TECHNICAL MEMORANDUM

AN ATLAS OF EASTERN PALM BEACH COUNTY SURFACE WATER MANAGEMENT BASINS

By

Richard M. Cooper
Jim Lane

#244

June 1988

Water Resources Division
Resource Planning Department
South Florida Water Management District

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This public document was promulgated at an annual cost of $247.50 or $.50 per copy to inform the public regarding Peak Runoff Estimation from Undeveloped Lands RP 190 500

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EXECUTIVE SUMMARY

This atlas contains information about the surface water management basins in Palm Beach County, Florida. The South Florida Water Management District (District) and the U.S. Army Corps of Engineers (COE) have primary authority over water management in these basins. The District has sponsored publication of this atlas so that up-to-date non-technical descriptions of the surface water management basins in Palm Beach County are available to District personnel, to local governments in Palm Beach County, and to other interested persons. By text, maps, and tables of information, the basins are defined and located within the county, and those canals, levees, and control structures within each basin and under the management of the District or the COE are located within the basin and are described and discussed with regard to their operation and management.

The surface water management basins of eastern Palm Beach County, Florida, were first delineated in the 1950s by the COE in their <u>General Design Memorandum</u> (GDM) for the Central and Southern Florida Flood Control Project (Project). Based on the hydrology of the basins, the COE designed and constructed a system of canals, levees, and control structures to provide flood protection for southern and central Florida. The Project is dynamic with new works being constructed and old ones being modified to meet the changing needs of southern Florida. Most of the works constructed under the Project are now under the management of the District.

Six basins are described: the C-18, C-17, C-51, C-16, C-15, and the Hillsboro Canal basins. These basins are located in the eastern half of Palm Beach County. Water Conservation Areas 1 and 2A and the Everglades Agricultural Area which occupy the western half of the county are included in separate memorandums.

The Project canals in Palm Beach County serve a variety of functions. The primary function of all the canals is to provide flood protection for the basins in which they occur. Secondary uses of the canals include land drainage for agriculture and urban or residential development, and regulation of groundwater table elevations to prevent saltwater intrusion into local groundwater. Many of the canals are used to supply water for irrigation and to recharge the wellfields of local municipalities. The Hillsboro Canal is used to discharge excess water from Water Conservation Area 1 to tidewater.

The Project control structures in Palm Beach County regulate the flow of water in the canals. In general they are used to discharge excess water from the basins during flooding and to maintain minimum water levels in the canals during drought periods. Some structures are usually closed to prevent water from passing from one basin to another, but can be opened to supply water from one basin or canal to another as necessary. The coastal structures have the additional function of preventing saltwater from a tidal or storm surge from entering those canals discharging to tidewater.

A bibliography is included with the atlas. It lists publications concerning hydrology and hydraulics, water use, water quality, and land use in Palm Beach County. For the reader unfamiliar with some of the concepts and words used in these descriptions, the appendices contain a discussion of some basic hydrologic and hydraulic concepts, and a glossary of terms.

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ACKNOWLEDGMENTS

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ABSTRACT

An atlas of the surface water management basins in eastern Palm Beach County, Florida, is presented. Six basins are described by text, maps, and tables of information. The basins are defined and located within the county, and the canals, levees, and control structures within each basin are located and are described and discussed with regard to their operation and management. Description and discussion of the canals, levees, and control structures in the basins are limited to those works constructed for the Central and Southern Flood Control Project.

AN ATLAS OF EASTERN PALM BEACH COUNTY SURFACE WATER MANAGEMENT BASINS

INTRODUCTION

This atlas contains information about the surface water management basins in Palm Beach County, Florida. The South Florida Water Management District (District) and the U.S. Army Corps of Engineers (COE) have primary authority over water management in these basins. The District has sponsored publication of this atlas so that up-to-date non-technical descriptions of the surface water management basins in Palm Beach County are available to District personnel, to local governments in Palm Beach County, and to other interested persons. By text, maps, and tables of information, the basins are defined and located within the county, and those canals, levees, and control structures within each basin and under the management of the District or the COE are located within the basin and are described and discussed with regard to their operation and management.

The surface water management basins of eastern Palm Beach County were first delineated in the 1950's by the COE in their General Design Memorandum (GDM) for the Central and Southern Florida Flood Control Project (Project). Presented in the GDM were the COE's analysis of the hydrology of each basin and an assessment of the flood risk for a storm of specified intensity and duration. Based on the hydrology of the basins, the COE designed a system of canals, levees, and control structures to provide some desired level of flood protection for each basin. Designs of these works were presented in the GDM and in the Detailed Design Memorandum for the Project. Most of the works constructed under the Project are now under the management of the District.

The Project is dynamic. As the population in South Florida has grown, and as land use and water demands have changed, the Project has evolved in response to these changes. Some parts of the original Project were never built, other parts have been rebuilt or modified, and as the need has arisen, new structures have been designed and constructed. In some cases, the basins themselves have been redefined. As the COE can not always participate in construction of new works, the District has occasionally assumed responsibility for design and construction of additions or modifications to the Project.

This atlas describes the six surface water management basins in eastern Palm Beach County, Florida, and the Project works associated with each. Atlases describing Water Conservation Areas 1 and 2A and the Everglades Agricultural Area which occupy western Palm Beach County are contained in separate memorandums.

Following the basin descriptions is a bibliography of publications related to the surface water management basins in Palm Beach County. A variety of subjects are included: hydrology, hydraulics of canals and structures, water use, water quality, and land use. Included under hydrology and hydraulics are publications describing various statistical and mathematical models used by the District to predict rainfall, runoff, and canal flow.

Although the basin descriptions are not technical, the reader unfamiliar with the hydrology of lands within the county and with basic water resources engineering may find some words and concepts unfamiliar. Where this is the case, the reader is referred to the appendices. Appendix 1, **BASIC CONCEPTS**, discusses the important concepts with which the reader should be familiar in order to understand the basin descriptions. Appendix 2 is a glossary of terms, abbreviations, and acronyms used in these descriptions. Also defined in the glossary are the District's designations for the various Project and District works: canals, levees, and control structures.

Using the Basin Descriptions

Surface water management basins (hereafter drainage basins) in Palm Beach County are identified by the same designation as the major Project canal located in that basin. For example, C-51 is a canal draining 165.3 square miles in east-central Palm Beach County. The drainage basin, therefore, is the C-51 basin. In most cases, the canal also has a common name by which it is known. For example, C-51 is known as the West Palm Beach Canal. The common name is given parenthetically in the chapter titles following the Project designation for the canal. One Project canal in Palm Beach County does not have a Project designation. In this case, the canal is referenced by name only.

The descriptions of the drainage basins in this atlas have been arranged by geographic location. They are presented as they occur from north to south in the county, beginning with the C-18 basin and ending with the Hillsboro Canal basin. All of the basins are shown on Figure 1. Map A (folded and placed in the pocket of the flyleaf) is a large map showing the basin boundary, canals, levees, and control structures relative to local roads and landmarks. This map should be referenced to precisely locate basin boundaries and District and Project works within the county.

Each description contains three parts. The first part is a written discussion of the basin and is divided into two sections. The first section, **Description of the Basin,** provides a general description of the basin and its Project and District works: the drainage area; the general location of the basin within the county; the purpose of and general operation of canals in the basin; the alignment of and direction of water flow in these canals; the location of inlets and outlets to the canals; and the location, purpose, and operation of structures controlling flow in the canals. The second section, **Comments on Design and Historic Operation,** provides commentary on a variety of topics related to the basin: the design storm (see **Design Storm** under **BASIC CONCEPTS**); significant changes to the basin and its works (e.g., urban development or enlargement of a canal) since the GDM was written, particularly with regard to any changes in flood protection for the basin; and proposals under consideration to redefine the basin or to modify any canals or control structures.

The second part of each basin description is a set of two maps. The first map locates the basin relative to other basins in Palm Beach County. The second map is a schematic drawing of the basin and its canals and control structures. It is intended that these maps should be used in conjunction with the written descriptions to understand the layout and operation of canals and structures in the basin. Major roads and landmarks are included on the schematic maps to help the reader locate the basin within the county. Precise location of canals or structures within the basin can be obtained by reference to Map A.

The third part of each basin description is a table presenting information about Project and District control structures (see **Control Structures** under **BASIC CONCEPTS**) located in the basin. The tables provide a physical description of each structure: type of structure, method of controlling water flow, and pertinent dimensions or elevations. Where a structure has been designed to pass a certain discharge under specified conditions of upstream and downstream water levels, this information is included as the design discharge, design headwater stage, and design tail water stage, respectively. The specified discharge is generally the flood discharge expected to pass the structure for the design storm (see **Design Storm** under **BASIC CONCEPTS**). In some cases, however, the design discharges may refer to water passed through the structure to supply downstream users or to maintain a specified water level in a canal downstream. If a structure was designed to be used to maintain a specified upstream water level under normal non-flooding conditions, this information is included as the optimum headwater stage. Peak water levels upstream and downstream of the structures, and peak discharges through the structures, are also given for those structures where this information has been recorded. Other information about the structures may be cited as relevant.

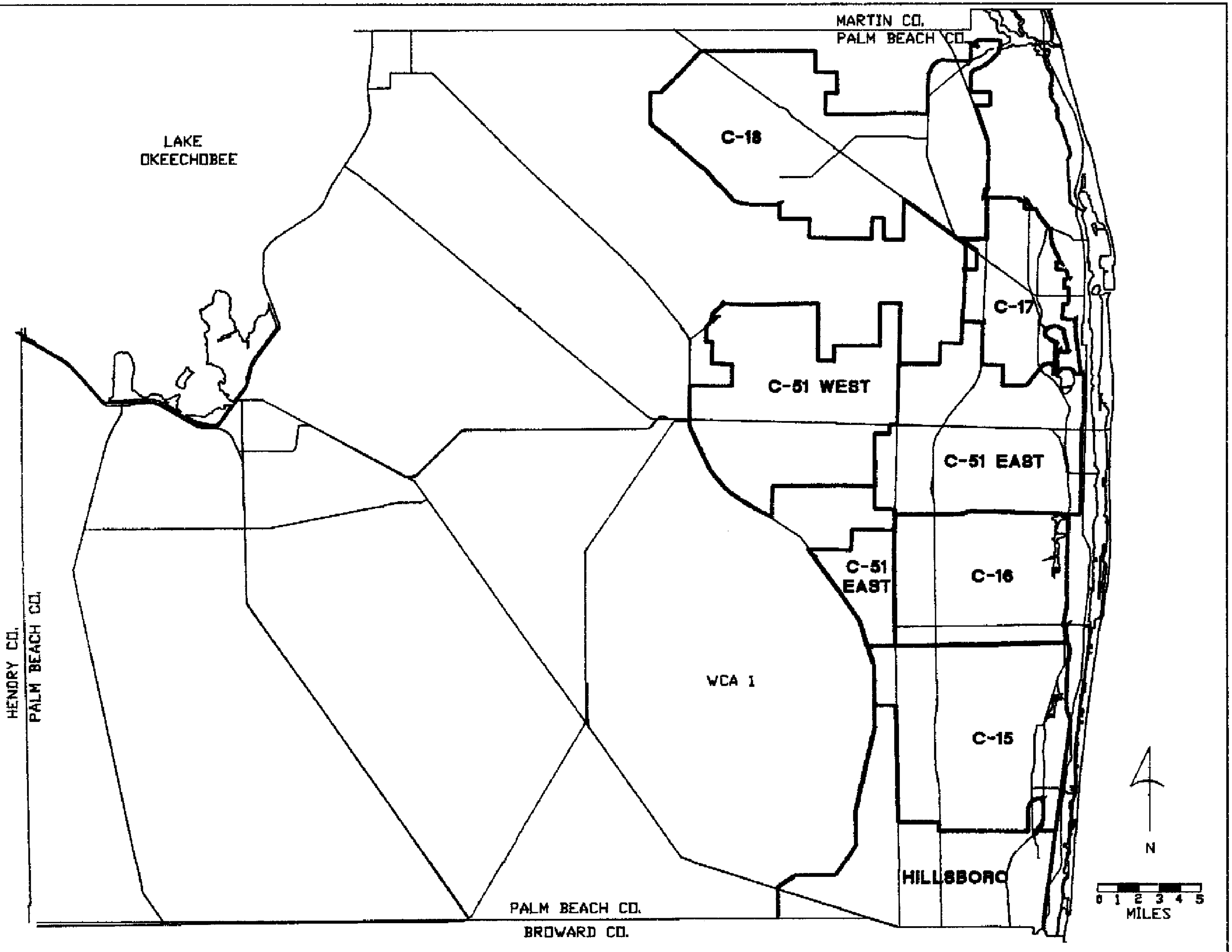

FIGURE 1 PALM BEACH COUNTY DRAINAGE BASINS

C-18 BASIN

Description of the Basin

The C-18 basin has an area of approximately 105.8 square miles and is located in northeastern Palm Beach County (Figure 2). The basin boundary relative to local roads and landmarks is shown on Map A. A schematic map showing the basin boundary, canals, and control structures is given in Figure 3.

