwater flow is very slow, it takes several days for the groundwater flow to reach the primary canals and then recede.

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The Comprehensive Land Use Plan for the City of Coral Gables (1) points out, under the heading of "drainage elements", that the "<u>present natural</u> <u>system of stormwater removal cannot adequately handle the large amounts of</u> <u>rainfall which this area receives. The Plan recommends that additions to the</u> <u>system (including structures) must accompany or take precedence over the</u> <u>infiltration techniques for effective drainage."</u>

Near the study area, the Florida Dept. of Transportation has a ditch alongside of Coral Way that is known as the Coral Way ditch. During the past storm event, the City of West Miami constructed a temporary connection between the ditch and one of the city's catch basins. Water was discharged to the ditch via a 4 inch diameter pipe at a rate of 600 gpm. After 24 hours of pumping, West Miami was able to lower the groundwater stage by as much as 2.0 feet(11).

HYDROLOGIC DATA BASE

PERIODS OF ANALYSIS

Daily records of rainfall, canal stages, structure operation, and groundwater stages were obtained from Dade County, the U.S.G.S., NOAA, and/or SFWMD records for the years 1968, 1979, 1980, 1981, and 1982. These years included periods when major flooding occurred in the West Miami study area.

Rainfall data were analyzed by first determining the monthly distribution of total annual rainfall. Daily rainfall values were next tabulated for rainfall periods that exceeded that average rainfall for that month. The amount of rain that fell during each of these events was then compared with rainfall events of one-day and two-day duration within 25-50-and 100-year return frequencies.

Daily stage and operation records for the Coral Gables and Tamiami Canals were analyzed for those periods when flooding occurred in the study area. Finally, daily groundwater data records or estimated levels were analyzed for

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periods when groundwater levels exceeded the minimum land surface elevation of 5.0 ft msl.

RAINFALL

Monthly distributions of total yearly rainfall for the years 1968, 1979, 1980, 1981, and 1982 from the Miami International Airport (MIA) and the District's Miami Field Station (MFS) are presented below in Table 1.

	<u> 1968 </u>		1979		1	.980	1	.981	1982	
	MIA	MFS	MIA	MFS	MIA	MFS	MIA	MFS	MIA	MFS
January	1.92	1.67	1.28	2.01	1.89	1.92	0.61	0.58	0.44	0.60
February	2.77	1.97	0.57	0.59	0.88	1.04	4.66	4.56	1.22	1.32
March	0.88	0.66	0.30	0.26	3.17	2.42	1 .3 2	1.74	4.22	6.50
April	1.27	0.69	17.29	12.41	10.20	10.33	0.05	0.04	NA*	9.40
May	18.54	17.93	5.29	6.95	2.14	2.39	4.94	5.34	NA	6.70
June	22.36	15.93	4.06	3.48	3.02	4.28	5.49	6.09	NA	NA
July	6.15	6.57	5.06	8 .36	9.40	9.26	2.78	4.78		
August	8.34	10.79	4.81	3.61	11.32	7.50	12.25	8.32		
September	11.11	6.44	13.36	11.84	5.60	8.58	14.79	12.88		
0 cto ber	8.71	9.4 3	3.63	6.22	6.05	2.88	1.62	2.28		
November	1.21	1.17	1.62	1.96	3.47	4.36	2.14	2.17		
December	0.13	0.30	2.84	3.67	0.20	0.95	0.14	0.21		
Total	83.39	73.55	60.11	61.36	57.34	55.91	50 .79	58.99		
*Not Avail	able									

Table 1. Monthly Rainfall Values (Inches) - MIA and MFS

The foregoing table depicts the monthly and annual rainfall variations between the two stations, which are only a few miles apart. Additionally, as the intent of this report was to analyze the structure operations during critical storm periods, further breakdown of the monthly values to daily values was necessary. The daily values for each month of the year, whenever the monthly values exceeded the average monthly rainfall (Table 2), is presented in Table 3.

Table 2. Average Monthly Rainfall Values - Miami International Airport

Month	Rainfall (Inches)
January	2.15
February	1.95
March	2.07
April	3.60
May	6.12
June	9.00
July	6.91
August	6.72
September	8.74
October	8.18
November	2.72
December	1.64
Total	59.80

Table 3.	Daily Rainfall	Values	When	the	Monthly	Total	Exceeded	the	Average
	<u>Year of 1968</u>								

	Rainfall	(Inches)
Date	MIA	MFS
May 19	4.42	0.00
20	1.03	1.94
21	0.12	0.38
22	0.21	0.19
23	0.25	1.81
24	0.46	0.26
25	0.30	0.00
26	2.22	0.00
27	0.03	3.29
28	0.20	0.00
29	1.20	0.32
30	0.21	0.00
31	<u>0.20</u>	1.72
	10.85	9.91

Table 3 (Continued)

Year	of	1968	
			"

		<u>Rainfall</u>	(Inches)
Date		MIA	MFS
June I		0.39	0.00
2			0.00
3		2.55	2./0
4		0.28	1.92
5		0.34	0.15
6		0.69	0.00
/		0.50	0.00
8		3.42	0.00
9		0.33	0.00
10		1.43	2.3/
11		0.02	1.41
12		0.01	1.89
13		0.04	0.12
14		0.41	0.00
15		0.11	0.00
16		1.46	1.12
1/		0.42	0.86
18		2.46	0.97
19		0.00	0.00
		15.97	13.57
September	24	0.34	0.25
	25	1.70	0.00
	26	2.49	0.88
	27	0.35	2.04
	28	0.04	0.00
	29	0.01	0.00
	30	1.72	0.49
		<u> </u>	2 66
		0.00	3.00
<u>Year of 1979</u>			
April 24		1.39	0.00
25		14.85	11.64
26		0.00	0.73
27		0.00	0.00
		16 24	12 37
		10+24	12.07
September	24	0.34	0.25
	25	1.70	0.00
	26	2.49	0.88
	27	0.35	2.04
	28	0.04	0.00
	29	U.UI	0.00
	30	1./2	<u>0.49</u>
		6.65	3.66
		-15-	

Table 3 (Continued)

Year of 1980

	<u>Rainfall</u>	(Inches)
Date	MIA	MFS
April 5	0.45	0.00
0 7	0.10	1 53
2	4.02	3 16
0 Q	0.01	0.00
10	0.09	2.28
10	0.05	
	5.51	6.97
July 13	0.15	0.00
15	U. 98 1 02	0.34
16	1.02	0.30
17	1.44	1.31
18	0.25	1.09
19	1.45	0.00
20	0.30	0.00
21	0.11	2.11
22	0.27	0.48
23	0.32	0.22
	7.12	6.84
<u>Year of 1981</u>		
August 16	1.28	0.00
17	2.50	2.70
18	2.75	7.80
19	0.19	1.45
20	1.31	0.28
21	0.10	0.33
	8.13	12.56
September 3	0.04	0.00
4	0.01	0.03
5	0.04	0.00
0 7	2 33	0.00
8	0.03	2.58
ğ	2.04	0.05
10	0.17	2.05
11	0.11	0.45
12	0.02	0.00
13	0.05	0.00
14	0.01	0.56
15	0.06	0.82
10	0.99	0.05
1/	0.13	1.25

Table 3 Year of	(Continued 1981 Septer	d) mber	<u>Rainfall (In</u>	ches)	MTA MES
		18 19 20 21 22 23 24 25 26 27 28 29	0.01 0.00 1.01 0.01 1.20 0.01 0.00 4.36 0.79 2.65 0.00 0.00	$\begin{array}{c} 0.32 \\ 0.00 \\ 0.00 \\ 0.32 \\ 0.07 \\ 0.00 \\ 0.00 \\ 0.00 \\ 0.00 \\ 0.00 \\ 4.05 \\ 0.08 \end{array}$	
			16.17	12.68	
<u>Year of</u>	1982				
	March	24 25 26	0.00 1.01 <u>0.08</u>	0.73 0.00 <u>1.10</u>	
			1.09	1.83	
	April	23 24 25 2 6	0.05 7.25 0.78 <u>0.91</u>	0.00 0.00 0.00 <u>8.72</u>	(Cumulative for 3 days)
			9.19	8.72	

The above table depicts that even the daily rainfall amounts measured at two nearby stations are different. Presently, West Miami does not have any raingage stations. The District has agreed to provide the city with a raingage station so that the exact quantity of rain that falls in the city can be measured in the future. However, rainfall amounts measured at these two stations were used in the analysis.

A report was recently prepared by the District which estimated the return frequencies for rainfall events of maximum 1 and 2 day durations (8). The Log-Pearson Type III Distribution was applied to estimate the rainfall and durations for rainfall events of 25, 50, and 100 year return frequencies. In Table 4, rainfall events having return frequencies of 25, 50, and 100 years for 1 and 2 day durations are presented for the study area.

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Table 4.	<u>Rainfall</u>	(Inches)	in	Events	of	0ne	and	Two	Day	Duration	that	0ccur
With 25,	50, and 100	Year Re	turn	Freque	nci	es						

Duration (Days)	Return Frequency	Rainfall (Inches)
1	1 Year in 25 Years	10
1	1 Year in 50 Years	12
1	1 Year in 100 Years	14
2	1 Year in 25 Years	12
2	1 Year in 50 Years	14
2	1 Year in 100 Years	16

A comparison of Tables 3 and 4 shows the study area received in excess of 10 inches of rainfall on only one particular day. This event occurred on April 25, 1979, when the study area received 14.85 inches of rain (MIA) on a single day. The return frequency of this rainfall is greater than 1 in 100 years. This event also exceeded the rainfall of a 2 day 1-in-50 year event.

However, as reported by the city engineer, this area has experienced three major flooding events during the past years. Therefore, the above comparison simply shows that past flooding in the study area was not caused by isolated major events. Flooding was probably due to a combination of antecedent hydrologic conditions (rainfall, groundwater, and canal stage) in the area.

CANAL STAGES UPSTREAM OF STRUCTURES DURING PAST STORM EVENTS

It was stated earlier in the text that the primary canals in the study area are the Tamiami and Coral Gables Canals. Presently, the upstream stages of the Tamiami Canal are controlled by S-25B. This is a new structure which was made operational after the 1970's. Before this, during the storm event of 1968, a structure existed on the Tamiami Canal near the FEC Railroad. Presented in Tables 5, 6, and 7, are the upstream stage records from the Tamiami Canal near the FEC RR, G-2 Coral Gables Canal, and S-25B.

A spot reading of the Coral Gables Canal during the April 1982 storm event was obtained from DERM. These readings are presented in Table 8.