The Project canal and the control structures in the C-18 basin have three functions: (1) to provide flood protection and drainage for the basin, (2) to augment flows in the Northwest Fork of the Loxahatchee River, and (3) to maintain a groundwater table elevation southwest of S-46 adequate to prevent intrusion of saltwater into local groundwater. Excess water in the basin is discharged to tidewater in the Southwest Fork of the Loxahatchee River by way of S-46. Water surface elevations in C-18 are controlled by S-46. Water supply to the Northwest Fork of the Loxahatchee River is made by way of G-92 and canals of the South Indian River Water Control District (SIRWCD). In general the only water supply to the C-18 basin is from local rainfall.

C-18 is the only Project canal in the C-18 basin. It is an extension of the Southwest Fork of the Loxahatchee River. C-18 has two branches. The west branch begins at the northeast corner of section 1 of Range 40E-Township 42S. The west branch is aligned approximately west to east. Flow in this branch is to the east. The east branch begins at State Road 710 one-half mile northwest of the intersection of State Road 710 with Northlake Boulevard. The east branch is aligned approximately south to north. Flow in this branch is to the north. The confluence of the two branches is near the northwest corner of section 29 of Range 42E-Township 41S. From the confluence of its two branches, C-18 extends to the northeast. Flow in this part of C-18 is to the northeast.

There are three Project control structures regulating flow in the C-18 basin: S-46, G-92, and the C-18 weir. Design criteria for the control structures in the C-18 basin are given in Table 1.

S-46 is a gated spillway located in the alignment of C-18, 350 feet north of Indiantown Road. The structure controls water surface elevations in C-18, and it regulates discharges to the Southwest Fork of the Loxahatchee River. A headwater stage is maintained by S-46 adequate to prevent intrusion of saltwater into local groundwater. During normal operation, the headwater stage is maintained near 14.5 ft NGVD. However, if the tailwater stage at the C-18 weir rises above 17.6 ft NGVD, the headwater stage at S-46 is lowered to 12.8 ft NGVD. Once the tailwater stage at the C-18 weir drops below 17.6 ft NGVD, the headwater stage at S-46 is allowed to rise gradually to 14.5 ft NGVD.

G-92 is a gated concrete-box culvert. The control structure has two functions: (1) to discharge excess water from the South Indian River Water Control District (SIRWCD) to C-18, and (2) to augment flows in the Northwest Fork of the Loxahatchee River with water from C-18. Operation of the structure is in accordance with a surface water management plan between the District and the SIRWCD. During flooding in the SIRWCD, up to 400 cfs can be discharged from the SIRWCD canal, C-14, through G-92 to the District's C-18 when the flood stage in C-14 exceeds 15.0 ft NGVD, and the stage in C-18 at G-92 is below 14.5 ft NGVD. During non-flooding conditions, if the headwater stage at S-46 is 12.5 ft NGVD or higher, sufficient water is discharged from C-18 to the Northwest Fork of the Loxahatchee River by way of G-92 and SIRWCD canals, to maintain a minimum flow of 50 cfs in the river. When the headwater stage at S-46 is below 12.0 ft NGVD, the gates on G-92 are closed and no discharge is made. For headwater stages at S- 46 between 12.0 and 12.5 ft NGVD, the gate opening at G-92 is 0.5 ft.

The C-18 weir is a steel sheet-pile weir located in the alignment of the western branch of C-18, 200 feet east of State Road 710. The weir maintains a stage of 17.6 ft NGVD in the western reach of the west branch of C-18. This headwater stage prevents over drainage of lands adjacent to C-18 upstream of the weir.

Comments on Design and Historic Operation

C-18 was designed to pass the runoff from a 1 - 30 year storm (60% of the Standard Project Flood) from mostly agricultural lands. It was assumed that the lands in the western part of the basin, the J. W. Corbett Wildlife Management Area and the test area for the Pratt and Whitney Aircraft Group, would act as a water storage area which would not release water to C-18 until after downstream floodwaters had receded. This assumption has proved to be incorrect. Runoff into the western branch of C-18 greatly exceeds that for which the western reach was designed. The South Florida Water Management District restricts runoff rates on permit applications to one inch per day for lands west of State Road 710. This rate protects pasture land in the area from flood damage, however, it still exceeds the design capacity (190 cfs or 0.16 inches of runoff per day) of the western reach and the C-18 weir.

A calculation of the hydraulic profile for the C-18 canal for runoff from the design storm shows the western branch above the C-18 weir to be greatly under designed; the eastern branch upstream of its confluence with the western branch to be adequate to pass the design storm runoff; and the lower reach of the west branch and C-18 below the confluence of the branches to have a capacity 30 percent in excess of the design capacity. The excess capacity results from the fact that various subdivisions in the basin were expected (in the original design) to discharge to the lower reach of the western branch. In fact, they discharge to the upper reaches of the east and west branches where channel capacity is less. This situation has increased the flooding in the upper reach of the western branch and decreased the flow elsewhere in C-18.

Flooding in the area upstream of the C-18 weir and in the area near the intersection of PGA Boulevard and State Road 710 has occurred several times. The latest flooding occurred during the September 22-24, 1983 storm. The area received up to 12.55 inches of rain.

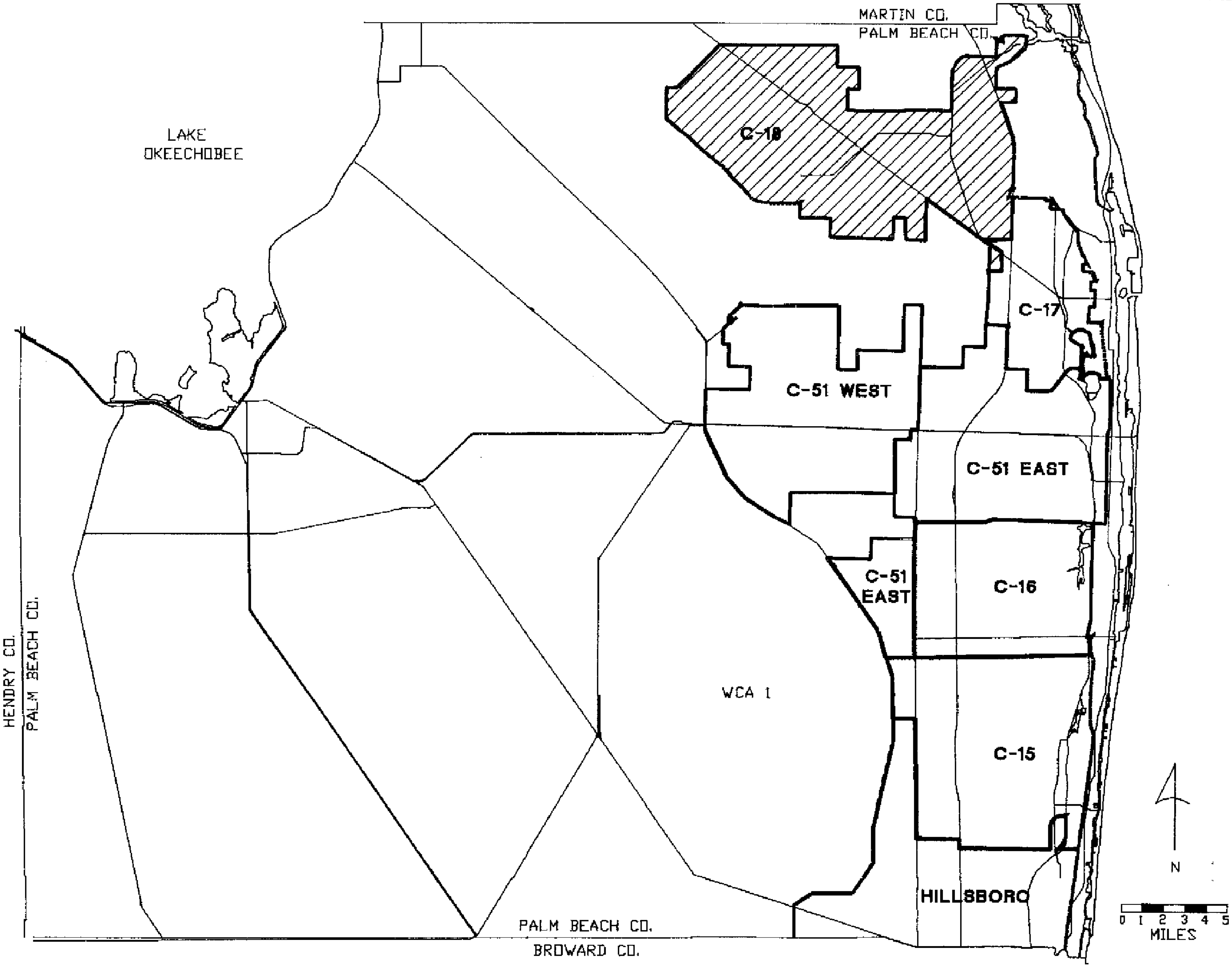

FIGURE 2 C-18 BASIN LOCATION MAP

C-18 BASIN

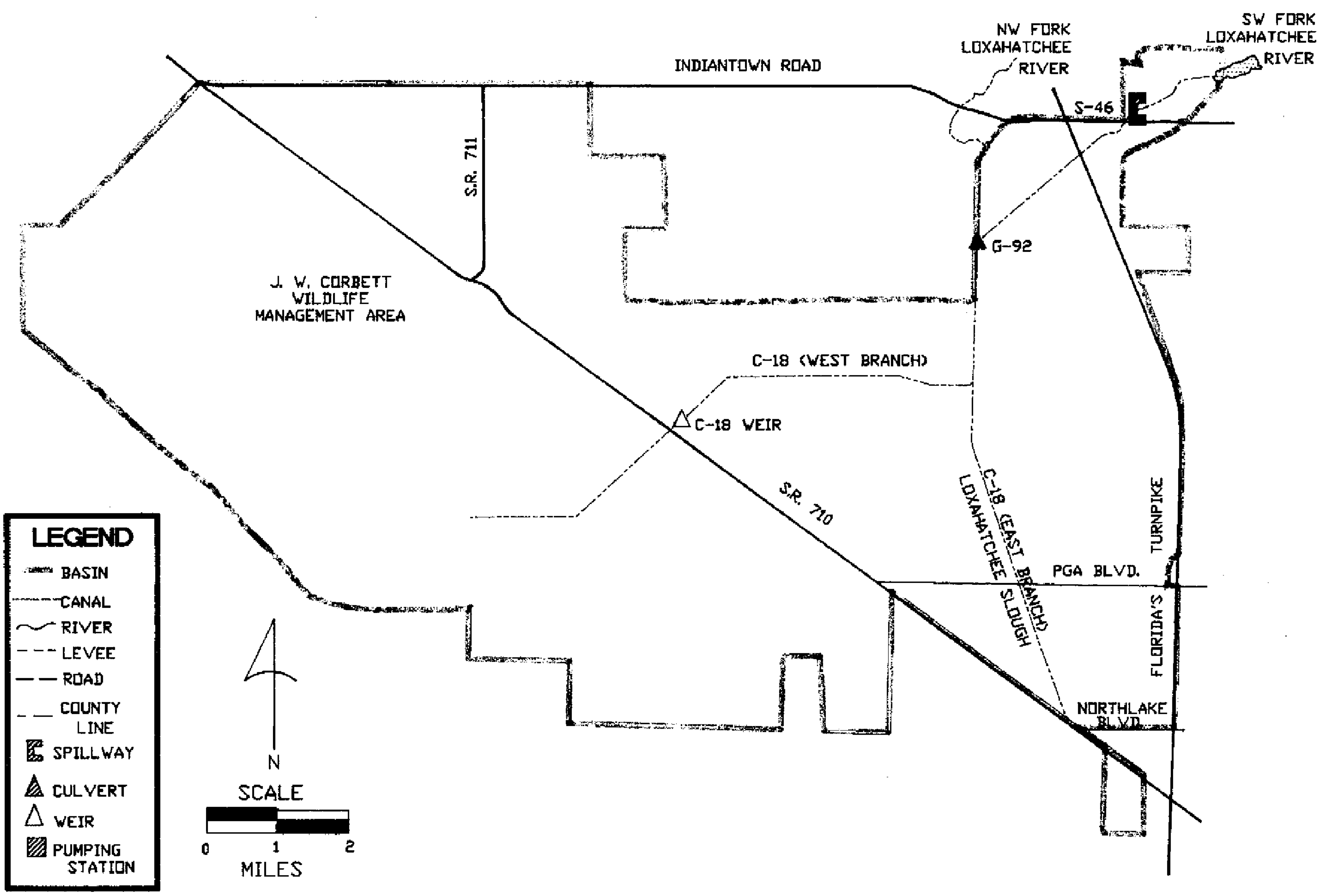

FIGURE 3. THE C-18 BASIN

TABLE 1. C-18 Basin Structures - Design Criteria

Structure	Type	Design HW Stage (ft NGVD)	Design TW Stage (ft NGVD)	Optimum Stage (ft NGVD)	Design Discharge (cfs)	Peak Stage (ft NGVD) Peak Discharge (cfs)	Date of Peak
S-46 Stage divide	Spillway, 3-gates 20ft x 8 ft Crest lgth = 60ft Crest elev = 6.7ft NGVD	12.8	2.2	HW = 14.5	3420	HW = 15.62 Q = 4300 Mean daily Q = 2730	10/15/65 9/24/83 9/26/60
G-92 Water supply to Northwest Fork Loxahatchee River	Existing: Box Culvert 10ft x 8ft x 100ft	>12.0			400	TW Lox = 16.2 HW C-18 = 15.4	9/27/83 9/27/83
C-18 Weir Stage divide	Sheet-pile, fixed crest weir Crest lgth = 93ft Weir crest elev = 17.64 ft NGVD	19.0	18.2	HW = 17.6	190	Hw = 18.6 Tw = 17.04 Q = 280	10/25/83 10/24/83 10/25/83

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

C-17 (EARMAN RIVER) BASIN

Description of the Basin

The C-17 basin has an area of approximately 33.0 square miles and is located in northeast Palm Beach County (Figure 4). The basin boundary relative to local roads and landmarks is shown in Map A. A schematic map showing the basin boundary, canals, and control structures is given in Figure 5.

The Project canal and the control structure in the C-17 basin have two functions: (1) to provide flood protection and drainage for the basin and (2) to maintain a groundwater table elevation southwest of S-44 adequate to prevent intrusion of saltwater into local groundwater. Excess water in the basin is discharged to tidewater in the Intracoastal Waterway by way of S-44. S-44 also controls water surface elevations in C-17. In general, the only water supply to the basin is from local rainfall.

C-17 is the only Project Canal in the C-17 basin. It begins just south of 45th Street and east of I-95 and is a continuation of a City of West Palm Beach canal. C-17 is aligned north-south approximately parallel to and east of I-95. North of Northlake Boulevard the canal turns to the east, discharging to the Intracoastal Waterway just north of Singer Island. Flow in the canal is to the north and then to the east to the Intracoastal Waterway.

There is one Project structure regulating flow in the C-17 basin. S-44 is a gated spillway located in the alignment of C-17 just east of A1A, six-tenths of a mile north of Northlake Boulevard. The structure controls water surface elevations in C-17, and it regulates discharges to the Intracoastal Waterway. Insofar as is possible, S-44 is operated to maintain a headwater stage of 6.6 ft NGVD during the wet season (May 15 to October 15), and a headwater stage of 7.1 ft NGVD during the dry season (October 15 to May 15). These stages are usually adequate to prevent saltwater intrusion into local groundwater. Design criteria for S-44 are given in Table 2.

Comments on Design and Historic Operation

C-17 was designed to pass the runoff from a 1 - 30 year storm. In 1955, when the Army Corps of Engineers (COE) completed its General Design Memorandum (GDM) for C-17, most land in the basin was unimproved (i.e., native range) or in agricultural production (i.e., improved pasture, truck crops, and citrus). There was some urban development along the east side of the basin. The study predicted that by the year 2005 the population in the basin would increase to 19,000. This population was exceeded by 1970, at which time, the District requested that the COE restudy the basin. A Survey Review Study completed in 1975 concluded that the design discharge for the basin should be for a 1 - 30 year storm for an urban area rather than for the 1 - 30 year storm for an agricultural area used in the original design. This increased the design discharge from 2070 cfs to 3700 cfs. C-17 would need to be enlarged and an additional gate added to S-44 to pass 3700 cfs from the basin. The study further concluded, however, that the benefit-cost ratio for making the required changes to C-17 and S-44 was less than 1.0 and that the COE could not participate in making these changes.

Some sections of the canal have already been enlarged under various free digging contracts. As there is sufficient demand for fill material in the area, the remainder of the canal can be enlarged by free digging at no cost to the COE or the District. A new proposal has been submitted to COE that includes only those modifications to S-44 necessary for the structure to pass 3700 cfs.

To implement the proposal, two bridges will need to be modified to increase the cross sectional area available for water flow under them. They are the Seaboard

Coast Line Railway bridge and the State Road 710 bridge. The Blue Heron Boulevard, the Lake Park Boulevard, and the Florida East Coast Railway bridges have been rebuilt in recent years and should be adequate.

Inflows to C-17 are by various canals under the management of local municipalities. Two important tributaries are City of West Palm Beach canals that drain the lands in the basin south of 45th Street. These canals join about 1200 ft south of 45th Street to form the canal that continues north of 45th Street as C-17. One canal flows to the north, parallel to I-95, from the Palm Beach Mall. Drainage from the west passes under I-95 near the Palm Beach Mall to join this canal. The other main tributary drains the lands to the east of Lake Mangonia and Clear Lake. Each of the canals has a control structure. The west canal has a fixed crest sheet-pile weir, and the east canal has a gated structure. Flow from both canals is controlled by a sheet-pile weir in C-17 just north of the 45th Street crossing. Crest elevation of this weir is 7.7 ft NGVD.

Some flooding occurs at less than the design discharge in the upper reach of the City of West Palm Beach canal that drains the area south of 45th Street and east of Lake Mangonia and Clear Lake. Some of the flooding results from the high stage held in the canal behind the weir at 45th Street. The proposal to modify S-44 includes a provision for the removal of the 45th Street weir. If the weir is removed, some of the flooding will be eliminated.

Two recent storms have caused runoff in excess of the design discharge of 2070 cfs for the basin. On March 29, 1982, for a maximum rainfall reported in Palm Beach Gardens of 15.01 inches, the discharge was 2680 cfs. The peak headwater stage at S-44 was 9.8 ft NGVD. For the storm of November 23, 1984, the peak discharge at S-44 was 2250 cfs.

The storm of April 22 - 26, 1982 had a peak discharge of only 1180 cfs on April 24. However, the City of West Palm Beach canal that drains the area east of Lake Mangonia experienced flooding at this discharge.

The M-Canal crosses the C-17 basin from west to east and discharges to Lake Mangonia. The M-Canal is not part of the C-17 system. It is part of the water supply system for the City of West Palm Beach. It supplies water from the water catchment area located west of Florida's Turnpike to Lake Mangonia to the east. There are no flows into the M-Canal from the C-17 basin. Because of a unique water control structure, called an "inverted siphon", the M-canal actually flows <u>under</u> the C-17 canal.