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Form No. 155				OPERAT	TION LO	0 G C.&S.F.F.C.D.
MONTH				STR	UCTURE I	AMIAMI CANAL CF.E.C.R.R. YEAR 1968
DATE & TIME	STAGE Upper & Lower	lleig) I	t of Gate Ope	ning in Bay 3	Number 4	REMARKS
1968 Jan.		(a) (b)				No change during month Closed full
Feb.						No change during month Closed full
March						— No change during month Closed full
April		-				- No change during month - closed full
5-14-68 11:00am	3.30 1.20					6 half needles out
5-16-68 3:40pm	2.88 1.40					- 3 half needles out
5 -2 0-68 10:00am	3.40 1.40					3 half and 2 full needles out
5-21-68 11:02am	3.28 1.54					3 half and 4 full needles out
5-26-68 4:00pm	3.08 1.95					6 half and 4 full needles out
5-29-68 8:16am	2.74 1.82					all needles out
June						all needles out ~~ No change during month
July						all needles out No change during month
8-2-68 4:20pm	2.82 1.54					- 6 half open
9-2-68 3:00pm	2.68					2 half open
9-25-68 1:30pm	<u>3.05</u> 2.38					6 half & 2 full open
9-26-68 3:45pm	<u>3.06</u> 2.68					open full
10-7-68 9:30am	2.00					Open full to 6 half out
10-16-68 2:25pm	2.42					All needles out
(a) BEFORE (b) AFTER CH STAGE RH	CHANGE T TANGE EADINGS ARE BI	ABLE 5.	STRUCTURE	AT TAMIA	MI CANAL -19-	AND FEC RR

FCD FORM 555 1967				OPERAT	ION LO	G G AMIAMI CANAL & F.E.C.R.R. VEAD 1968
MONTO		 T		SIRU		1969
DATE & TIME	STAGE Upper & Lower	lleight 1	of Gate Ope 2	ning in Bay 1 3	Number	REMARKS
10-30-68	2,48	(a)				
10:30am	1.42	(b)				6 half needles out
Nov.						No change during month
12-2-68 10:30am	2.54		· · · · · · · · · · · · · · · · · · ·			5 half needles in - l out
12-31-68 10:18am	2.75 0.76	•				all closed
1-11-69	3.20	A11 c1	osed			_
9:00pm	0.90	6 half	needles	out		_
1-17-69 2:30pm	2.64 1.26	<u>6 half</u> All in	needles	out		
1-20-69 10:12am	3.34 0.76	All in 5 half	needles	out		
1-30-69 3:15pm	2.52	5 half All in	needles	out		
2-14-69	2.86	A11	in - 0	losed ful	1	
9:15AM	1.30	2 hal	f needles	out		
2-15-69	3.60	2 ha1	f needles	out		
6:00PM	0.96	5 hal	f - 1 ful	l out	P#+-#UU	
2-24-69	2.80	5 ha]	f - 1 ful	1 out		
11:00AM	1.06	all i	n - clos	ed full		·
March						No change during month
April						No change during month
5-5-69 3:30pm	<u>3.32</u> 1.42	a 3 hal	ll_in 7es out			-
5-22-69 4:00pm	3.00 0.96	<u>3 hal</u> close	<u>ves out</u> I			
6-6-69	3.00	all c	osed			
9:00am	0.90	6 half	full ou			······································
6-6-69 4:00pm	4.16 2.04	6 half all need	full ou lles out			
6-26-69 9:00am	2.68 2.20	all need 5 half d	lles out out			
(a) BEFORE C (b) AFTER CH. STAGE RE.	HANGE Ange Adings are be	TABLE 5	(Continu	ied)	-20-	SHEET 5

								معمور وراري محمد وحمد الم			
n	1	9 6 8 G-	2 CORAL	GABLES C	ANAL 13	-54-40					
A Y	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	100	NOV
1	•	2.90	2.92	2.60	2.40		2.35	2.10	·····	2.65	· · · · · · · · · · · · · · · · · · ·
2	2.95	2.89		2.60			2.37	2.40		2.22	
3	2.93			2.64	2.35	3.42	2.24		2.72	1.80	·*************************************
4	2.94		2.84	2.59		3+00			2.70	2.13	2.26
5	2.94	3.04	2.84	2.58		2.50		2.97	2.73		
6		3.05			2.50	2.75		2.89	2.73		2.30
7		3.06	2.88		2.64	2.74		2.84		1.56	2.35
8	2.86	3.01	2.86	2.50	3.00	1	2.20	2.85		2.37	
9	2.87	2.99		2.48	3.00		2.50	2.82	2.58	2.24	2.22
10	2.90			2.50	3.10	3.26	2.35		2.76	2.20	1.94
1	3.00		2.85	2.48	3.55	3.18	2.10		2.65	2.33	ana Tanana a T
12	2.99	2.95	2.80	2.48		3.48	2.60	3.35	2.86		2.69
3		2.56	2.90	ta per maneration a complete de	3.50	2.50		2.92	3.20		· · · · · ·
4			2.84		2.40	2.30		2.74		2.53	2.79
5	2.95	2.90	2.80	2.48	3.20		2.24	2.58		2.47	
6	2.94	2.87		2.48	3.17		2.27	2.45	2.70	2.58	
7	2.90			2.43	3.18	2.30	2.53		2.57	2.53	
8	2.93		2.86	2.42		2.50	2.68		2.55		2.85
9	3.08	2.95	2.82	2.47	3.77	2.50	2.74	2.35	2.89		in the presence of the second s
20		2.95	2.82		2.22	2.67		2.60	2.88	2.15	
?1		2.92	2.77		3.05	2.18		2.60	وور و مار با فار ماه و معاون ا معالی از است ا	1.90	2.85
2	3.09		2.77	2.42	3.05		2.48	2.75		1.95	
3	3.04	2.92		2.40	3.05	·····	2.40	2.75	2.90	•	
4	3.07			2.37	2.95	1.75	2.25		2.95	2.60	
5	3.04		2.70	2.40		2.32	2.40		2.97		2,80
6	3.00	3.04	2.72	2.52	3.27	2.25	2.52	1.75	2.35		
7		2.98	2.73		3.10	2.78		2.80	2.27		
8		2.93	2.72		2.78	2.50		2.75		2.20	
9	2.91	2.90	2.70	2.41	2.73		2.21	2.93		2.25	
0	2.90			2.39		2.82		2.95	1.83		
1	2.90				2.80	· · · · · · · · · · · · · · · · · · ·	2.17			2.27	
N	2.96	2.95	2+80	2.48	2.94	2.65	2.38	2.68	2.68	2.24	2.50
				and there is a sum of the second s	· · · · · · · · · · · · · · · · · · ·	H	TGH	3 - 77			
	·····	······································									
										R	

-21-

METROPOLITAN DADE COUNTY WATER CONTROL DIVISION

CORR FACTORS

STAGE RECORD

☐ Min-Max Gage ☐ Min-Max MK II ☐ Continuous Recorder

H15	Low	Date

Year <u>1979</u> Gage Designation <u>4-2</u>

	Ja	anuary		Fe	bruary			March			April	
	Hi	Spòt	Low	Hi	Spot	Low	Hi	Spot	Low	Hi	Spot	Low
1		1					278	2170	265			
2							276	269	265	240	234	225
3	3.00	285	277							239	234	273
4	294	288	279							240	230	223
5	295	289	283	353	247	<u>२</u> ५ व	276	768	241			
6		1		273	2/66	262	274	21.9	262	212	2.4	230
7				272	266	261	279	273	265			
8	296	282	277	273	260	261	277	272	267			
9	289	204	277	273	268	241	278	200	265			
10	289	281	277				277	267	263	240	233	224
11					1					225	220	224
12	286	2180	273	274	1265	258	277	267.	264	231	22/2	222
13		siden an		275	1269	257	272	2:00	260	234	297	222
14				277	1270	257	269	263	257			
15				217	268	256	263	143	194			
16	2 ?2	24.4	272	274	268	260	268	240	255	•		
17	290	276	272)		233	226	211
18	281	270	205	· · · · ·				1		231	244	218
19	287	281	263				269	254	180	229	221	115
20		Î.		274	287	252		\mathbf{n}	•	227	219	214
21		ļ		273	20,6	261	268	24	245		-	
22	293	277	267	279	273	261	259	451	247			
23	284	278	272	135	274	266	251	d a sur		224	214	1.209
24	284	217	270				248	<u> </u>		220	213	207
25	285	278	273				244					
26	284	275	271	284	276	207	255	245	242	497	414	515
27				282	274	270	253	245	241	020	384	377
28				280	2.7.2	2100	250	242	236			
29					1,201		257	238	234			ļ
30							247	225	731			
31												
		BLE 7.	G-2, COR	AL GABL	ES CANAL	. STAGE I	RECORD _					4 1

Sea Level Datum of 1929, S.L.D.

WATER CONTROL DIVISION

CORR FACTORS

H1.	Low	Date

STAGE RECORD

□ Min-Max Gage □ Min-Max MK II □ Continuous Recorder

Year 1979 Gage Designation G-2

Hi Spot Low HI Spot Low HI Spot Low HI Spot Low 1 387 753 357 257 261 241 1 <th></th> <th></th> <th>May</th> <th></th> <th></th> <th>June</th> <th></th> <th></th> <th>July</th> <th>· · · · · · · · · · · · · · · · · · ·</th> <th>· A</th> <th>ugust</th> <th></th>			May			June			July	· · · · · · · · · · · · · · · · · · ·	· A	ugust	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		Hi	Spot	Low	Hi	Spot	Low	Hi	Spot	Low	Hi	Spot	Low
2 362 345 340 (291 283 310 297 294 3 363 242 237 295 286 277 304 294 281 4 350 350 344 205 294 244 200 271 304 294 281 4 350 350 364 244 200 271 1 1 5 3244 360 201 297 276 271 1 1 6 1 307 294 200 271 1		387	353	337	309	299	291	· · · · ·					{
3 $3 = 3 - 2 + 2 - 23 = 7$ $2 - 3 - 5 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 3 - 2 - 2$	2	363	345	340	. — -			291	289	283	310	299	294
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	3	363	343	235		$\left[\right]$		295	258	277	304	294	ZEL
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	4	280	332	329	305	299	294	2	1	, , , , , , , , , , , , , , , , , , , ,		i	
6 a_17 294 287 27 301 291 287 7 301 291 287 313 $3at$ 287 8 301 291 287 313 $3at$ 287 9 302 303 201 291 291 241 313 $28t$ 10 325 294 207 393 364 484 327 12 584 277 373 364 484 327 393 364 484 12 302 261 277 317 367	5	324	300	300	305	234	200	287	276	271		Ň	
7 301 291 287 312 321 287 8 1 303 1 303 1 1 312 321 287 9 1 325 1 1 323 1 1 10 1 325 261 297 294 1 1 11 325 265 307 294 144 1 1 12 1 307 292 281 277 330 364 184 31 302 281 277 330 364 184 12 13 12 12 12 12 12 12 12 12 12 13 13 13 143 15 15 16 12 12 14	6				217	294	287	282	100	271			
8 1 303 1 303 9 1 325 299 201 201 201 11 325 299 297 294 204 104 12 364 297 294 207 294 204 12 364 297 297 294 207 294 207 14 201 201 297 297 297 297 297 15 317 309 292 297 297 297 297 15 317 309 292 297 297 297 297 16 314 309 292 297 297 297 297 18 317 307 297 298 299 297 297 19 / 314 397 298 290 297 290 297 21 317 297 297 290 297 290 297 297 21 197 297 297<	7				301.	291	287	_	$ \rangle$	• •	313	301	237
9	8					1	303						
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	9												
11 325 249 297 294 264 12 304 252 277 330 969 284 3 302 242 277 373 969 284 3 302 242 277 372 297 284 14 201 473 277 272 297 297 15 317 309 292 884 287 207 297 15 317 309 292 887 207 297 297 297 16 319 309 305 201 297 297 297 297 297 18 311 303 301 493 215 208 297 298 20 / 314 297 298 297 297 297 297 297 297 297 297 297 297 297 297 297 297 297	10	, ·						301	299	267		-	
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	11	325	1299	299			1	301	1294	224			
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	12				304	2/22	27	370	309	284			ļ
14 $2n^2$ $2n^2$ $3n^2$ $2n^2$	3		1		303	2/81	277	319	302	302			
15 317 309 292 $n.89$ (283) 270 308 109 294 311 292 283 16 319 309 304 433 270 308 109 294 2131 292 283 17 318 3117 307 303 301 243 275 308 294 294 283 18 321 3017 303 301 243 275 308 299 291 308 299 291 308 299 291 308 291 291 291 291 291 291 291 291 291 291 290 283 290 283 211 309 304 292 295 297 283 211 309 304 291 304 292 295 272 291 292 295 292 292 292 292 292 292 292 292	14		Ì		292	173	272	317	302	297			
16 319 309 $30 \times$ 301 302 294 297 17 318 311 307 303 301 143 175 308 299 291 18 311 307 303 301 143 175 308 299 291 19 / 314 307 266 ////////////////////////////////////	15	317	309	292	284	1283	270	308	299	294	311	292	283
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	16	319	309	30×					1/				
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	17	318	311/	307							302	294	285
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	18	327	3017	303	302	1293	275	308	1299	291			
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19	,			314	307	1288						
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	20		/	1	314	256	1292	-				4	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	21	317	1298	293	303	1299	290			1			
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	22	204	1292	1287	301	291	288				·		
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	23	298	2-87	282			·	342	318	290		1/	ļ
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	24	296	2:10	276			 	324	319	305	319	346	219
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	25	295	744	1777	···	j	·	······		1			
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	25		<u> </u>	1	<u> </u>		1	324	309	304			ł
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	27			<u> </u>	298	290	283	3:1	309	204			
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	28				2.00	12.35	2.55			J.	293	285	<u>h73</u>
- 323 30 303 31 317 304 300 TABLE 7 (Continued)	1 29	330	317	278	1020	263	283	· · · · · · · · · · · · · · · · · · ·			212	2.21	27-
31 317 304 300 292 28k 277 TABLE 7 (Continued)		323	30	305]		ŀ				· · · · · · · · · · · · · · · · · · ·
TABLE 7 (Continued)	31	317	304	300				1			292	284	277
		τ,	ABLE 7 (Continue	d)	1							<u> </u>

Sea Level Datuzzo of 1929, S.L.D.

METROPOLITAN DADE COUNTY WATER CONTROL DIVISION

CORR. FACTORS

STAGE RECORD

□ Min-Max Gage Min-Max MK II Continuous Recorder

Hi. Date Low

Year <u>1979</u> Gage Designation G-Z

	S	eptembe	er	0c	tober		1	Vovembe	r	D	ecember	1
	Hi	Spot	Low	Hi	Spot	Low	Hi	Spot	Low	Hi	Spot	Low
1				280	364	253	295	284	285			
2				371	<i>357</i>	352	303	294	285			
3		/		364	329	340				291	2-9	258
4	30%	301	203	357	344	333				290	263	259
5	3.04	z·tij	7.67	352	341	335			-	289	222	2:60
6	200	2199	2 99							292	274	259
7	312	304	290				304	294	264	307	299	272:
8							304	294	287			
9				343	320	315	305	294	289			
10	1212	301	292	1327	3/14	311		-		372	201	294
11	314	303	295	322	310	305				321	299	295
12	321	211	117	324	300	305				311	284	279
13	19: A	31					305	295	788	312	285	280
14							827	214	290			
15		•					321	304	298			
16				347	39	300	308	342	295	•		
17												
18				347	331	325				284	269	259
19		304		338	325	318				287	280	229
20	317	303	29					- 1 June -		287	274	261
21		/								283	TI)	267
22					1							
23		· \		334	300	2007						
24				312	304	200						
25	かかみ	310	292	315	307	249						
26	332	324	304		1		290	261	266		-	
27	272	326	155		1					-26-7	241	202
28	2.56	2119	<u>:/]</u>				291	282	212			
23	· · · · · · · · · · · · · · · · · · ·			305	244	286	291-	284-	217	·····		
- 30	314	299	295	303	2.97	267	292	284	2709			
31		····•		203	294	289				CAL	10/2	351
	TAB	LE 7 (Co	ontinued)									
	·					-24-				•		

Sea Level Datum of 1929, S.L.D.

ETROPOLITAN DADE COUNTY WATER CONTROL DIVISION

CORR. FACTORS

STAGE RECORD

□ Min-Max Gage □ Min-Max MK II □ Continuous Recorder

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Hi.	Low	Date
•		

Year <u>1980</u> Gage Designation <u>G-Z</u>

	Ĵ١	anuary		Fe	bruary			March			April	
	Hi	Spot	Low	Hi	Spot	Low	Hi	Spot	Low	Hi	Spot	Low
1				201	219	215		!		217	C' A	245
2	279	266	257		(322	294	265
3	272	264	255							300	289	282
4				281	268	2620	331	403	279			
5			·	217	248	Un	340	149	2.95			
6				273	270	240		797-	147			
7							297	289	277	297	-297	269
8	291	280	267	277	1274	257		1		207	299	270
9	292	287	279				-			307	294	289
10	242	286	278							307	299	288
11	202	7. 80	273	287	274	267	295	274	269	306	297	281
12				274	1-าา	24	285	279	267		-	
!3				278	264	260	285	279	260		``````````````````````````````````````	
14	288	251	273	279	1274	259	287	281	262			
15	288	281	277	287	281	268		$\frac{1}{2} = \frac{1}{2} \left[\frac{1}{2} + \frac{1}{2} \right]$				
16	289	280	278							303	237	279
17	289	281	268		• • •		282	274	257	397	289	287
18	290	282	273				297	272	266	LAZ	219	272
19				292	280	269	292	269	267	•	-	
20			•		4 × 4.4		278	269	264			
21	2009	271	267		Ì		272	271	264	320	291	271
2	2,91	245	2666	2 - 1 						319	270	27/
23	286	217	242							200	279	275
24	286	240	25				279	275	265	270	291	272
25	276	270	254	292	281	275	277	271	245	C Fp	7.9.4	284
26				288	268	263	7.88	274	255		•	
27		i		279	2.73	2.12		1.1.1	245	291	251	1-10
$\frac{1}{28}$	315	300	243	214	2.74	261	279	274	246		i i	
29			·	<u>-r-A</u> +	<u>- 64</u>	254						
n										297	279	271
31			10				279	271	261			
		TABLE 7	(Continu	ued)								· · · · · · · · · · · · · · · · · · ·
						-2	5			,		· ·

Sea Level Datum of 1929, S.L.D.

STRUPULITAN DADE COUNTY WATER CONTROL DIVISION

CORR FACTORS

STAGE RECORD

H1 Low Date

Year_

□Min-Max Gage □Min-Max MK II □Continuous Recorder

____ Gage Designation _

		May			June			July		August		
	Hi	Spot	Low	Hi	Spot	Low	Hi	Spot	Low	Hi	Spot	Low
_1	291	2:79	274					_		314	311	294
2	287	279	274	295	R-79	272	315	195	285			
: 3	<u>,</u>	1		294	278	271	317	197	287	:		
4				295	2279	272					1	
5		/		287	241	267	···					
6	290	2/84	275	277	264	265				309	299	288
7	289	282	277				311	291	289	305	244	294
8	287	281	274				314	2419	294	-	<u> </u>	· · · · · · · · · · · · · · · · · · ·
9	288	282	225	271	264	248	3:4	745	250			
10				269	169	251	3/2	253	274			
11			······	279	7-74	259	309	198	28%			
12	304	292	276	287	1.80	267		-				
13				282	276	261						
14							203	1257	275		1	
15	297	284	274				ろい	12-84	220			
16	296	22	271	292	162	20	200	1.88	271			
17			ر :	291	161	257	320	806	279			
18_							334	327	301			
19	241	481	273	29 -	1		\sim				-	
20	290	129	213	295	Z = 7	287	\sim	4. 				
21							338	371	315	·	S LL S	
2	240	784	264				374	7:16	311		. : : : : : : : : : : : : : : : : : : :	
23				298	293	283	-270	517	J.IZ		1	
24				297	212	282	17771	-1-1-9	5/2	<pre>/</pre>	,	
25		ţ		299	792	285	321	315	311		ΕŢ	
26		<u> </u>		299	2/89	285		, ,		347	319	2.9.7_
27				202	191	287		· :	\sim	343	318	287
28	29.8	12	279		Ĵ,		322	401 (<u>\@4</u> 2	342	3114	29-
- 29 -		<u>-</u> []-	<u></u>							342	-3+6	-28-1
30	299	264	274	314	307	284			$\geq_{1} \zeta_{1}$			
31	T/	··· ·* ·\ \DIE 7 /	l 🔧				317	304	292			
	I	NDLE / {	CONTINUE	a)		l		·				· · · · · · · · · · · · · · · · · · ·

-26-Sea Level Datum of 1929, S.L.D. TROPOLITAN DADE COUNTY ATER CONTROL DIVISION

CORR. FACTORS

STAGE RECORD

□ Min-Max Gage □ Min-Max MK II □ Continuous Recorder

H1 Low Date

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08 Year _

Gage Designation _____

	Se	eptembe	er	0c	tober		N	iovembe	r	De	ecember	
	Hi	Spot	Low	Hi	Spot	Low	Hi	Spot	Low	Hi	Spot	Low
_1					1					210		292
2					/			$\langle \rangle$		605		292
3	うちら	334	298				2/2	304	292		ŕ	
4	357	340	248			÷			247		N. N.	
5	355	347	335				304	303	297	403	299	295
6				302	247	287	304	302	261			
. 7				211	299	259	309	301	292			-
8	354	394	331	301	289	284			Ú	308	308	294
9	352	374	321	322	313	299		ik ta asm.		309	301	295
10	941	333	325	318	309	307		Sector.		307	297	292
11	342	384	325				-	1		304	296	291
12	326	327	317				310	300	287	305	291	287
	· · · · ·		J				309	299	286			-
14				317	299	294	310	204	288		ب اللہ ہوتی ہوتی ہوتی ہوتی ہوتی ہوتی ہوتی ہوت	• •
15	549	2/29	221	323	318	242				298	287	282
16	30	341	322	324	319	297	-	2		293	285	282
17	257	324	324	325	ろう	312	322	312	292	297	290	282
18	357	341	324					}		298	291	283
19	345	337	332							297	291	238
20		j.		324	301	293	319	305	299		and the second se	
21		1.		.307	297	292	318	30X	299	297	250	285
22	341	321	317	300	295	287	310	303	295	297	292	276
23	341	221	311	301	241	285		1				
24	261	220	3711	200	290	219	310	703	295			
25	227	3,11	3.07				304	30.2	24 1	*		
26	312	200	297		2 m						·	
27		<u>`</u> ~		304	299	291		2 Hereitari Here				
28					Í			<u>i</u> .	<u> </u>			
29								÷		217	289	28/
				304	298	252				247	287	282
31			· · · ·	304	298	242						
	TABLE	7 (Cont	inued)									
			·	·		-	27-		•	· · ·		

Sea Level Datum of 1929, S.L.D.

METROPOLITAN DADE COUNTY WATER CONTROL DIVISION

STAGE RECORD

□ Min-Max Gage □ Min-Max MK II □ Continuous Recorder

H1 ·	LOW	Date

8 Year ____

Gage Designation <u>G-Z</u>

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•	S	eptembe	er	00	tober		1	lovembe	r	D	ecember	
	Hi	Spot	Low	Hi	Spot	Low	H1	Spot	Low	Hi	Spot	Low
1												
2												
3												
4						;						
5				\$ 7,62	155	1.52						
6												
7												
8	3.33	226	226									
9										329	316	294
10							319	3/6	309			
11					<u> </u>							
12	. <u> </u>					[· · · · ·	·			
13				31	219	120				3/8	3/5	3/0
14												
15				321	318	315	<u> </u>	ļ	ļ			
16	346	251	240	ļ			<u> </u>	ļ				
17	316	204	251	<u> </u>				ļ	·	327	305	305
18]		ļ				<u> </u>	ļ			
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26			<u> </u>	212	510	<u>410</u>			<u> </u>			
	- <u></u>			211	2/2	710		<u> </u>				
Q 	362	291	129	2/1	2/0	<u>-10</u>						
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Sea Level Datum of 1929, S.L.D.

METRUPULITAN DADE COUNTY WATER CONTROL DIVISION

CORR FACTORS

STAGE RECORD

☐ Min-Max Gage ☐ Min-Max MK II []Continuous Recorder

H1 -	LOW	Date

Year .

81 Gage Designation <u>6-2</u>

	May			June		July			August			
	H1	Spot	LOW	Hi	Spot	Low	Hi	Spot	Low	Hi	Spot	Low
	218	211	ios	253	252	223	285	275	275			
2											i.e.	
3				224								-
4	222	200	195							3.04	3.04	2.63
5	214	200	192							3.08	3.07	3.03
6	23	199	111				298	284	207	3.11	3.08	3.01
7	217	209	191'									
8	~85	279	277		·		284	273	273			
9												
10							279	217	2.77	3.08	204	3.02
11	289	267	254	2,89	279	238					2.92	263
1 12	209	260	263	279	275	275				4.11	3.02	3,00
13								L		3.02	3.02	2.99
11	2.68	2.62	2.51									
15					·		ļ	 	ļ			
16			···				280	260	260			
17				277	252	252	260	256	256			<u>.</u>
18										4.15	1.86	1.58
19				252	242	242				3:35	1.29	1.20
20							273	272	253	3.69	2.03	1.34
21					; ;					3 45	IN8	14)
22	267	2.4)	2.41			·	225	266	366	·		
23												
24							· · · · ·			2.93	0.53	0.10
25				781	275	241		 		2.04	0.48	0.25
26	243	2.32	1.83							2.17	073	2.5.0
27							()		<u>A</u>	2.81	1.28	0.32
28							271	169	764	3.09	1.5.9	1.23
79				282	9.8.0	267		A 7 -	<u></u>			
<u>, 30</u>							271-	269	368			
31	та Ат	BLE 7.	(Continu	ed)								
L S								l				and a second
				_		-2	9-					

Sea Level Datum of 1929. S.L.D.