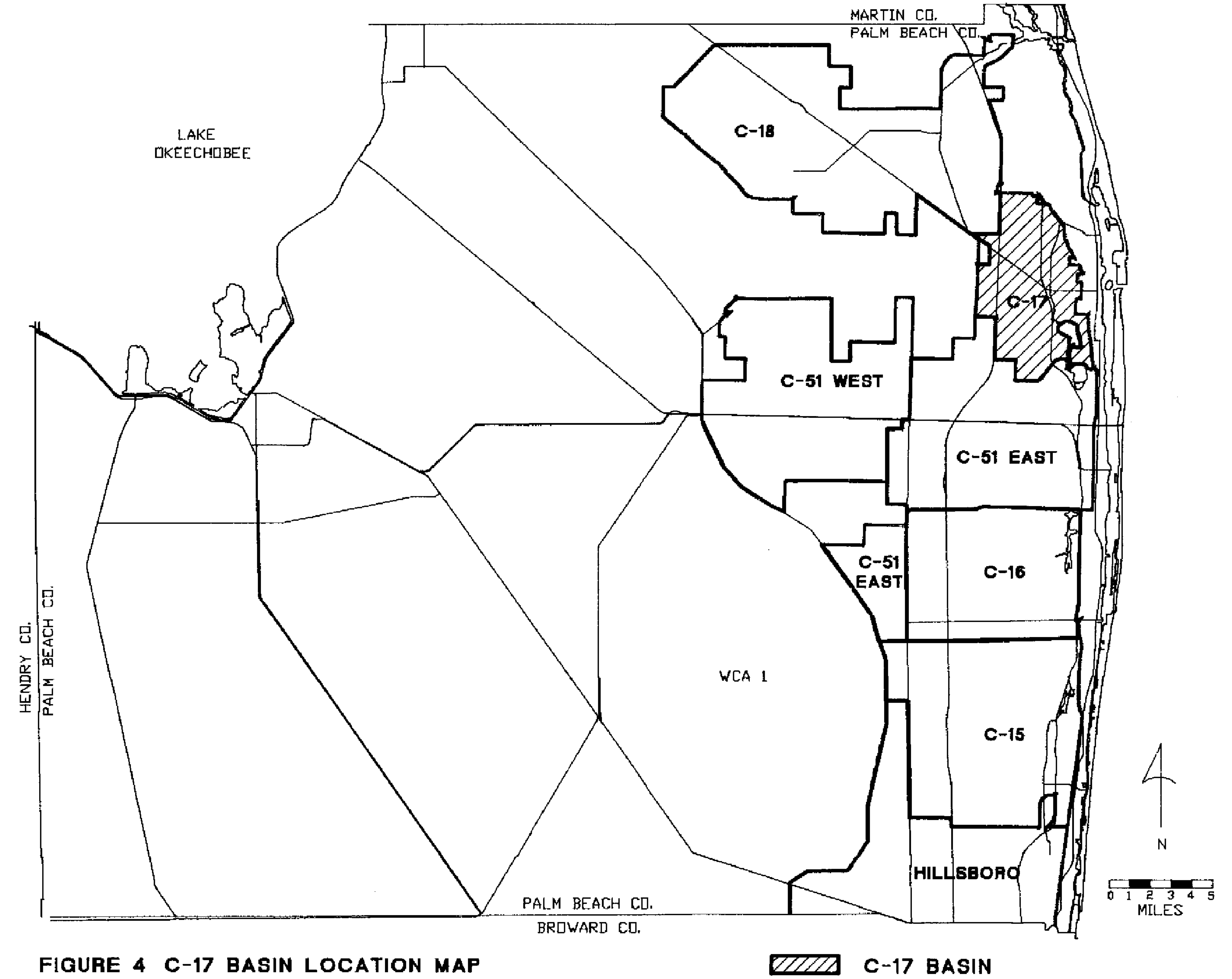

FIGURE 4 C-17 BASIN LOCATION MAP

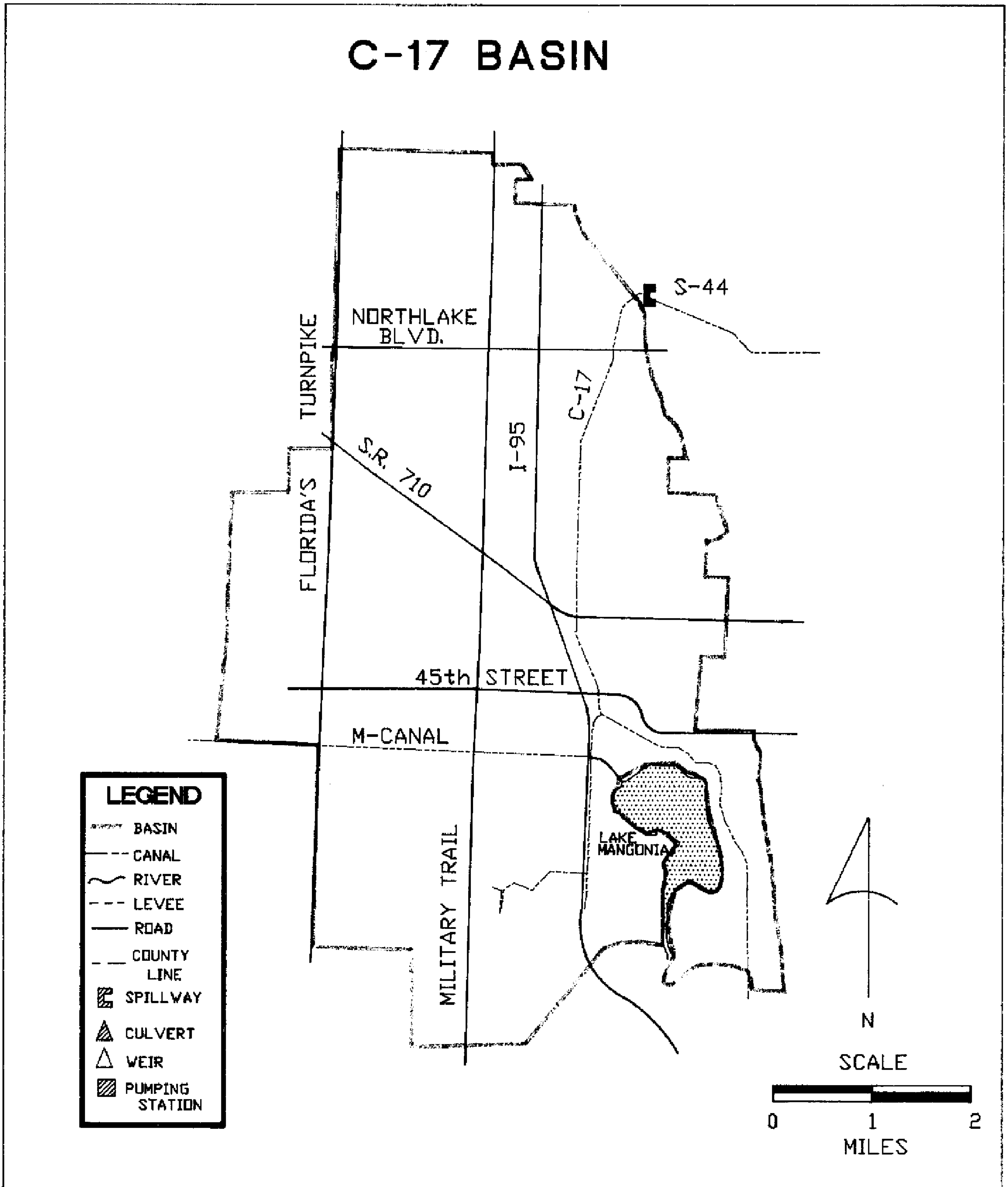

FIGURE 5. THE C-17 (EARMAN RIVER CANAL) BASIN

TABLE 2. C-17 Basin Structures - Design Criteria

Structure	Type	Design HW Stage (ft NGVD)	Design TW Stage (ft NGVD)	Optimum Stage (ft NGVD)	Design Discharge (cfs)	Peak Stage (ft NGVD) Peak Discharge (cfs)	Date of Peak
S-44 Stage divide	Spillway, 2 gates, 20ft x 3.3ft Crest lgth = 40ft Crest elev = 3.3ft NGVD	9.0	-3.1 to 3.9	HW = 6.6 (West season) HW = 7.1 (Dry season)	2070	HW = 9.8 Q = 2680	3/29/82 3/29/82

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

C-51 (WEST PALM BEACH CANAL) BASIN

Description of the Basin

The C-51 basin has an area of approximately 164.3 square miles and is located in eastern Palm Beach County. The basin is comprised of two subbasins, C-51 West (79.5 square miles, Figure 8) and C-51 East (84.8 square miles, Figure 8). State Road 7 is generally the boundary between the basins. The basin boundaries relative to local roads and land marks are shown in Map A. Schematic maps showing the basin boundaries, canals, and control structures are given in Figures 7 and 9.

The Project canal and the control structures in the C-51 basin have four functions: (1) to provide flood protection and drainage for the basin, (2) to discharge, under certain conditions, flood flows from the L-8 basin to tidewater, (3) to supply water to the basin during periods of low natural flow, and (4) to maintain a groundwater table elevation west of S-155 adequate to prevent intrusion of saltwater into local groundwater. Excess water in the east basin is discharged to tidewater in the Intracoastal Waterway by way of C-51 and S-155. Excess water in the west basin is discharged to tidewater by way of G-124 and S-155 or to Water Conservation Area (WCA) 1 by way of S-5AE, S-5AW, and S-5A. Excess water in the L-8 basin is discharged to tidewater through the C-51 basin by way of S-5AE, G-124, and S-155. Water surface elevations in the eastern reach of C-51 are controlled by S-155 and in the western reach by G-124 and S-5A. Water supply to the basin is made in one of three ways: (1) from WCA 1 by way of S-5AS and S-5AE, (2) from Lake Okeechobee by way of Hurricane Gate Five (HG-5), the L-10/L-12 borrow canal, S-5AW, and S-5AE; or (3) from Lake Okeechobee by way of Culvert #10A, the L-8 borrow canal, and S-5AE.

C-51 is the only Project canal in the C-51 basin. It is that part of the West Palm Beach Canal east of L-40. C-51 is aligned parallel to and south of State Road 80 from L- 40 to Congress Avenue. East of Congress Avenue the canal extends to the south and then to the east, connecting to the Intracoastal Waterway east of Lake Clarke.

There are six Project structures controlling flow in the C-51 basin: S-155, G-124, S-5AE, S-5AW, S-5AS, and S-5A. Design criteria for the control structures in the C-51 basin are given in Table 3.

S-155 is a gated spillway located in the alignment of C-51 at Dixie Highway. The structure controls water surface elevations in C-51, and it regulates the discharge to the Intracoastal Waterway. Under normal operation, S-155 maintains a headwater stage of 8.0 ft NGVD. During periods of heavy rainfall, the headwater stage at S-155 is lowered to 7.3 ft NGVD or less. These stages are adequate to prevent saltwater intrusion into local groundwater.

G-124 is a set of culverts located in the alignment of C-51, 3.5 miles west of State Road 7. Both gates and flash boards are used to control water flow through the structure. The structure is normally closed and acts as a divide between the east and west basins. The gates are opened for either of two reasons: (1) to discharge excess water from the western C-51 basin or the L-8 basin to tidewater when S-5A is unable to discharge the excess flows to WCA 1, and C-51 can accept the flows without flooding occurring in the eastern basin; or (2) to permit water supply to the eastern C-51 basin from the western basin or from WCA 1.

S-5AW, S-5AS, S-5AE, and S-5A are located at the west end of C-51 near its junction with the L-10/L-12 borrow canal and the L-8 borrow canal. These structures are operated in conjunction with one another to control runoff into or from the C-51 basin, and to supply water to the C-51 basin from WCA 1 and Lake Okeechobee for irrigation and to maintain the optimum stage in C-51.

S-5AE is a gated spillway located in the east levee of L-8 at the west end of C-51. The gates are closed whenever flood conditions are imminent downstream in C-51 (i.e., the headwater stage at G-124 in C-51 is greater than 13.0 ft NGVD, or the tailwater stage at S-5AE is greater than 13.0 ft NGVD and the headwater stage is greater than the tailwater stage). The gates can be opened to discharge water from the L-8 and C-51 basins to the S-5A basin if the above conditons do not exist and flood conditions exist in the western part of the C-51 basin and if S-5A has capacity in excess of the water being removed from the S-5A basin. During periods of low natural flow (i.e., when the headwater stage at S-155 in C-51 is below 8.0 ft NGVD), S-5AE is opened to supply water to the C-51 basin from Lake Okeechobee by way of Culvert 10A and the L-8 borrow canal, and Hurricane Gate Five (HG-5) and the L-10/L-12 borrow canals. (Note: HG-5 is scheduled to be replaced with a gated spillway, S-352.)

S-5AS is a gated spillway located at the junction of L-7 and L-40 at the southern end of the L-8 borrow canal. It controls flows between WCA 1 and the L-8 borrow canal, the L-10/L-12 borrow canal, and C-51. Subject to availability of water in WCA 1, the gates can be opened to supply water to C-51, to the L-10/L-12 borrow canal, and to the L-8 borrow canal as necessary to meet agricultural requirements for irrigation and to maintain the optimum stages in the canals. The gates can also be opened to pass flood flows from the L-8 borrow canal to WCA 1 when the canal stage exceeds the stage in WCA 1; however, this is a rare occurrence.

S-5AW is a gated spillway located in the west levee of L-8 at the east end of the L-10/L-12 borrow canal. The gates are closed whenever a flood condition exists in the S-5A basin (i.e., S-5A cannot lower the stage in the L-10/L-12 borrow canal at Canal Point below 12.5 ft NGVD). The gates can be opened, in the absence of the above conditions, whenever a flood condition exists in the L-8 basin or in the western portion of the C-51 basin (see S-5AE, above). The excess flows in these basins are then pumped to WCA 1 by S-5A. During periods of low natural flow, the gates can be opened to supply water, if available, from the S-5A basin to the L-8 and C-51 basins.