<u>Date</u> 4/23 4/24	Stages (Feet, MSL)
4/25 4/26 4/27	2.24 - 3.94
4/28 4/29 4/30	3.16 - 3.26

Table 8. Coral Gables Canal Stages During the April 1982 Storm Event

Tables 9 and 10 include the data for S-25B for the periods in April 1979,

August 1980, August and September 1981, and April 1982 when major storm events or flooding occurred in West Miami.

Table 9.	Maximum,	Average,	and	Minimum	Daily	Stages,	S-25B	Upstream)

1 979	St	age (Ft,	MSL)	1980	Stage	, (Ft, MS	<u>sl)</u>
April	Minimum	Average	Maximum	August	Minimum	Average	Maximum
20	-	2.20		8	-	2.80	_
21	-	2.18	-	9	-	2.85	-
22	-	2.18	-	10	2.80	2.85	2.90
23	-	2.15	-	11	2.58	2.74	2 .9 0
24	2.15	2.35	2.35	12	2.58	2.76	2 .95
25	-	2.50	-	13	2.75	2.84	2.93
26	1.15	1.82	2.50	14		2.85	-
27	1.10	1.97	2.85	15	2.55	2.74	2.93
28	1.00	1.80	2.60	16	2.55	2.72	2.90
29	1.20	2.05	2.90	17	2.58	2.75	2.93
30	1.18	1.99	2.80	18	2.55	2.73	2.92
				19	2.55	2.73	2.92
				20	2.60	2.70	2.80
				21	2.55	2.72	2 .9 0
				22	2.52	2.67	2.82
				23	2.52	2.71	2.90
				24	2.52	2.71	2.90
				25	2.52	2.70	2.88
1.001				1 001			
1901 August	Minimum	Avonado	Maximum	September	Minimum	Avonago	Maximum
AUGUSL	<u>Mana Ingun</u>	Average	Max mum	<u>Sebremmer</u>	$\frac{\mathbf{P}(111)\mathbf{P}(11)$	Average	<u>1102 111011</u>
14 15	~	2.00	-	2	0.92	1.70	2.40
15	2 05	2.06	2 20	J A	0.03	1.05	2.45
17	2.60	2 96	3.20	4 5	0.50	1.57	2.25
10	2.00	2.05	2.20	5	0.75	1 52	2.00
10	1 20	2.20	2.60	0 7	0.95	1.00	2 · I 2
20	1 00	1 02	2.00	8	0.00	1 44	1 08
20	T.00	エ・フレ	6 · UJ	0	0.20	T + 44	** 20

Table 9	9 (Cont	inued)						
21	•	1.05	1.71	2.38	9	0.80	1.51	2.22
22		0.80	1.45	2.10	10	0.80	1.51	2.22
23		0.70	1.39	2.08	11	0.70	1.37	2.05
					12	0.65	1.45	2.25
					13	0.70	1.47	2.25
					14	2.60	3.10	2.85
					15	2.60	2.79	2.98
					Sentember	Minimum	Average	Maximum
					16	2.70	2.85	3.00
					17	1 35	1 95	2.55
					18	1 35	1 95	2 55
					10	1 36	1 77	2 20
					20	1.55	1 02	2.20
					20	1.30	2 02	2.00
					22	1.35	2.02	2.70
					22	1.35	1.95	2.00
					23	1.35	1.9/	2.60
					24	1.35	2.15	2.95
					25	2.00	2.50	3.00
					26	1.25	2.00	2.75
					27	1.35	2.05	2.75
					28	1.25	1.90	2.55
					29	1.15	1.77	2.40
					30	1.10	1.72	2.35

Table 10. S-25B Stages During Storm Event of April 1982

Date	<u>Stages (Ft, MSL)</u>
4/23	4.35
4/24	4.15
4/25	2.15
4/26	1.95
4/27	1.95
4/28	1.55
4/29	0.88
4/30	0.98

GROUNDWATER STAGES

The U. S. Geological Survey has several groundwater monitoring wells around the study area. The closest monitoring well with continuous groundwater data (F-179) is located on S.W. 32nd Avenue and 24th Terrace. This monitoring well is east of the project area. Another groundwater monitoring well with continuous record, G-857, existed at S.W. 70th Avenue and 12th Street until 1969. This is the closest monitoring well to the study area. In order to utilize the data from this station to gain -31insight into the groundwater situation of the project area, a linear correlation model was run between the daily groundwater stages from these two stations. A linear relationship was established between the two stations as follows:

 $G_{-}(857) = .943 + .8816 \times F(179)$

The correlation coefficient between the daily values from the two stations was determined to be .919.

Table 11 presents the actual groundwater stage from Well F-179 and the simulated groundwater stage for Well G-857 for the years 1979, 1980, 1981, and 1982.

Months	<u>1979</u>	<u>1980</u>	<u>1981</u>	
January February March April	2.11 1.78 1.77 1.89	2.20 2.24 2.18 2.79	- 2.02 1.97	
May June July	2.75 2.58 2.28	2.28 2.56 2.37	1.65 2.19	
August September October	2.19 2.78 3.23	2.47 2.67 2.81	3.67	
November December	2.60 2.41	2.78	-	

Table 11. Monthly Groundwater Stages - Well F-179 (Ft.	NGVD)
--	-------

Groundwater Stages During Storm Events - Wells F-179 and G-857 YEAR-1968 Month-June Month-September

<u>Day</u>	<u>F-179</u> <u>Ft (NGVD)</u>	<u>G-857</u> Ft (NGVD)	Day	<u>F-179</u> <u>Ft (NGVD)</u>	<u>G-857</u> Ft(NGVD)
1	-	4.65	24	-	-
2	-	4.55	25	3.07	3.64
3	-	4.25	26	-	-
4	-	7.00	27	-	-
5	4.45	5.56	28	-	-
6	_	5.25	29	-	-
7	_	4.90	30	3.65	4,16
8	_	5.50	<i>4-</i>		
9	_	5.70			

Table 11 (Continued)

10	3.91	6.00
11	-	6.50
12	-	6.05
13	-	6.00
14	-	5.10
15	4.34	4.75
16	-	4.60
17	-	4.20
18	-	4.15
19	3.23	3.79
20	-	-

Groundwater Stages During Storm Events - Wells F-179 and G-857 YEAR-1979

Month-June			Month-	Month-September			
	F- 179	G-857		F-179	G-857		
Day	Ft (NGVD)	Ft (NGVD	Day	Ft (NGVD)	(Ft (NGVD)		
24	1.55	2.30	25	2.84	3.46		
25	3.42	3.95	26	2.99	3.58		
26	3.42	3.95	27	3.12	3.69		
27	3.31	3.86	28	3.26	3.81		
28	3.20	3.76	29	3.41	3.95		
29	3.18	3.74	30	3.67	4.17		

YEAR-1980

			I CAR-1	900		
Month-April			Month-August			
		F-179	G-857		F-179	G-857
	Day	Ft (NGVD)	<u>Ft (NGVD)</u>	Day	Ft (NGVD)	Ft (NGVD)
	5	2.52	3.06	9	2.19	2.87
	6	2.48	3.13	10	2.14	2.82
	7	2.90	3.50	11	2.16	2.85
	8	2.97	3.56	12	2.21	2.89
	9	2.99	3.58	13	2.41	3.07
	10	2.99	3.58	14	2.41	3.07
	11	2.95	3.54	15	2.35	3.01
				16	2.30	2.97
	Month-	July		17	2.28	2.95
	13	2.27	2.94	18	2.30	2.97
	14	2.27	2.94	19	2.54	3.18
	15	2.26	2.93	20	2.54	3.18
	16	2.26	2.93	21	2.83	3.43
	17	2.26	2.93	22	2.84	3.45
	18	2.26	2.93	23	2.81	3.42
	19	2.27	2.94	24	2.77	3.38
	20	2.28	2.95	25	2.72	3.34
	21	2.38	3.04			
	22	2.65	3.28			
	23	2.66	3.29			
	24	2.61	3.24			
	25	2.53	3.17			
Table 11 (Continued)

(000000	iucu)				
		YEAR-1	981		
Month-August					
	F-179	G-857		F-179	G 857
Day	Ft (NGVD)	Ft (NGVD)	Day	Ft (NGVD)	Ft (NGVD)
15	2.36	3.02	3	3.04	3.62
16	2.89	3.49	4	2.99	3.58
17	3.56	4.08	5	2.95	3.54
18	5.18	5.51	6	2.88	3.48
19	4.97	5.32	7	2.86	3.46
20	4.70	5.08	8	2.86	3.46
21	4.50	4.91	9	2.92	3.51
22	4.22	4.66	10	2.93	3.52
			11	2.90	3.50
			12	2.85	3.45
			13	2.81	3.42

Year 1981						
-,	Month-S	eptember				
		<u>F-179</u>	<u>G-857</u>			
	<u>Day</u>	<u>Ft (NGVD)</u>	<u>Ft (NGVD)</u>			
	14	2.77	3.38			
	15	2.90	3.50			
	16	2.90	3.50			
	1/	2.84	3.45			
	18	2.84	3.45			
	19	2.78	3.39			
	20	3.71	4.21			
	21	3./1	4.21			
	22	3.55	4.07			
	23	3.30	4.02			
	24	5.30	5.92			
	25	6.68	6 92			
	20	6 79	6 02			
	28	6 38	6 65			
	20	5 76	6.02			
	30	5 25	5 57			
	50	J.LJ	J + J7			
T-61- 10	<u></u>		Duration Acuit 100	2 Channe Friender Martin	1 F 170 and	
the Simula	Ground	water Stages	During April 198	2 Storm Events - wei	1 F-179, and	
the simula	alea sta	ges for well	6-007			
			F-179	G-857		
		Date	(Feet)	(Feet)		
		4/23/82	2.02	2.72		
		4/24/82	3.95	4.42		
		4/25/82	4.07	4.53		
		4/26/82	4.63	5.02		
		4/27/82	4.65	5.01		
		4/28/82	4.22	4.66		
		4/29/82	4.16	4.60		
		4/30/82	3.94	4.41		

The groundwater stages show that the water level was above the land surface during several past storm events. As there is no monitoring well in the project area, the District has provided the City of West Miami with groundwater measuring equipment which is to be installed in a well located on a school property.

ANALYSIS OF CRITICAL FLOODING EVENTS

Critical flooding events were defined by superimposing the groundwater and canal stages on the minimum ground elevation of the area for given storm events. As this analysis was based on the daily records, groundwater stages greater than those that were plotted may have occurred for a few hours during a particular day. The stages should be exact, however, from one day to the next. Performance analysis was then made for several past hydrologic events to derive conclusions regarding the operation of District control structures. Storm Event of April 1982

The District prepared a preliminary report of the rainstorm of April 23-26, $1982^{(12)}$. As the report is regional in nature, however, it could not be used for this site specific analysis of West Miami. Rainfall distributions from the two stations in the West Miami area are presented in Table 3. Stages from the Coral Gables Canal are presented in Table 8, the upstream stage of S-25B in Table 10, and the actual groundwater stage and the simulated stage in Table 12. The minimum ground elevation of the area, along the western portion, is 5.0 ft. MSL. Figure 6 presents the superimposition of the groundwater and canal stages for this storm event.

The plot depicts that the lowest elevation area of West Miami had standing water for at least two days. The data plotted are end-of-the-day data. Groundwater stages may have been higher during certain hours of the day. Canal levels were significantly lower than groundwater stages. The average canal stage in the Coral Gables Canal was at 3.0 ft MSL; however, S-25B was

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fully open and the upstream stage was below 2.0 ft. MSL. Therefore, there was a significant hydraulic head between the groundwater elevation and the canal stages. This did not help the City of West Miami's flooding problem. In order to reduce the flooding, the city constructed a temporary outfall structure at the Coral Way ditch and pumped water from one of the catch basins to the ditch. Within 48 hours they were able to reduce the groundwater stages by as much as 2.0 feet. This last flooding episode clearly shows that lowering of the canal stages alone does not solve the West Miami flooding problem.