S-5A is a pump station located on the south side of the L-10/L-12 borrow canal just west of S-5AW and the L-8 borrow canal. It discharges to WCA 1. The pump station has three functions: (1) to mitigate flooding by removing excess water from the S-5A basin at a maximum rate of three-quarters of an inch of runoff per day, (2) to transfer to WCA 1 regulatory releases of water discharged from Lake Okeechobee to the L-10/L-12 borrow canal, and (3) to remove, when capacity is available, flood flows from the L-8 basin and western portion of the C-51 basin to WCA 1.

Comments on Design and Historic Operation

C-51 provides less than 1 - 10 year flood protection for the C-51 basin. Considerable flooding occurs in both the eastern and western basins with a 1 - 30 year storm. S-155 in the eastern basin was designed to give the eastern basin 1 - 30 year flood protection. However, without a divide structure just west of U. S. Highway 441 and a pump station to remove water from the western basin, there will continue to be flooding in the basin during storms of severity equal to or greater than a 1 - 10 year storm. The Army Corps of Engineers has studied the feasibility of constructing a divide structure at U. S. Highway 441 and of constructing a pump station at the western end of C-51 to pump 3400 to 3800 cfs of runoff from the western basin. However, a decision as to where the runoff from the western basin should be pumped has not been made. Presumably, if a suitable location to receive the pumped discharge from the western C-51 basin can be determined, a final design will be made and implemented.

Inflows to C-51 are by various Lake Worth Drainage District (LWDD) canals. These canals (e.g., E-1, E-2, E-3, E-4, and the Stub Canal) can have very large inflows to C-51. Depending on the stages in C-51,the Stub Canal alone can have inflows to C-51 of up to 1500 cfs. This is approximately 30 percent of the capacity of S-155.

Clear Lake and Lake Mangonia at the northeast corner of the C-51 basin are part of the City of West Palm Beach water supply system. Under operation as a water supply system, these lakes are hydrologically independent of the C-51 basin. Regulated inflows to the lakes from the M-Canal replenish water withdrawn, for the City of West Palm Beach municipal water supply, in excess of water supplied by rainfall. Rainfall is an unregulated inflow to the lakes. If a severe storm causes enough rainfall on the lakes to raise the stage in Clear Lake above 14.5 ft NGVD, up to 250 cfs of flow can be passed from Clear Lake to the Stub Canal. The 250 cfs discharge to the Stub Canal allows the 14.5 ft NGVD stage in Clear Lake to be maintained for rainfall from at least a 1 - 100 year storm.

The drainage area of the C-51 basin has recently been decreased. Lands formerly in the north central part of the basin that are in the Indian Trail Water Control District (M-1 Acreage, Figure 9) now normally drain to the L-8 basin. Under an emergency situation, however, water can be discharged from these lands to the C-51 basin with the approval of the Executive Director of the District.

Prior to the construction of S-155, the control at Dixie Highway consisted of a gated spillway and a set of culverts with risers and flashboards. The peak discharge for this control was 5800 cfs on March 29, 1982. The peak headwater stage was 10.86 ft NGVD.

The worst flooding in the basin was caused by Hurricane Donna and Tropical Storm Florence in September 1960. The stage at Forest Hill Boulevard was 11.3 ft NGVD, and the stage at the Village of Royal Palm Beach was 16.7 ft NGVD.

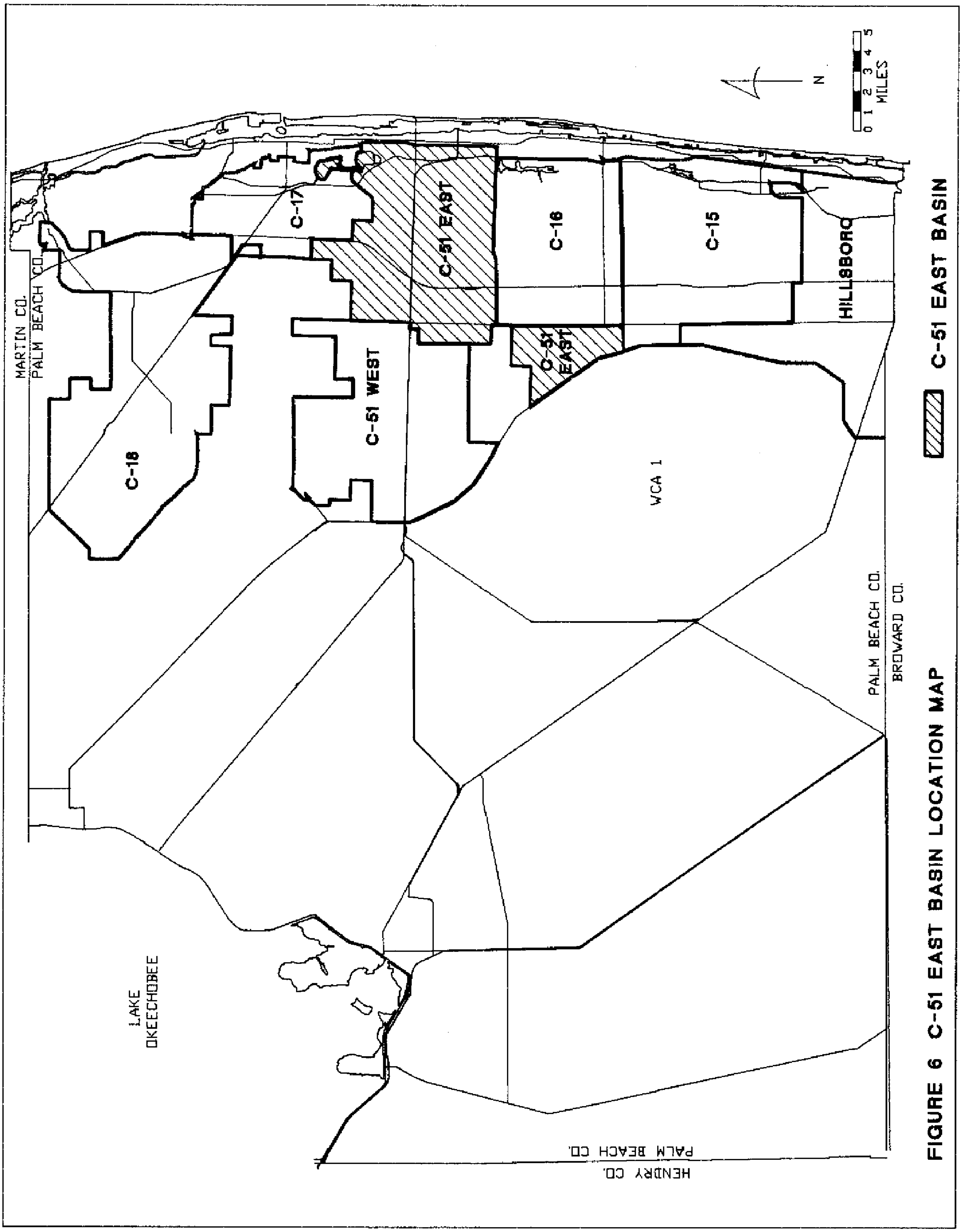

FIGURE 6 C-51 EAST BASIN LOCATION MAP

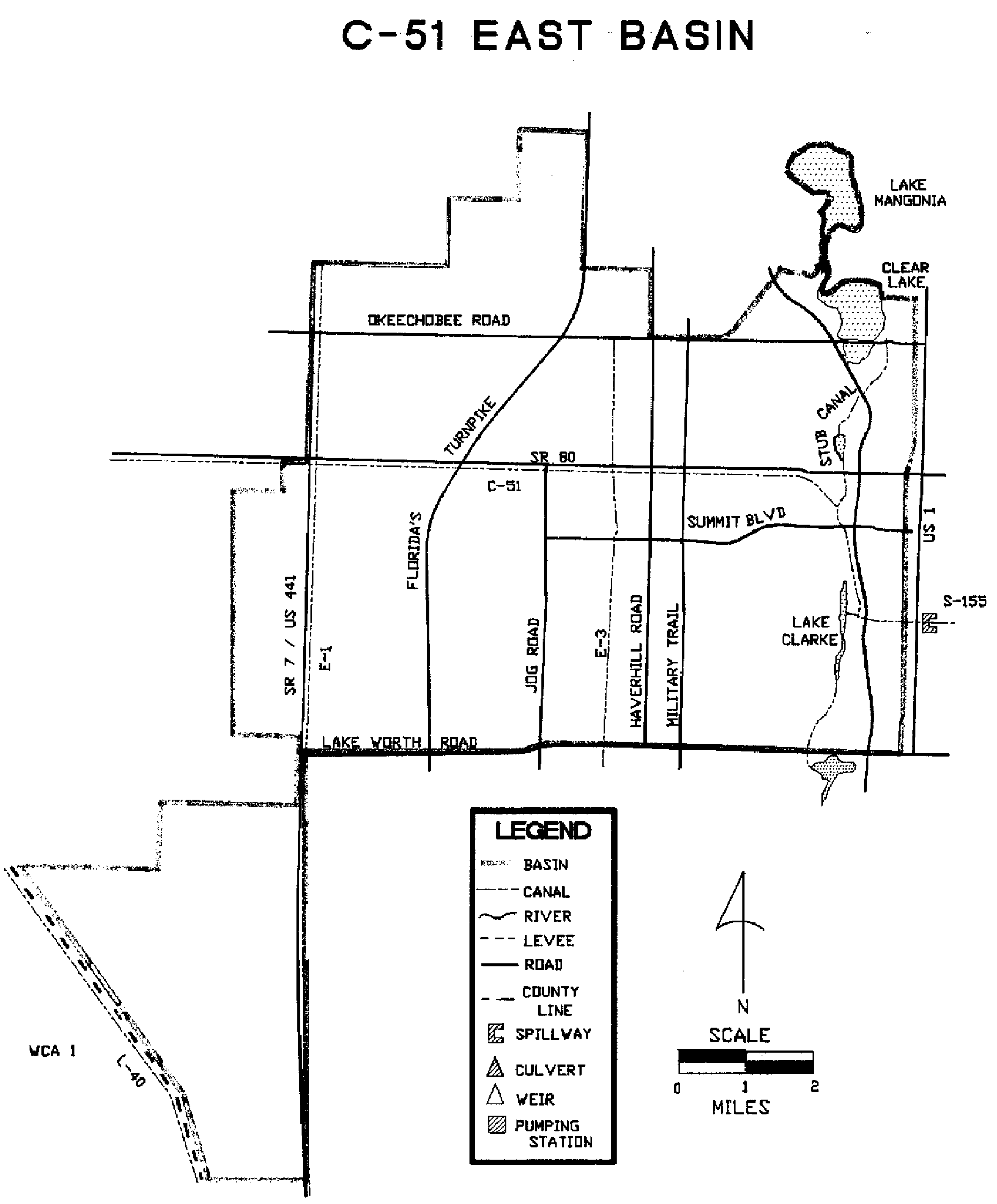

FIGURE 7. THE C-51 EAST BASIN

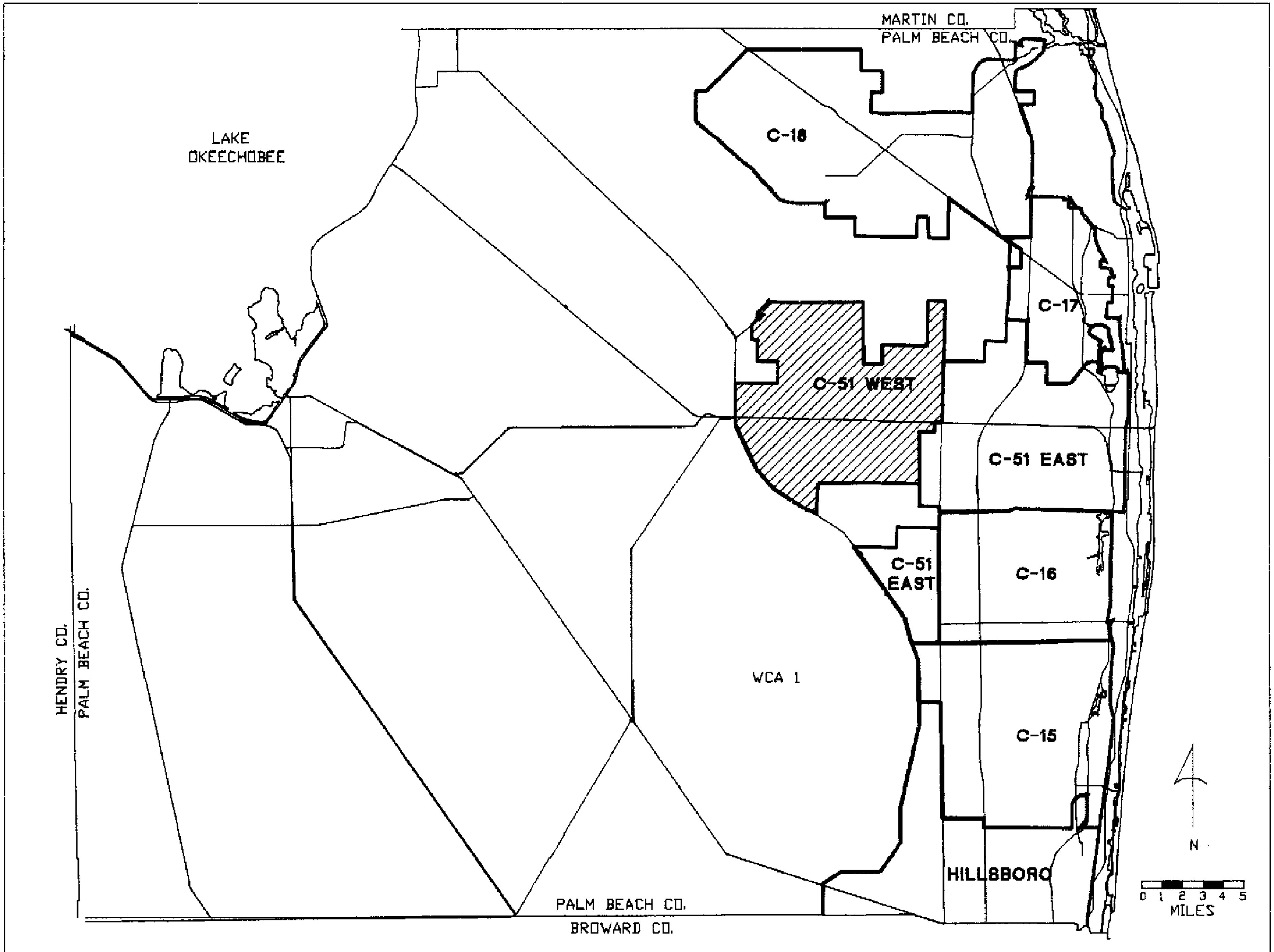

FIGURE 8 C-51 WEST BASIN LOCATION MAP

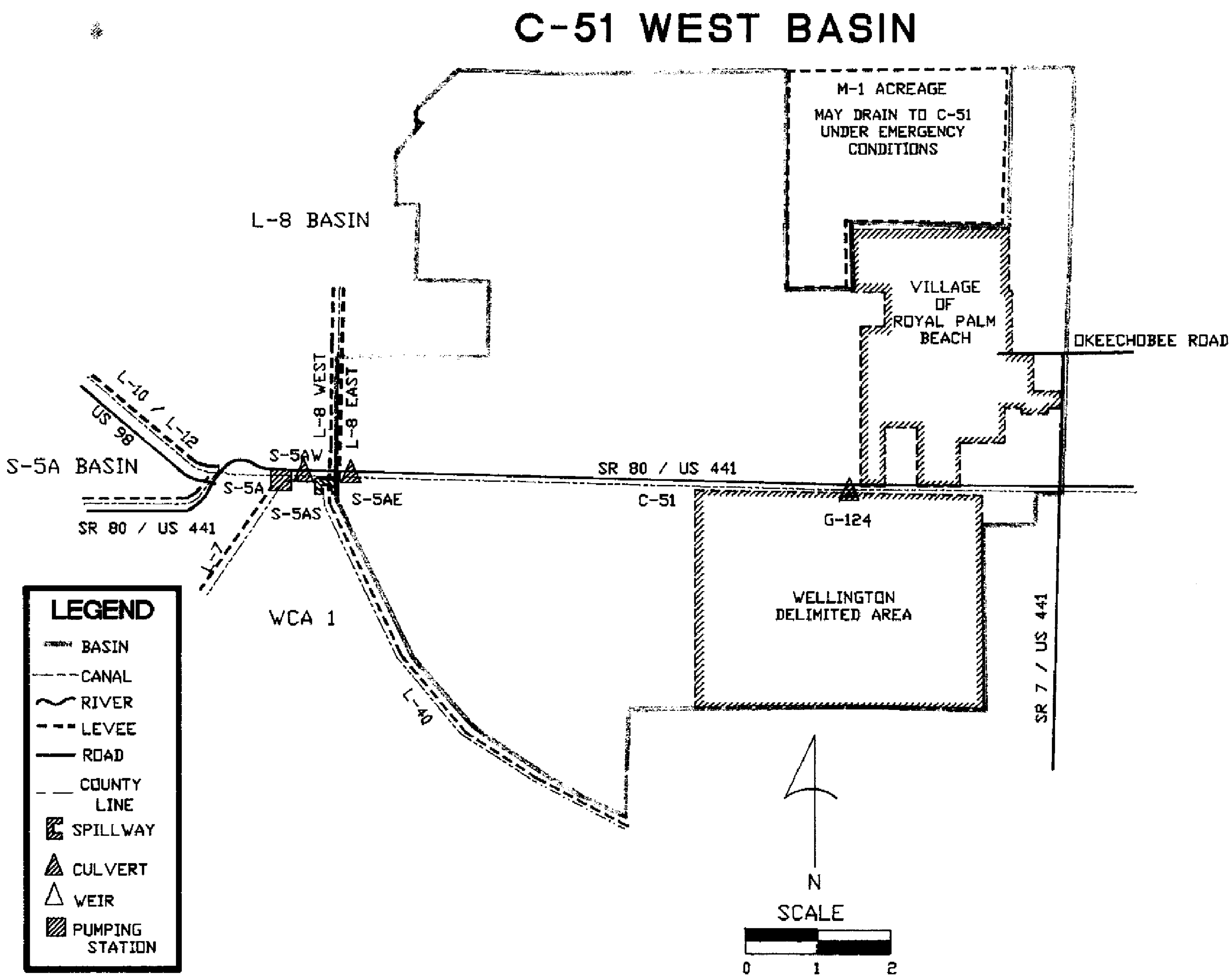

FIGURE 9. THE C-51 WEST BASIN

TABLE 3. C-51 Basin Structures - Design Criteria

Structure	Type	Design HW Stage (ft NGVD)	Design TW Stage (ft NGVD)	Optimum Stage (ft NGVD)	Design Discharge (cfs)	Peak Stage (ft NGVD) Peak Discharge (cfs)	Date of Peak
S-155 Stage divide	Spillway, 3 gates 25ft x 9.7ft Weir lgth = 75ft Weir elev = 1.8ft NGVD	8.5	-1.0 to 2.0	HW = 8.0	4800	HW = 10.68 Q = 5800	3/29/82 3/29/82
G-124 Divide structure-east and west basins. Water supply, flood discharges-west to east basins	Culvert 1-36in CMP,2-66in CMP 4-72in CMP (2-72in CMP's have slide gates and 2 have risers and boards) Invert elevs : 36in CMP = 7.0ft NGVD 66in CMP = 5.0ft NGVD 72in CMP = 5.0 ft NGVD			H W = 12.5			
S-5AE Water supply to C-51. Flood discharge, L-8 borrow canal to C-51.	Box culvert, 2-7ft x 7 ft box x 65ft reinforced concrete with slide gates Invert elev = 1.0ft NGVD	11.5	10.0	Not used to control stage	700	Q (east) = 960 Q (west) = 930 TW = 16.37 HW = 19.34	10/3/59 3/29/82 9/26/60 9/27/60
S-5A	Pump Station 6 units: 800 cfs each	13.0	24.1	HW = 10.5 (wet season) HW = 11.5 (dry season)	4800		
S-5AW Divide structure	Gated culvert 2-7 ft x 7 ft box × 80 ft Reinforced concrete box Invert elev = -1.75 to 0.3 ft NGVD	13.0	11.5	Not used to control stage	700		
S-5AS	Gated spillway 2 Gates 19.3 ft high × 22.8 ft wide Net crest length = 44.0 ft Crest elev = 1.0 ft NGVD	18.0	17.9	Not used to control stage	2000		

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

C-16 (BOYNTON CANAL) BASIN

Description of the Basin

The C-16 basin has an area of approximately 52.8 square miles and is located in eastern Palm Beach County (Figure 10). The basin boundary relative to local roads and landmarks is shown in Map A. A schematic map showing the basin boundary, canals, and control structure is given in Figure 11.

The Project canal and the control structure in the C-16 basin have two functions: (1) to provide flood protection and drainage for the C-16 basin, and (2) to maintain a groundwater table elevation west of S-41 adequate to prevent saltwater intrusion into local groundwater. Excess water in the basin is discharged to tidewater in the Intracoastal Waterway by way of S-41. Water surface elevations in C-16 are regulated by S-41. Water supply to the basin is from local rainfall and by pumping from WCA 1 by Lake Worth Drainage District (LWDD) pumps.

C-16 is the only Project canal in the C-16 basin. It is an extension of the LWDD's Boynton Canal. The Boynton Canal ends, and C-16 begins at the Lake Ida Canal (LWDD canal E-4) eight-tenths of a mile west of I-95. Flow in the canal is to the east with discharge to the Intracoastal Waterway.

There is one Project control structure regulating flow in the C-16 basin. S-41 is a gated spillway located in the alignment of C-16, 260 feet east of U. S. Highway 1. The structure controls water surface elevations in C-16, and it regulates discharges to the Intracoastal Waterway. Under normal operation, S-41 maintains a headwater stage of 8.2 ft NGVD. During periods of heavy rainfall, the headwater stage at S-41 is lowered to 7.7 ft NGVD or less. These stages are adequate to prevent saltwater intrusion into local groundwater. Design criteria for S-41 are given in Table 4.

Comments on Design and Historic Operation

C-16 was designed to pass the runoff from a 1-30 year (60% of the Standard Project Flood) storm. The design stage at the west end where LWDD canal E-4 joins C-16 is 9.0 ft NGVD.

Inflows to C-16 are by various LWDD canals. Because some of the north-south flowing LWDD canals do not have divide structures between the C-16 and the C-15 basins, between the C-16 and C-51 Basins, and between the C-15 and the Hillsboro Canal basins, some interbasin transfer of water may occur. This is especially true in the western portions of the basins. Lands in the C-16 and C-15 basins between L-40 and Florida's Turnpike may, under some conditions, drain to the Hillsboro Canal or to C-51 by way of LWDD canal E-1

The LWDD canal system was designed for 1 - 25 year flood protection. The entire system has not yet been constructed to design specifications. LWDD requires developers planning to drain to the LWDD canals to improve the canals to design specifications. As more of the western area of the C-16 basin is developed the discharge at S-41 will probably increase.