Storm Event of September 1981

Groundwater stages and the canal levels for the rainfall event of September 3-29 are presented in Figure 7. Up to the 23rd of the month, the study area already had received more than 8.37 inches of rainfall. S-25B stages were fluctuating between 2.0 and 2.5 ft. MSL. Groundwater stages were already higher than 3.0 ft. MSL. On the 25th of the month the study area received another 4.36 inches of rainfall. Even though the canal stages were lowered to 2.2 ft. MSL (19th of the month) before the rainfall of the 25th, groundwater stages jumped to almost 7.0 ft. MSL. The low-lying area was under water for more than 10 days. On the 29th of the month, the area was still under water. On that particular day, S-25B stage was at 2.38 ft. MSL. There was a hydraulic head of 2.4 ft. MSL from the groundwater to the canal. In other words, the storm water could not be removed from the basin quickly, and it took more than 10 days for the groundwater stages to recede.

Rainstorm of August 16-21, 1981

During a 5-day period in August (16-21) the study area received anywhere from 8.13 to 12.56 inches of rainfall. Even though the canal stages were lowered, the low-lying area of the City of West Miami was under water for more

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than 4 days. Figure 8 shows that during a 2-day period (20-21 August) S-25B stage dropped by 0.77 ft., whereas the groundwater stage dropped by only 0.42 ft. This was during the period when canal stage was at almost optimal level and then was dropped to 2.0 ft. MSL. This confirms the fact that there is a slight (but ineffective in terms of alleviating flooding in West Miami) drop in the groundwater stage when canal levels are dropped below optimal levels. Rainstorm of April 24-27, 1979 (Figure 9)

During the four day period, the study area received between 12.37 to 16.24 inches of rain (Figure 9). On the 25th of the month, Miami International Airport received 14.85 inches and the Miami Field Station received 11.64 inches. This one day storm event exceeded the return frequency of 1-in-100 years, and occurred during the dry season when the groundwater elevation (at F-179) was lower than the Coral Gables Canal stages. No flooding occurred in the basin from this single, isolated dry month storm event.

Hydrologic Events of June 1 - 19, 1968

In the past, this event received considerable attention. The former Mayor of the City of West Miami (Edmund P. Cooper) wrote a letter to the District charging that the water conservation areas were the major cause of this 1968 flooding event. Additionally, a letter was also sent to the Hon. Dante B. Fascell, Congressman from Miami. The District's field investigation (Figure 10) concluded as follows:

- 1. There was no positive storm drainage to primary canals.
- The seepage drains which had been provided were not adequate to carry off the storm water.

In this current report, the analysis of this particular event has been re-examined. Presented in Figure 10 is the rainfall that fell on the area, as

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well as groundwater stages and Coral Gables Canal stages. Tamiami Canal, near the FEC RR, was fully open.

The total rain that fell in the study area during the 20-day period varied from 15.97 inches at Miami International Airport to 13.57 inches at the Miami Field Station. This rain fell during the period when the basin had already received typical south Florida rain. On the 2nd and 3rd of the month, the study area received another 3.75 inches of rain. On the 3rd of the month, Coral Gables Canal had a stage elevation of 3.42 ft. MSL. The groundwater stage in the basin started to rise from the 3rd of the month. The study area was under water for 14 days. The canal was maintained at the lowest stage (fully open ~ all needles were out), groundwater stages did not drop rapidly, even though there was enough hydraulic head between the groundwater and the canal stage. Due to lack of positive outfall, it took 14 days for the groundwater to recede.

OBSERVATIONS

Analysis of several rainstorm events in the West Miami area reveals that flooding occurs more often from long durations of rainfall. Even though the structures are fully open, it takes many days for the groundwater to reach the canal and recede. As stated earlier, when the headwater elevation rises to 3.0 ft MSL, the gates open automatically at the rate of six inches per hour. In past years, however, on many occasions gates were opened manually before they reached the headwater elevation of 3.0 ft. MSL.

Analysis also shows that lowering of the canal stages will help West Miami to some extent. This is due to two factors: 1) If the canal stages are lowered, than there is more storage in the system, and 2) A higher hydraulic head difference between the groundwater and the canal is created. Lowering of the canal stages alone, however, is not sufficient to alleviate

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West Miami's reoccurring flooding problems as evidenced during the April 1982 event.

Several alternatives (both regional and local in nature) were evaluated to help West Miami solve its flooding problems.

PART 2. SURFACE WATER MANAGEMENT ALTERNATIVES

There are several alternatives (both regional and local in nature) which can be utilized to solve West Miami's flooding problems. They are as follows:

- 1. Placement of secondary control structures upstream of the present structures and lowering the stages downstream to 1.8 ft. MSL.
- 2. Lowering of the stages at the existing structures.
- Removal of sheet pile structures and replacing them with more efficient structures.
- 4. Injection of stormwater into sub-surface reservoirs.
- 5. Inter-connection of the existing catch basins and placement of an outfall structure in the Coral Way ditch (DOT's canal).

Alternatives 1, 2, and 3 are regional in nature. The function of these alternatives is to create additional storage space for runoff generated during storm events. However, analysis of the past storm events indicates that reduction in canal stages alone (Alternative 2) would not significantly reduce the amount or the duration of flooding in West Miami. Therefore, emphasis will now be placed on evaluating the alternative of placing secondary control structures, maintaining higher heads behind these structures, and lowering the stages at the present structures.

Alternatives 4 and 5 are local in nature. These alternatives rely primarily on local solutions to alleviate local flooding problems. Alternative 4 examines the idea that runoff generated in a basin can be injected and stored in the subsurface formation of the basin itself, which is regarded as a vast

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storage reservoir. Alternative 5 is the method of disposing of runoff water from the basin in the safest and guickest possible way.

Alternative 1. Lower Canal Stages/Add New Secondary Structures

Alternative 1 serves the same purpose as Alternative 2 except that it allows for maintaining higher heads above the secondary control structures. Presently, this alternative is preferable to alternative 2, as optimal water levels must be maintained to protect the Metro-Dade Water & Sewer Authority wellfields from saltwater intrusion.

A surface water-groundwater interface model was calibrated to evaluate the effect that placement of secondary control structures would have on the groundwater elevation of the area. Results derived from the model show that due to a lower groundwater elevation in the area (1.8 ft. as compared to 2.8 ft.), less of the area ponds. Additionally, as the canal stage is lowered by 1.0 ft. downstream, the groundwater stage reduces by 0.2 ft. (see Appendix for the computer study).

It can be stated, based on the model results, that Alternative 1 will somewhat lessen the areal extent of flooding and also maintain lower groundwater stages in the area. However, this solution alone is expensive and, by itself, will not be enough to solve the City of West Miami's flooding problems. Additionally, due to high groundwater stages behind the secondary control structures, the area west of West Miami will experience more severe flooding problems than encountered in the past.

Alternative 2. Lower Control Stages

This alternative has been practiced by the District during periods when the area receives high amounts of rainfall. At present, due to the stratigraphic location of the Miami-Dade S&WA wellfields, canal stages and, in turn, groundwater stages, cannot be lowered on a permanent basis especially during the dry months. As with Alternative 1, this alternative by itself will not solve West Miami's flooding problem.

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During the April 1982 storm event, S-25B gates were open full; however, as lowering of the canal stages was not enough, the city had to pump water from one of the catch basins and discharge it to the Coral Way ditch. With this combination, they were able to lower the groundwater stages in 48 hours to a safe stage.

Alternative 3. Replace Existing Structures

It was stated earlier in the text that a sheet pile structure is located on the Coral Gables Canal. During storm events, these sheet piles are difficult to operate. The designed discharge rate of G-97 is only 640 cfs, which is 40% of the standard project flood. Dialogue has already started with the Corps of Engineers (Interagency Meeting of January 27, 1982) to replace this structure with a larger and more efficient automatic structure. The Corps of Engineers stated they will verify project authorization and explore available options. With the new. larger structure in place, the District will be able to discharge more water to the ocean than it presently can. This will enable the groundwater stage to recede faster than it does now. However, as in Alternatives 1 and 2, this enlargement of discharge facility will not solve West Miami'a flooding problem by itself.

<u>Alternative 4.</u> Inject Storm Water Into Subsurface Reservoirs

Storm water can be injected into the underground formation via deep wells. According to Department of Environmental Regulation Chapter 17-28 rules for underground injection control, storm water injection wells are classified as Class V wells. Criteria and standards, as they apply to Class V wells, are presented in the following pages.

This alternative is a viable solution to West Miami's recurring flooding problem. It is, however, in the first place a very costly solution, and secondly, with EPA's designation of the Biscayne aquifer as the sole source, it might be difficult to get an operating permit from the DER.

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CODING: Words underlined are additions; words in struck through type are deletions from existing law.

PART V - CRITERIA AND STANDARDS FOR CLASS V WELLS 1 17-28.51 General 2 (1) Part V sets forth criteria and standards to regulate all 3 injection wells not regulated in Parts I-IV. 4 (a) Generally, wells covered by this Part inject 5 non-hazardous fluids into or above formations that contain 6 underground sources of drinking water. It includes all wells 7 listed in Section 17-28.03(1)(e) but is not limited to those types 8 of injection wells. 9 (b) It also includes wells not covered in Class IV that 10 inject natural and manmade radioactive materials in concentrations 11 in water above natural background, provided these concentrations 12 do not exceed current drinking water standards in Chapter 17-22, 13 F.A.C. 14 (2) Classification of Class V Wells 15 Various types of Class V wells that exist or may exist in 16 Florida are grouped together by expected water quality of the 17 injected fluid, to facilitate determination of permitting, 18 operating, and monitoring requirements for these wells. The 19 groups are: 20 (a) Group 1 - Those wells associated with thermal 21 energy exchange processes, which include air conditioning return 22 flow wells and cooling water return flow wells. Cooling water 23 return flow wells may be part of a closed-loop system, with no 24 hazardous additives, or part of an open-loop system that may use 25 additives.

Group 2 - Class V wells in Group 2 include recharge (b) 27 wells, saltwater intrusion barrier wells, connector wells, and 28 subsidence control wells. 29

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(c) Group 3 - Wells in this group are part of 30 domestic waste treatment systems, and include swimming pool 31 drainage wells. · 1 (d) Group 4 - Group 4 wells are non-hazardous 2 industrial and commercial disposal wells, and include septic 3 system wells, laundry waste, dry wells, sand backfill 4 wells, and nuclear disposal wells injecting only low level 5 radioactive wastes. б (e) Group 5 - Group 5 wells include lake level drainage 7 and stormwater drainage wells. 8 (f) Group 6 - Geothermal wells and 'other' wells are 9 included in this group. 10 (3) The use of any Class V well for injection shall not 11 present a hazard to any existing or future use of an underground 12 source of drinking water. 13 17-28.52 Well Construction Standards for Class V Wells 14 (1) The variety of Class V wells and their uses dictate a 15 variety of construction designs consistent with those uses, and 16 precludes specific construction standards for each type of Class V 17 well outlined in this rule. However, a well must be designed and 18 constructed for its intended use, in accordance with good 19 engineering practices, and the design and construction must be 20 approved by the Department. 21 (2) The Department may apply the design criteria for Class I 22 wells (Part II of this rule) and other factors to the construction 23 of Class V wells. 24 (3) Class V wells shall be constructed so that their 25 intended use does not violate the water quality standards of 26 Chapter 17-3, F.A.C. Migration or mixing of aquifers of 27 substantively different water quality (through the construction or 28 use of a Class V well) shall be prevented by preserving the 29 integrity of confining beds between these aquifers through 30 cementing or some other method acceptable to the Department. 31

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(4) All Class V wells shall be constructed by a licensed
water well contractor.

3 17-28.53 Operating Requirements for Class V Wells

4 (1) All Class V wells shall be operated in such a manner 5 that they do not present a hazard to an underground source of 6 drinking water.

7 (2) Pretreatment may be required for existing wells to
8 insure that the injected fluid does not violate water quality
9 standards.

10 (3) The Department shall impose operating requirements on 11 Group 1 - cooling water return flow wells on an open-loop system, 12 with additives; Group 3, except for swimming pool drainage wells; 13 Group 4; and Group 6.

14 (4) The Department may impose operating requirements on 15 Group 2 and 5.

16 17-28.54 Monitoring Requirements for Class V Wells

(1) The need for monitoring is determined by the type of well, nature of the injected fluid, and water quality of the receiving aquifer. The Department may impose monitoring requirements for Groups 1, 2, 3, 5 and 6.

(2) The nature of the fluid being injected into or above an
underground source of drinking water from Group 4 wells is such
that the Department shall require monitoring for wells in this
group.