The peak discharge at S-41 occurred on March 29, 1982. The flow was 5600 cfs. The Standard Project Flood discharge is only 5300 cfs. Flooding has occurred in the basin for storms smaller than the design storm.

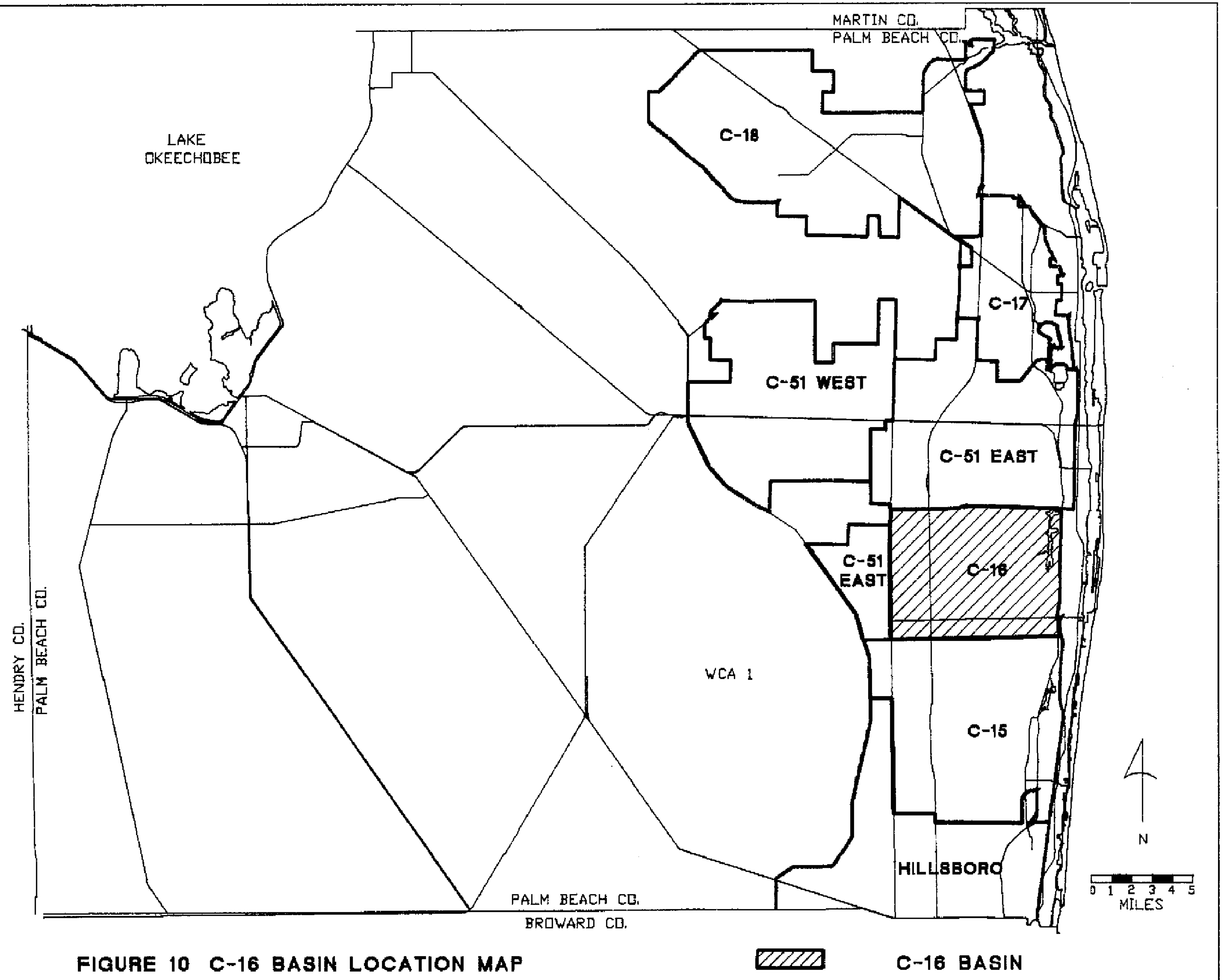

FIGURE 10 C-16 BASIN LOCATION MAP

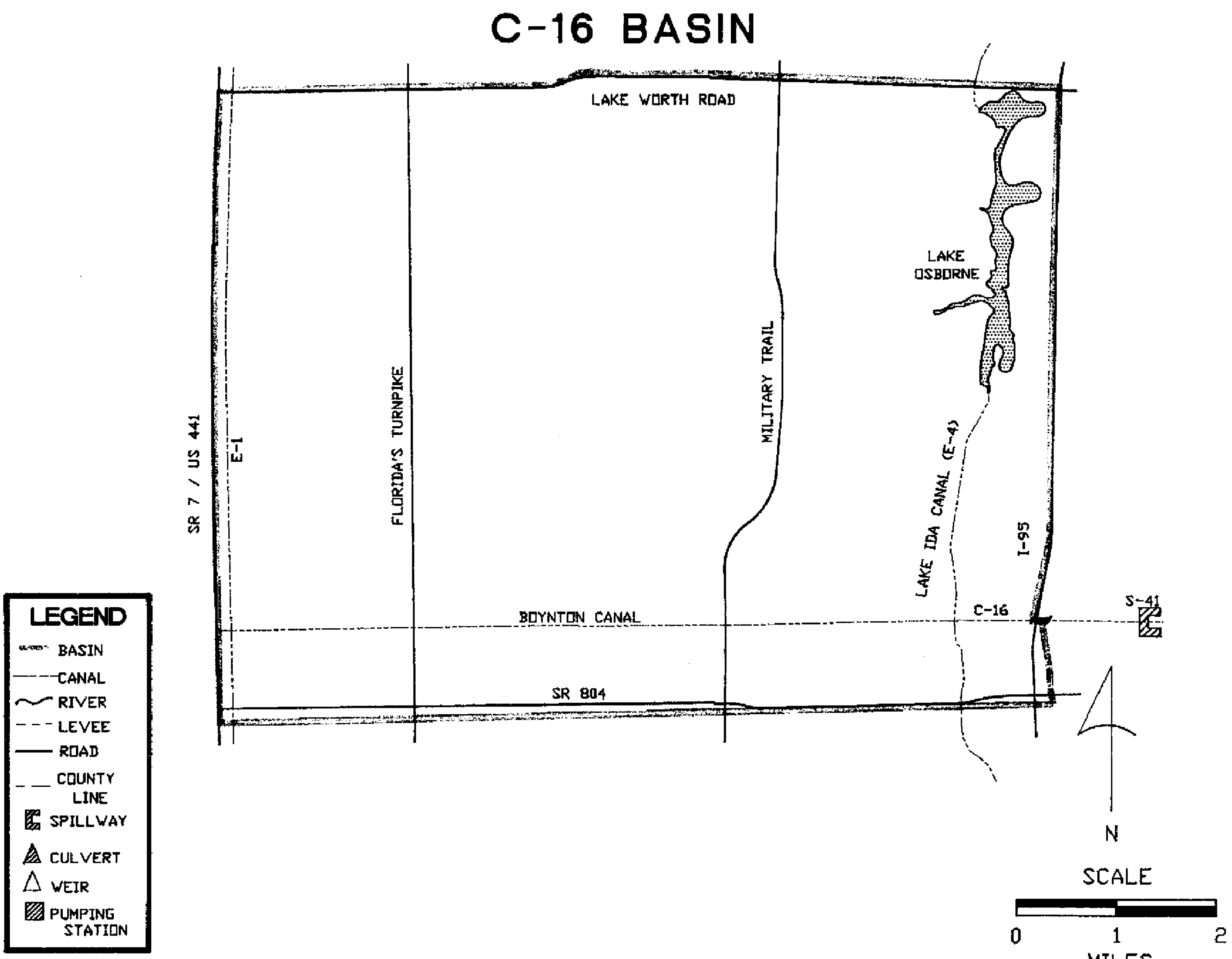

FIGURE 11. THE C-16 BASIN

TABLE 4. C-16 Basin Structures - Design Criteria

Structure	Type	Design HW Stage (ft NGVD)	Design TW Stage (ft NGVD)	Optimum Stage (ft NGVD)	Design Discharge (cfs)	Peak Stage (ft NGVD) Peak Discharge (cfs)	Date of Peak
S-41 Stage divide	Spillway, 2-gates 25ft x 9ft Crest lgth = 50ft Crest elev = -0.4ft NGVD	8.1	1.8	HW = 8.2	4600	Hw = ~9.5 Q = 5600	3/29/82 3/29/82

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

C-15 BASIN

Description of the Basin

The C-15 basin has an area of approximately 74.6 square miles and is located in southeastern Palm Beach County (Figure 12). The basin boundary relative to local roads and landmarks is shown on Map A. A schematic map showing the basin boundary, canals, and control structure is given in Figure 13.

The Project canal and the control structure in the C-15 basin have two functions: (1) to provide flood protection and drainage for the C-15 basin, and (2) to maintain a groundwater table elevation west of S-40 adequate to prevent saltwater intrusion into local groundwater. Excess water in the basin is discharged to tidewater in the Intracoastal Waterway by way of S-40. Water surface elevations in C-15 are regulated by S-40. Water supply to the basin is from local rainfall and by pumping from WCA 1 and the Hillosboro Canal by Lake Worth Drainage District (LWDD) pumps.

C-15 is the only Project canal in the C-15 basin. It is an extension of the LWDD lateral (west to east flowing) canal L-38. L-38 ends, and C-15 begins at the El Rio Canal (LWDD canal E-4) six-tenths of a mile west of I-95. Flow in the canal is to the east with discharge to the Intracoastal Waterway.

There is one Project structure controlling flow in the C-15 basin. S-40 is a gated spillway located in the alignment of C-15, 510 feet east of U. S. Highway 1. The structure controls water surface elevations in C-15, and it regulates discharges to the Intracoastal Waterway. Under normal operation, S-40 maintains a headwater stage of 8.2 ft NGVD. During periods of heavy rainfall the headwater stage at S-40 is lowered to 7.7 ft NGVD or less. These stages are adequate to prevent saltwater intrusion into local groundwater. Design criteria for S-40 are given in Table 5.

Comments on Design and Historic Operation

C-15 was designed to pass the runoff from a 1-30 year (60% of the Standard Project Flood) storm. The design stage at the west end where the LWDD canal E-4 joins C-15 is 9.0 ft NGVD.

Inflows to C-15 are by various LWDD canals. Because some of the north-south flowing LWDD canals do not have divide structures between the C-15 basin and the Hillsboro Canal basin to the south and the C-16 basin to the north, some interbasin transfer of water may occur. This is especially true in the western portion of the basins. Lands in the C-16 and C-15 basins between L-40 and the Florida's Turnpike may, under some conditions, drain to the Hillsboro Canal by way of LWDD canals E-1 or E-3.

The LWDD canal system was designed for 1-25 year flood protection. The entire system has not yet been constructed to design specifications. LWDD requires developers planning to drain to the LWDD system to improve the canals to design specifications . As more of the western area of the C-15 basin is developed, the discharge at S-40 will probably increase.

The peak discharge of 4050 cfs at S-40 occurred April 25, 1979. The headwater stage was 9.9 ft NGVD. Flooding has occurred in the basin for storms smaller than the design storm.