(3) The Department shall determine the frequency of
monitoring based on the location of the well, the nature of the
injected fluid and, where applicable, the requirements of Chapters
17-6 and 17-19, F.A.C.
17-28.55 Reporting Requirements for Class V Wells

(1) Reporting requirements are determined by the type of well and nature of injected fluid. When necessary and where

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applicable, reporting shall be in accord with Chapters 17-6 and 17-19, F.A.C.

3 (2) Reporting for Group 1 - cooling water return flow wells 4 on an open-loop system, with additives; Group 3, except for 5 swimming pool drainage wells; reporting for Group 4 and Group 6 6 will be required.

7 (3) The Department may require reporting for Groups 2
8 and 5.

9 17-28.56 Plugging and Abandonment

(1) The Department may order a Class V well plugged and 10 abandoned when it no longer performs its intended purpose, or when 11 it is determined to be a hazard to the ground water resource. 12 (2) Prior to abandoning Class V wells the well shall be 13 plugged with cement in a manner which will not allow movement of 14 fluids between underground sources of drinking water. The 15 proposed plugging method and type of cement shall be approved by 16 the Department. Placement of the cement shall be accomplished by 17 any recognized method which is acceptable to the Department. 18 19

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1 PART VI - CLASS V WELL PERMITTING

2 17-28.61 General

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(1) Underground injection through a Class V well which began 3 operation after the effective date of this rule is prohibited 4 except as authorized by permit issued under this Part. The 5 construction or modification of any well required to have a permit 6 under this Part is prohibited until the permit has been issued. 7 In addition to the specific provisions of this Part, the general 8 permitting provisions of Chapter 17-4, Part I, F.A.C., shall 9 apply. 10

(2) No UIC authorization by permit or rule shall be allowed where a Class V well causes or allows movement of fluid containing any contaminant into underground sources of drinking water, and the presence of that contaminant may cause a violation of any primary drinking water regulation under Chapter 403, F.S. and Chapter 17-22, F.A.C. or which may adversely affect the health of persons.

(3) If at any time the Department learns that an existing
Class V well may cause a violation of primary drinking water
regulations under Chapter 403, F.S. or Chapter 17-22, F.A.C., the
Department sHall:

(a) Require a permit for such Class V well;

(b) Order the injector to take such actions including where required, closure of the injection well as may be necessary to prevent the violation; or

(c) Take enforcement action.

(4) Whenever the Department learns that a Class V well may be otherwise adversely affecting the health of persons, the Department may prescribe such actions as may be necessary to prevent the adverse affect, including any action authorized under paragraph (2) of this Section.

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Notwithstanding any other provision of this Section, the (5) 1 Department may take emergency action upon receipt of information 2 that a contaminant which is present or is likely to enter a public 3 water system may present an imminent and substantial endangerment 4 to the health of persons. 5 The owner or operator of any new or existing Class V (6) 6 well shall, within one year of the effective date of an 7 underground injection control program, notify the Department of 8 the existence of any well meeting the definitions of Class V under 9 his control, and submit the inventory information required in 10 paragraph (7) below. 11 (7) As part of the inventory, the Department shall require 12 at least the following information: 13 (a) Facility name and location, including a plot plan 14 showing location of well(s); 15 (b) Name and address of legal contact; 16 (c) Ownership of facility; 17 (d) Nature and type of injection wells, including 18 installed dimensions of wells and construction materials; 19 Operating status of injection wells, including (e) 20 history of injection; 21 (f) Volume of injected fluid; 22 (g) Nature of injected fluid; 23 Description of injection system, including (h) 24 monitoring well(s), if any. 25 (8) A group of similarly designed injection wells owned and 26 operated by the same applicant serving the same purpose may be 27 permitted as a system rather than as individual wells. 28 (9) The owner of a Class V well shall be responsible for 29 notifying the Department of a change in ownership. Until such 30 time as notice of change in ownership is submitted, the owner 31

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reflected on the permit/clearance shall be responsible for the 1 operation of the well and ior damages resulting from improper 2 operation of the wells. 3 17-28.62 Construction/Clearance Permit 4 (1) All Class V wells must obtain a two-part Construction/ 5 Clearance Permit. The applicant must submit to the Department at б least the following information before receiving permission 7 to construct: R (a) Facility name and location; 9 (b) Name and address of legal contract; 10 (c) Ownership of facility; 11 (d) Name and address of driller; 12 (e) Description and use of proposed injection system, 13 including type and construction of injection wells, nature and 14 volume of injected fluid, and any proposed pretreatment. 15 (2) Upon completion of the well construction, the driller 16 shall certify with the Department that the well has been completed 17 in accordance with the approved construction plan, and submit any 18 other additional information required by the construction permit 19 before the well can be put into service. 20 (3) The Department may issue a clearance letter or 21 authorization to use, which is non-renewable and non-expiring. 22 The clearance letter may contain operating and reporting 23 requirements. 24 (4) Initial and/or periodic testing of the well may be 25 required for all Class V wells. 26 27 **µ7-28.63** Operating Permit (1) In addition to a Construction/Clearance Permit, 28 permittees of these wells shall obtain an operating permit for: 29 (a) Cooling water return flow wells on an open-looped 30 31 System, with additives; Group 3 wells except for swimming pool

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drainage wells; and Group 4 and 6 wells. 1 (b) Class V wells in Groups 2 and 5 do not require an 2 operating permit. 3 (2) Operating permits shall be issued for a period not to 4 exceed five years. S (3) At least 60 days prior to expiration of an operating 6 permit, the permittee shall apply for renewal of his permit. 7 17-28.64 Plugging and Abandonment Permit 8 (1) The permittee of any Class V well shall apply for a 9 Plugging and Abandonment Permit when the well is no longer used or 10 usable for its intended purpose or other purpose as approved by 11 the Department. The application shall include the proposed 12 plugging plan and justification for abandonment. 13 (2) Upon completion of plugging and abandonment procedures, 14 the engineer of record shall provide certification of completion 15 in accordance with the plans and specifications. 16 The permittee of any Class V well may be required to (3) 17 provide evidence, such as a sealed copy of certification from the 18 county clerk, that a surveyor's plot of the location of the 19 abandoned well has been recorded in the county courthouse property 20 records. 21 22 23 24

> CODING: Words <u>underlined</u> are additions; words in struck through type are deletions from existing law.

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<u>Alternative 5.</u> Inter-connection of the Existing Catch Basins and Placement of an Outfall Structure in the Coral Way Ditch (DOT Canal)

This alternative examines the effect of modifying direct surface discharge in order to alleviate the flooding problem of the City of West Miami. At present, the City of West Miami has no direct outfall facility. Runoff water generated from storm events enters the french drain system, reaches the groundwater table, and starts moving slowly toward the point of discharge (primary canals).

Discharge of groundwater to the primary canals is dependent on the hydraulic properties of the water table aquifer. These properties include the transmissivity, the hydraulic gradient (difference in canal and the groundwater table stages) and the width through which the groundwater flow leaves the basin. Examination and analysis of several past storm events reveals that even though the District structures were open, and sufficient hydraulic head existed between the groundwater and the canal stages, it generally took many days for the groundwater stage to recede. However, during the storm event of April 1982, groundwater stages were lowered by more than 2 feet within 48 hours by a combination of groundwater flow and direct discharge from the basin.

The City of West Miami constructed a temporary outfall facility and discharged water from one of the catch basins to the Coral Way Ditch at a rate of 600 gpm (1.33 cfs). It should be stated that District Structure 25B was open during this event also. This combination of direct discharge and the groundwater discharge solved West Miami's flooding problem within 48 hours. This clearly indicates that some positive outfall capability must be provided by the City of West Miami for future

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flood problems.

Preliminary economic calculations for this alternative and comparison with the cost of other alternatives indicates this to be the most cost effective approach.

CONCLUSIONS

This study clearly demonstrates the need of a positive outfall structure to alleviate flooding conditions in the City of West Miami. Based on the analysis of several water management alternatiaves, the most economical solution for West Miami is the interconnection of all the catch basins and extension of an outfall (pipe) structure at Coral Way ditch. This recommendation, for construction of an outfall structure, is not new. As far back as 1968, after the June storm, the District informed West Miami city officials that the seepage drains were not adequate to carry off storm water. The Comprehensive Land Use Plan for the area, as prepared by the city planners, also pointed out that under the heading of "drainage element" the present system of storm water removal (through the seepage trench) could not adequately handle the large amounts of rainfall which the area receives. The Comprehensive Land Use Plan also recommended that additions to the system (including structures) must accompany or take precedence over the infiltration technique for effective drainage.

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- 8. South Florida Water Management District, 1979. Preliminary Report on the Severe Storm of April 24-25, 1979.
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APPENDIX

PURPOSE

Two spring storm events, April 24-25, 1979, and April 23-26, 1982, as well as a summer event, the August 16-20, 1981 storm, were benchmarks used to investigate alternatives to minimize flooding in the West Miami area. The canal system for the study area is shown in Figure 1. The stages maintained at the canals during the simulation of the storm events are also indicated in Figure 1. This system was the basis for which the following alternatives were compared and evaluated:

<u>Alternative 1</u>: A secondary structure is imposed at the intersection of C-4 and the Coral Gables Canal. C-4 upstream has a minimum stage of 4.0 ft. m.s.l. (see Figure 2). The minimum stage at S-25B is lowered from 2.2 ft. m.s.l. to 1.8 ft. m.s.l. The coastal structure at the Coral Gables Canal is moved farther downstream (south of Red Road, see Figure 2), and the minimum stage modified from 2.2 ft. m.s.l. to 1.8 ft. m.s.l.

<u>Alternative 2</u>: The same as Alternative 1, except that the secondary structure is moved upstream to the intersection of Snapper Creek and C-4 Canals, near the West Dade Expressway (see Figure 3).

I. Surface Modeling

A. Surface Ponding

At the beginning of each day, rainfall is read into the model. The rainfall is divided uniformly over hourly time steps and added to the surface ponding value corresponding to the previous time step. This process is repeated every time step. The surface ponding is initialized as 0.0 for every node point.

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B. Overland Flow

Manning's equation is used to compute overland flow in the model. The roughness coefficient used in the model is considered a function of land use type. The flow is treated as flow through a wide open channel; thus, the hydraulic radius is approximately by the water depth. The hydraulic gradient is estimated using the following relationship:

 $HG = \frac{HU-HD}{DX} \text{ or } HG = \frac{HU-HD}{DY}$ where HU = ELLS(X,Y) + POND(X,Y)and HD = ELLS(LX,LY) + POND(LX,LY) HG is the hydraulic gradient HU = Upstream stage HD = Downstream stage DX = Distance in the east-west direction DY = Distance in the north-south direction ELLS(X,Y) = elevation of land surface, in feet m.s.l. at upstream node point POND(X,Y) is the ponding depth, in feet above land surface at upstream

node point. LX,LY are X and Y coordinates at downstream node point. Since Manning's equation is one-dimensional, and used with a twodimensional groundwater equation, overland flow is computed twice in each time step, once in the north-south direction, and once in the east-west direction.

C. Channel Flow

The channel flow routine is a mass balance procedure that sums the inflows and outflows of a canal during one time step to determine the position of the water surface at the end of the time step.

The flow processes included are:

- 1. Structure discharge (COUT)
- 2. Groundwater movement into or out of canal (CGINF)
- 3. Overland flow in or out of canal (VOLOV)

A canal is a continuous channel reach, bounded by upstream and downstream structures. The following assumptions were incorporated:

- 1. The width of a canal is constant.
- A simple weir approximation of outflow is used based on the canal stage and the assumed width of the hypothetical weir.
- 3. If the canal stage is equal to the minimum stage at the structure, the outflow is zero. In this study the canals are not allowed to fall below the minimum stage, but are allowed to fluctuate above the minimum level.

D. Evapotranspiration

The ET losses are based on potential ET (PET) and a linear reduction equation to calculate actual ET based on the depth to the water table. PET varies with land use and time of year. The model uses 12 monthly PET values for each of the four land use types: 1-urban, 2-agricultural, 3-swamp, and 4-vacant. Each land use has a shallow root zone (SRZ), and a deep root zone (DRZ) that are used to determine the actual amount of ET in the following way:

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- ET = PET when the water table is at or above the shallow root zone.
- ET = zero when the water table is below the deep root zone.
- $ET \approx PET * (DRZ-DPH)/(DRZ-SRZ)$ when the water table is between the shallow and the deep root zones where DPH is the distance from the land surface to the water table (ELLS(X,Y)-H(X,Y)).

The PET and the shallow and deep root zone values for each land use are shown in Table 1.

II. Groundwater

Groundwater was based on the finite difference approximation of two dimensional transient equation for unconfined aquifers:

 $Tx \frac{\partial^2 h}{\partial x^2} + Ty \frac{\partial^2 h}{\partial y^2} = S \frac{\partial h}{\partial t} + RCHG$

Where Tx and Ty are transmissivity values in the x and y direction, respectively.

S is the storage coefficient assumed to be 0.2.

h is the hydraulic head.

RCHG is the recharge which includes wellfield pumpage, groundwater seepage to or from canals, surface ponding, and ET.

III. Description of Model Runs

Model Area

The model area is about 150 square miles bounded north by C-7, west by Snapper Creek Canal, and extension of C-2, south by C-2 and east by the coastline. The grid resolution is one-third mile in the north-south and east-west direction. The area includes C-6, C-7, Tamiami east, Coral Gables Canal, and C-2 basins.

Model Runs

Three runs, one for each alternative and one for the present system were done for the three storm events mentioned earlier. The time step was one hour.

- 1. For the April 1979 storm, the average yearly lowest groundwater table for the period 1960-1975, published by USGS, is input.
- For the April 1982 storm, the groundwater table at the end of March 1982 is used.
- 3. For the August 1981 storm, the average groundwater table for the period 1960-1975 is input.

An additional run using daily rainfall from April 23-30, 1982, with the average highest groundwater table as the initial condition was done to evaluate the alternatives in an event with little initial groundwater storage. Daily rainfall for several stations, such as Miami International Airport and the Miami Field Station, were used. Rainfall for each node point is estimated by linear interpolation between station values. The calculated values are divided uniformly over the 24 hourly time steps. Thus, the rainfall distribution is much smoother, but less than the maximum hourly rainfall. In addition, the spatial distribution of rainfall is smoother than the actual variation due to the linear interpolation. The initial stages, if available either from the daily water readings or from the reports of the storm events published by the S.F.W.M.D., were input. For canals with more than one downstream structure, the average stage of the downstream structures was input. If the stage was not available, the initial stage was assumed to be the minimum stage.

Results of the Model Run

 Tables 2-5 give the simulated groundwater table, ponding depth, and head (groundwater level + ponding depth) at specified dates for various locations in the study area. The results for the present system, and the two alternatives are presented. The groundwater

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table is given in ft. m.s.l., the ponding depth in feet, and the head in ft. m.s.l.

2. <u>Contour Plots of Simulated Storms</u>

a.	<u>April 24-25, 1979 Storm</u>	
	Figures 1A-1 thru 1A-3	Groundwater table under the present system
	Figures 1B-1 thru 1B-3	Groundwater table for Alternative 1
	Figures 1C-1 thru 1C-3	Groundwater table for Alternative 2
b.	April 23-25, 1982 Storm	
	Figures 2A-1 thru 2A-3	Groundwater table under the present system
	Figures 2B-1 thru 2B-3	Groundwater table for Alternative 1
	Figures 2C-1 thru 2C-3	Groundwater table for Alternative 2
c.	August 16-20, 1981 Storm	1
	Figures 3A-1 thru 3A-3	Groundwater table under the present system
	Figures 3B-1 thru 3B-3	Groundwater table for Alternative 1
	Figures 3C-1 thru 3C-3	Groundwater table for Alternative 2
d.	April 23-30 rainfall wit	h high initial groundwater table
	Figures 4A-1 thru 4A-3	Groundwater table under the present system
	Figures 4A-4 thru 4A-8	Ponding depth Alternative under the
	Figures 4B-1 thru 4B-3	Groundwater table for Alternative 1
	Figures 4B-4 thru 4B-8	Ponding depth for Alternative 1
	Figures 4C-1 thru 4C-3	Groundwater table for Alternative 2
	Figures 4C-4 thru 4C-8	Ponding depth for Alternative 2

IV. Summary and Conclusions

The response of the groundwater table, and the ponding depth to changes in the operation and modifications to the system, takes place at nodes at or near the canals involved. The greater the distance from the canals, the lesser the response of groundwater stage and/or ponding depth to the change. Thus, the rate of surface flow and/or groundwater seepage into the canals determines the relative efficiency of each alternative to minimize flooding.

The findings from Alternative 1 are:

- A. <u>West Miami</u> Area
 - The groundwater level is 0.1 ft. lower than under the present system. This is evident under the storm events analyzed.
 - The average ponding depth is 0.01 ft. lower than under the present system. This can be seen in Table 5, and by comparing Figure 4B-5 with 4A-4 and Figure 4B-6 with 4A-6.

B. Along C-4 West of Coral Gables Canal

- The ponding depth is 0.01 to 0.1 ft. greater during periods of heavy rainfall (April 23-26, 1982 and April 25-26, 1979). This can be seen in Tables 1 and 5 and by comparing Figure 4B-5 with 4A-5.
- The groundwater table was 0.2-0.3 ft. higher the day before the heaviest rainfall as shown in the analyses of the April 1982 and August 1981 events.
- 3. The groundwater level after the storm event was 0.5-0.8 ft. higher than under the present system. This is the case for all storm events analyzed.

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C. Groundwater Levels

The groundwater level along C-4 and the Coral Gables Canal, east of the structure is 0.1-0.2 ft. lower than under the present system.

The findings from Alternative 2 are:

- A. The ponding depth in the West Miami area was reduced about 0.01 ft. as shown in Table 5. After the storm event, groundwater levels were 0.1-0.2 ft. lower than under the present system. (This was the case for all storm events analyzed.)
- B. Along C-4 and the Coral Gables Canal, groundwater levels were
 0.1-0.2 ft. lower

The conclusions drawn from the above shows that Alternative 2 would be the more efficient method. Any flood relief provided to the City of West Miami by Alternative 1 could prove to be at the expense of increased flooding in the areas adjacent to C-4 west of the secondary structure.

V. Limitations of Model Results

Information concerning each node of the model output is simply the <u>average</u> value for the particular 1/3 mi. x 1/3 mi. node area. Thus, the model does not include any sub-grid scale variations. For example, suppose the head (groundwater level + ponding depth) for a particular node is 6.2 ft. above m.s.l., and the land elevation input is 6.1 ft. m.s.l., the model shows the ponding depth to be 0.1 ft. for the entire node area. There may be smaller scale variations in land elevation, that is, part of the area may be 6.5 ft. above m.s.l. and part 5.7 ft. m.s.l. Thus, if the model says the head is 6.1 ft., then some of the area is dry, while the part at 5.7 ft. is pounded 0.4 ft. Moveover, there may be flooding in an area where the model says it is dry because in reality part of the land within the node area may be below the topographic values used in the node.

A more detailed analysis of the location and depth of the flooding will require additional data not presently available. It will also require a survey of management practices imposed on local drainage canals by the local water companies.






POTENTIAL EVAPOTRANSPIRATION DATA (SRZ = shallow root zone, DRZ = deep root zone)

Land Use	<u>SRZ</u>	DRZ	PET (Annual)
1) Urban	2.01	10.0'	20.5"
2) Agricultural	2.0'	5.0'	41.6"
3) Swamp	-0.5'	6.0'	54.3"
4) Vacant Land	3.0'	10.0'	38.4"

PET (Avg. In/Day) for Each Land Use

<u>Month</u>	1	2	3	4
January	.036	.072	.093	.066
February	.046	.090	.120	.085
March	.058	.118	.153	.108
April	.067	.114	.184	.130
May	.073	.149	.195	.137
June	.068	.138	.175	.124
July	.067	.139	.180	.128
August	.067	.136	.177	.127
September	.059	.120	.157	.112
October	.054	.108	.144	.100
November	.042	.085	.111	.079
December	.036	.071	.093	.066

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APRIL 24-25, 1979 STORM EVENT

		Present System		11A	Alternative 1			Alternative 2		
Location	Date	G.W.	Pond	Head	G.W.	Pond	Head	G.W.	Pond	Head
Cit <mark>y of We</mark> st Miami	April 25 April 26 April 30	6.5 6.0 4.4	0.0 0.0 0.0	6.5 6.0 4.4	6.4 5.9 4.3	0.0 0.0 0.0	6.4 5.9 4.3	6.4 5.8 4.2	0.0 0.0 0.0	6.4 5.8 4.2
Sweetwater	April 25 April 26 April 30	6.3 6.3 4.3	0.3 0.2 0.0	6.6 6.5 4.3	6.3 6.3 4.7	0.4 0.3 0.0	6.7 6.6 4.7	6.3 6.3 4.2	0.3 0.2 0.0	6.6 6.5 4.2
Along C-4 nr. Coral Gables Canal	April 25 April 26 April 30	6.3 5.3 4.0	0.0 0.0 0.0	6.3 5.3 4.0	6.7 5.6 4.5	0.0 0.0 0.0	6.7 5.6 4.5	6.2 5.2 3.9	$0.0 \\ 0.0 \\ 0.0$	6.2 6.2 3.9
Along C-4 east of Coral Gables Canal	April 25 April 26 April 30	6.4 5.4 3.8	0.0 0.0 0.0	6.4 5.4 3.8	6.3 5.2 3.8	0.0 0.0 0.0	6.3 5.2 3.8	6.3 5.2 3.7	0.0 0.0 0.0	6.3 5.2 3.7
Along C-4 south of Miami Airport	April 25 April 26 April 30	5.3 5.0 4.2	0.0 0.0 0.0	5.3 5.0 4.2	5.3 4.9 3.9	0.0 0.0 0.0	5.3 4.9 3.9	5.3 4.8 3.9	0.0 0.0 0.0	5.3 4.8 3.9
Along Coral Gables Canal	April 25 April 26 April 30	5.5 5.2 4.1	0.0 0.0 0.0	5.5 5.2 4.1	5.5 5.2 4.0	0.0 0.0 0.0	5.5 5.2 4.0	5.5 5.0 3.9	0.0 0.0 0.0	5.5 5.0 3.9

APRIL 23-26, 1982 S

		Present System					
Location	Date	G.W.	Pond	Head			
City of West Miami	April 23 April 24 April 26 April 30	2.4 4.8 5.1 4.4	0.0 0.0 0.0 0.0	2.4 4.8 5.1 4.0			
Sweetwater	April 23 April 24 April 26 April 30	2.8 5.4 5.2 4.1	0.0 0.0 0.0 0.0	2.8 5.4 5.2 4.1			
Along C-4 nr. Coral Gables Canal	April 23 April 24 April 26 April 30	2.5 4.7 4.6 3.9	0.0 0.0 0.0 0.0	2.5 4.7 4.6 3.9			
Along C-4 east of Coral Gables Canal	April 23 April 24 April 26 April 30	2.1 4.4 4.3 3.7	0.0 0.0 0.0 0.0	2.1 4.4 4.3 3.7			
Along C-4 south of Miami Airport	April 2 3 April 24 April 26 April 30	1.5 3.8 3.9 3.5	0.0 0.0 0.0 0.0	1.5 3.8 3.9 3.5			
Along Coral Gables Canal	April 23 April 24 April 26 April 30	2.5 4.6 4.6 4.1	0.0 0.0 0.0 0.0	2.5 4.6 4.6 4.1			

STORM EVENT

Alto	ernative	1	<u>Alte</u>	rnativ	e 2	
G.W.	<u>Pond</u>	Head	<u>G.W.</u>	Pond	Head	
2.3	0.0	2.3	2.2	0.0	2.2	
4.7	0.0	4.7	4.7	0.0	4.7	
5.0	0.0	5.0	5.0	0.0	5.0	
4.3	0.0	4.3	4.3	0.0	4.3	
3.0	0.0	3.0	2.8	0.0	2.8	
5.7	0.0	5.7	5.3	0.0	5.3	
5.6	0.0	5.6	5.1	0.0	5.1	
4.6	0.0	4.6	4.0	0.0	4.0	
2.7	0.0	2.7	2.4	0.0	2.4	
5.2	0.0	5.2	4.5	0.0	4.5	
5.2	0.0	5.2	4.4	0.0	4.4	
4.7	0.0	4.7	3.7	0.0	3.7	
2.0	0.0	2.0	2.0	0.0	2.0	
4.2	0.0	4.2	4.2	0.0	4.2	
4.2	0.0	4.2	4.1	0.0	4.1	
3.5	0.0	3.5	3.4	0.0	3.4	
1.4 3.7 3.6 3.2	$0.0 \\ 0.0 \\ 0.0 \\ 0.0 \\ 0.0$	1.4 3.7 3.6 3.2	1.4 3.7 3.7 3.3	0.0 0.0 0.0 0.0	1.4 3.7 3.7 3.3	
2.4	0.0	2.4	2.4	0.0	2.4	
4.5	0.0	4.5	4.5	0.0	4.5	
4.5	0.0	4.5	4.4	0.0	4.4	
4.0	0.0	4.0	3.8	0.0	3.8	

AUGUST 16-20, 1981 STORM

			Pr	Present System				
<u>Locat</u>	ion	Date	G.W.	Pond	Head			
City	of West Miami	August 1 August 18 August 23	7 4.3 8 6.0 2 5.4	$0.0 \\ 0.0 \\ 0.0$	4.3 6.0 5.4			
Sweet	water	August 12 August 18 August 22	7 4.5 8 6.3 2 5.0	0.0 0.4 0.0	4.5 6.7 5.0			
Along Coral	C-4 nr. Gables Canal	August 17 August 18 August 22	7 4.0 3 5.7 2 4.7	0.0 0.0 0.0	4.0 5.7 4.7			
Along Coral	C-4 east of Gables Canal	August 17 August 18 August 22	3.8 3 5.5 2 4.5	0.0 0.0 0.0	3.8 5.5 4.5			
Along Miami	C-4 south of Airport	August 17 August 18 August 22	7 3.9 3 5.3 2 4.7	0.0 0.0 0.0	3.9 5.3 4.7			
Along Canal	the Corgal Gales	August 17 August 18 August 22	7 4.1 3 5.7 2 5.0	0.0 0.0 0.0	4.1 5.7 5.0			

EVENT

Alte	ernative	21	Alte	ernativ	е 2
<u>G.W.</u>	Pond	Head	G.W.	Pond	Head
4.2	0.0	4.2	4.2	0.0	4.2
5.9	0.0	5.9	5.9	0.0	5.9
5.3	0.0	5.3	5.3	0.0	5.3
4.8	0.0	4.8	4.5	0.0	4.5
6.3	0.5	6.8	6.3	0.4	6.7
5.6	0.0	5.6	5.0	0.0	5.0
4.5	0.0	4.5	3.8	0.0	3.8
6.2	0.0	6.2	5.3	0.0	5.3
4.5	0.0	4.5	4.4	0.0	4.4
3.8	0.0	3.8	3.8	0.0	3.8
5.5	0.0	5.5	5.3	0.0	5.3
4.4	0.0	4.4	4.4	0.0	4.4
3.8	0.0	3.8	3.8	0.0	3.8
5.0	0.0	5.0	4.9	0.0	4.9
4.4	0.0	4.4	4.4	0.0	4.4
3.9	0.0	3.9	3.9	0.0	3 .9
5.7	0.0	5.7	5.6	0.0	5.6
4.9	0.0	4.9	4.8	0.0	4.8

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		Pro	<u>esent S</u>	<u>ystem</u>	Alte	ernate	1	Alt	<u>ernate</u>	2
Location	Date	<u>G.W.</u>	Pond	Head	<u>G.W.</u>	Pond	Head	<u>G.W.</u>	<u>Pond</u>	Head
City of West Miami	Day 2 (April 24 rainfall)	7.5	0.07	7.57	7.6	0.06	7.56	7.5	0.06	7.56
	Day 3 (April 25 rainfall)	7.5	0.01	7.51	7.5	0.01	7.51	7.5	0.01	7.51
	Day 8 (April 30 rainfall	5.5	0.0	5.5	5.3	0.0	5.3	5.3	0.0	5.3
Sweetwater	Day 2	6.3	0.5	6.8	6.3	0.6	6.9	6.3	0.5	6.8
	Day 3	6.3	0.4	6.7	6.3	0.5	6.7	6.3	0.4	6.7
	Day 8	4.6	0.0	4.6	5.1	0.0	5.1	4.5	0.0	4.5
Along C-4 nr.	Day 2	6.2	0.0	6.2	6.7	0.01	6.71	6.1	0.0	6.1
Coral Gables Canal	Day 3	5.5	0.0	5.5	6.0	0.0	6.0	5.4	0.0	5.4
	Day 8	4.3	0.0	4.3	5.0	0.0	5.0	4.2	0.0	4.2
Along C-4 east of	Day 2	6.5	0.0	6.5	6.5	0.0	6.5	6.3	0.0	6.3
Coral Gables Canal	Day 3	5.5	0.0	5.5	5.6	0.0	5.6	5.4	0.0	5.4
	Day 8	4.3	0.0	4.3	4.2	0.0	4.2	4.1	0.0	4.1
Along C-4 south of	Day 2	5.3	0.05	5.35	5.3	0.05	5.35	5.3	0.05	5.35
Miami Airport	Day 3	5.3	0.04	5.34	5.3	0.02	5.32	5.3	0.03	5.33
	Day 8	4.7	0.0	4.7	4.4	0.0	4.4	4.6	0.0	4.6
Along the Coral Gables	Day 2	6.8	0.0	6.8	6.7	0.0	6.7	6.6	0.0	6.6
Canal	Day 3	6.5	0.0	6.5	6.4	0.0	6.4	6.3	0.0	6.3
	Day 8	5.4	0.0	5.4	5.3	0.0	5.3	5.2	0.0	5.2

RUN USING APRIL 23-30, 1982 RAINFALL WITH AVERAGE YEARLY HIGHEST INITIAL GROUNDWATER CONDITION



GROUNDWATER TABLE FOR END OF APRIL 25 1979 - existing structures (present system)

Figure 1A-1

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GROUNDWATER TABLE FOR END OF APRIL 26 1979 - existing structures (present system)

Figure 1A-2



GROUNDWATER TABLE FOR END OF APRIL 30 1979 - existing structures (present system)

.

Figure 1A-3



GROUNDWATER TABLE FOR END OF APRIL 25 1979 - secondary structure at C-4 & C-Coral Gables (Alternative 1)

Figure 1B-1



GROUNDWATER TABLE FOR END OF APRIL 26 1979 - secondary structure at C-4 & C-Coral Gables (Alternative 1)

Figure 1B-2



GROUNDWATER TABLE FOR END OF APRIL 30 1979 - secondary structure at C-4 & C-Coral Gables (Alternative 1)

Figure 1B-3



CROUNDWATER TABLE FOR END OF APRIL 25 1979 - secondary structure at C-4 & C-Snapper Creek (alternative 2)

Figure 1C-1

F,



GROUNDWATER TABLE FOR END OF APRIL 26 1979 - secondary structure at C-4 & C-Snapper Creek (Alternative 2)

Figure 1C-2



GROUNDWATER TABLE FOR END OF APRIL 30 1979 - secondary structure at C-4 & C-Snapper Creek (alternative 2)

Figure IC - 3



GROUNDWATER TABLE FOR END OF APRIL 23 1982

Figure 2A-1



GROUNDWATER TABLE FOR END OF APRIL 24 1982

Figure 2A-2



GROUNDWATER TABLE FOR END OF APRIL 26 1982



GROUNDWATER TABLE FOR END OF APRIL 30 1982

Figure 2A-4





Figure 2B-2

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GROUNDWATER TABLE FOR END OF APRIL 26 1982

Figure 2B-3



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GROUNDWATER TABLE FOR END OF APRIL 24 1982

Figure 2C-2



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CROUNDWATER TABLE FOR END OF APRIL 26 1982



GROUNDWATER TABLE FOR END OF APRIL 30 1982



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CROUNDWATER TABLE FOR END OF AUGUST 17 1981 - existing structures

Figure 3A-1



CROUNDWATER TABLE FOR END OF AUGUST 18 1981 - existing structures

Figure 3A-2



GROUNDWATER TABLE FOR END OF AUGUST 22 1981 - existing structures

Figure 3A-3



GROUNDWATER TABLE FOR END OF AUGUST 17 1981 - secondary structure at C-4 and C-Coral Gables (Alternative 1)





CROUNDWATER TABLE FOR END OF AUGUST 18 1981- secondary structure at C-4 and C-Coral Gables (Alternative 1)





GROUNDWATER TABLE FOR END OF AUGUST 22 1981 - secondary structure at C-4 and C-Coral Gables (Alternative 1)

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Figure 3B-3


GROUNDWATER TABLE FOR END OF AUGUST 17 1981 - secondary structure at C-4 and C-Snapper Creek (Alternative 2)

Figure 3C-1

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GROUNDWATER TABLE FOR END OF AUGUST 18 1981 - secondary structure at C-4 and C-Snapper ; Creek (Alternative 2)

Figure 3C-2

7.



CROUNDWATER TABLE FOR END OF AUGUST 22 1981 - secondary structure at C-4 and C-Snapper Creek (Alternative 2)

Figure 3C-3



GROUNDWATER TABLE FOR END OF APRIL 24 1982 - existing structures (present system)



GROUNDWATER TABLE FOR END OF APRIL 25 1982 - existing structures (present system)



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GROUNDWATER TABLE FOR END OF APRIL 30 1982 - existing structures (present system)



PONDING DEPTH.IN FEET*10 FOR END OF APRIL 24 1982 - existing structures (present system)



PONDING DEPTH.IN FEET*10 FOR END OF APRIL 25 1982 - existing structures (present system)



PONDING DEPTH.IN FEET*10 FOR END OF APRIL 26 1982 - existing structures (present system)

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PONDING DEPTH.IN FEET #10 FOR END OF APRIL 27 1982 - existing structures (present system)

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GROUNDWATER TABLE FOR END OF APRIL 24 1982 - secondary structure at C-4 & C-Coral Gables (Alternative 1)



GROUNDWATER TABLE FOR END OF APRIL 25 1982 - secondary structure at C-4 & C-Coral Gables (Alternative 1)



GROUNDWATER TABLE FOR END OF APRIL 30 1982 - secondary structure at C-4 & C-Coral Gables (Alternative 1)

Figure 48-3



PONDING DEPTH, IN FEET*10 FOR END OF APRIL 24 1982 - secondary structure at C-4 & C-Coral Gables (Alternative 1)



PONDING DEPTH IN FEET*10 FOR END OF APRIL 25 1982 - secondary structure at C-4 & C-Coral Gables (Alternative 1)



PONDING DEPTH.IN FEET*10 FOR END OF APRIL 26 1982 - secondary structure at C-4 & C-Coral Gables (Alternative 1)



PONDING DEPTH.IN FEET*10 FOR END OF APRIL 27 1982 - secondary structure at C-4 & C-Coral Gables (Alternative 1)



ONDING DEPTHAIN FEET*10 FOR END OF APRIL 28 1982 - secondary structure at C-4 & C-Coral Gables (Alternative 1)

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Figure 48-8

G.C C.C C.S

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-c.cc.c.c.c.s.c.c.

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Figure 4C-1

GRAPHIC RESOURCES CORPORATION, NUMITAGICN BEACH, CALIFORNIA, (74) 898-3

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CROUNDWATER TABLE FOR END OF APRIL 25 1982 - secondary structure at C-4 & C-Snapper Creek (Alternative 2)



GROUNDWRTER TABLE FOR END OF APRIL 30 1982 - secondary structure at C-4 & C-Snapper Creek (Alternative 2)



PONDING DEPTH.IN FEET*10 FOR END OF APRIL 24 1982 - secondary structure at C-4 & C-Snapper Cree (Alternative 2)



PONDING DEPTH.IN FEET*10 FOR END OF APRIL 25 1982 - secondary structure at C-4 & C-Snapper Creek (Alternative 2)



PONDING DEPIH, IN FEET*10 FOR END OF APRIL 26 1982 - secondary structure at C-4 & C-Snapper Creek (Alternative 2)



FONDING DEPTH.IN FEET*10 FOR END OF APRIL 27 1982 - secondary structure at C-4 & C-Snapper Creek (Alternative 2)



PONDING DEPTH.IN FEET*10 FOR END OF APRIL 28 1982 - secondary structure at C-4 & C-Snapper Creek (Alternative 2)