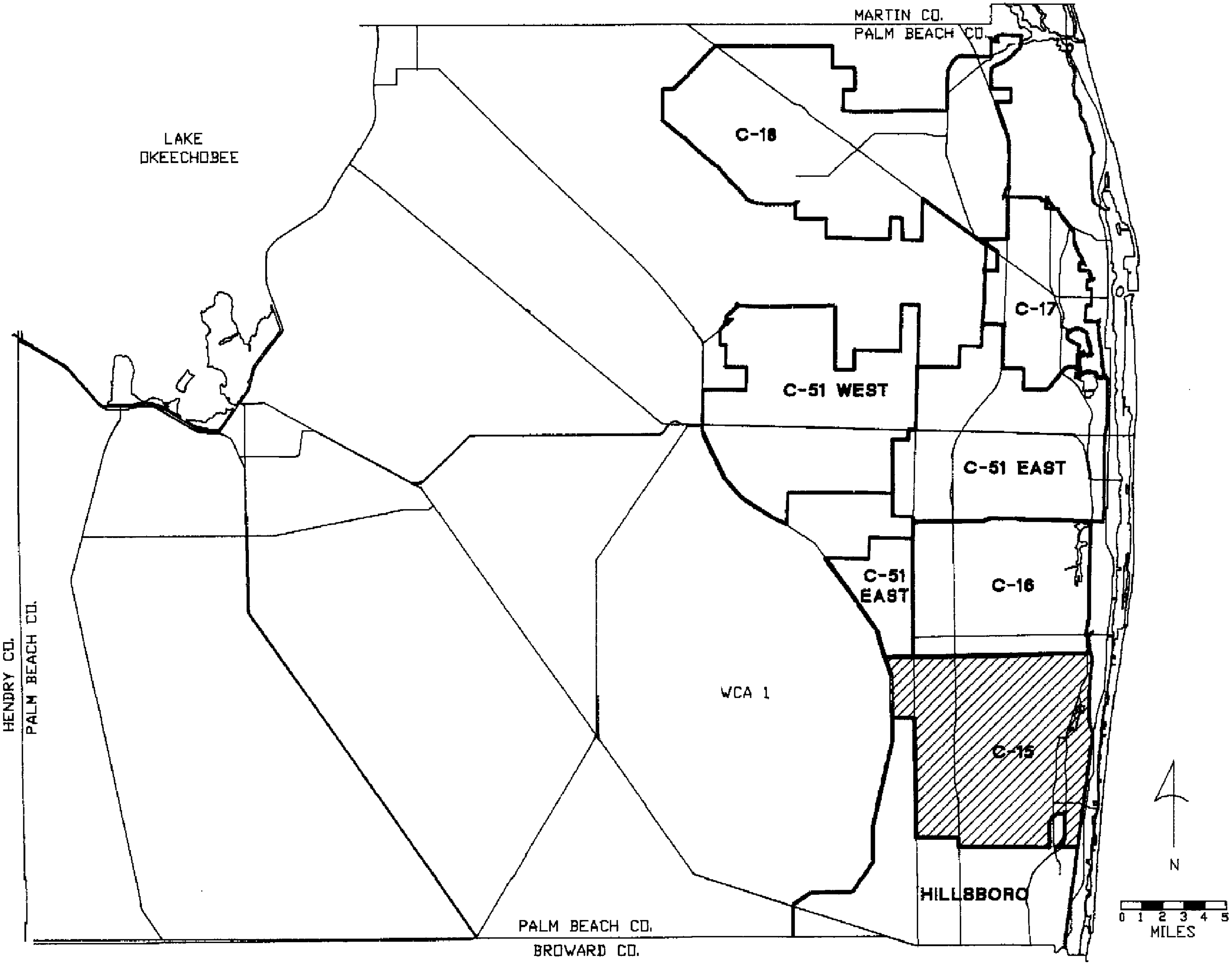

FIGURE 12 C-15 BASIN LOCATION MAP

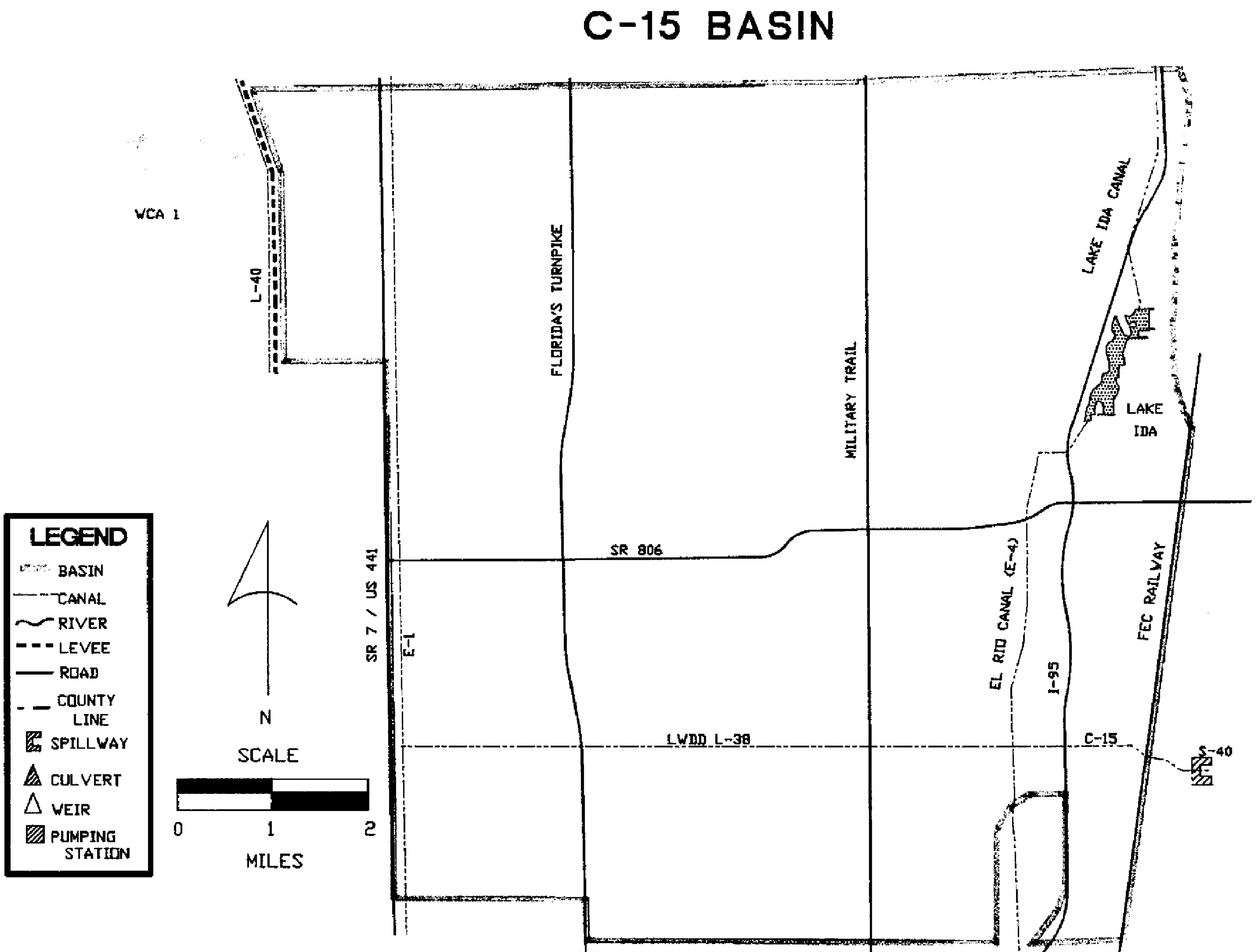

FIGURE 13. THE C-15 BASIN

TABLE 5. C-15 Basin Structures - Design Criteria

Structure	Type	Design HW Stage (ft NGVD)	Design TW Stage (ft NGVD)	Optimum Stage (ft NGVD)	Design Discharge (cfs)	Peak Stage (ft NGVD) Peak Discharge (cfs)	Date of Peak
S-40 Stage divide	Spillway, 2-gates 25ft x 9ft Crest lgth = 50ft Crest elev = -0.4 t NGVD	8.2	2.7	HW = 8.2	4800	HW = ~9.9 Q = 4050	4/25/79 4/25/79

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

HILLSBORO CANAL BASIN

Description of the Basin

The Hillsboro Canal basin has an area of approximately 102.5 square miles and is located in northeastern Broward County (62.3 square miles, Figure 14) and southeastern Palm Beach County (40.2 square miles). The basin boundary in Broward County relative to local roads and landmarks is shown on Map A. A schematic map showing the basin boundary, canals, and control structures is given in Figure 15.

The District operated and maintained canals and control structures in the Hillsboro Canal basin have five functions: (1) to provide flood protection and drainage for the basin, (2) to supply water to the basin during periods of low natural flow, (3) to convey excess water from Water Conservation Area (WCA) 1 to tidewater, (4) to intercept and control seepage from WCA 2A, and (5) to maintain a groundwater surface elevation west of Deerfield Lock adequate to prevent saltwater intrusion into local groundwater. Excess water in the basin is discharged to tidewater by way of the HIllsboro Canal and Deerfield Lock. Excess water in WCA 1 is discharged to the Hillsboro Canal by way of S-39 and subsequently to tidewater by way of Deerfield Lock. Deerfield Lock also regulates water surface elevations in the Hillsboro Canal. Water supply to the basin is from WCA 1 by way of S-39, from WCA 2A by way of seepage to the L-36 borrow canal, and from local rainfall. The seepage rate to the L-36 borrow canal is regulated by the stage held in the canal by S-39A and S-38B.

The section of the L-36 borrow canal between the Hillsboro Canal and S-38B is the only Project canal in the basin. The Hillsboro Canal is operated and maintained by the District, but is not a Project canal.

The Hillsboro Canal connects Lake Okeechobee to the Atlantic Ocean. It enters the basin through S-39 at the intersection of L-36 and L-40. Within the Hillsboro Canal basin, the Hillsboro Canal is aligned parallel to and just north of State Road 827 west of State Road 7 and parallel to and one-half mile north of State Road 810 east of State Road 7. Direction of flow in the canal is normally to the east with discharge to the Intracoastal Waterway just west of the intersection of A1A and State Road 810.

The L-36 borrow canal is aligned north-south along the western boundary of the basin and south of the Hillsboro Canal. The canal intercepts seepage from WCA 2A and is tributary to the Hillsboro Canal. Direction of flow in the canal is to the north to the Hillsboro Canal.

There are three Project control structures regulating flow in the Hillsboro Canal basin: S-38B, S-39, and S-39A. Deerfield Lock (G-56) regulates flow in the Hillsboro Canal, and it is operated and maintained by the District, but it is not a Project structure. Design criteria for these structures are given in Table 6.

S-38B is a gated culvert located in the alignment of the L-36 borrow canal just north of Wiles Road at the North Springs Improvement District pump station. The structure is always closed and acts as a divide between the Hillsboro Canal basin and the C-14 basin. The pump station discharges up to 110 cfs of water to either side of S-38B. This water is drainage from the southeast corner of the Hillsboro Canal basin.

S-39 is a gated spillway located in the alignment of the Hillsboro Canal at the intersection of L-39 and L-40. This structure regulates discharges from WCA 1 to the Hillsboro Canal basin. During normal operation S-39 is opened to supply water to the Hillsboro Canal basin as required to maintain the optimum stage at Deerfield Lock. When WCA 1 is over schedule the structure may be opened to discharge excess water in the WCA to tidewater, by way of the Hillsboro Canal, provided two conditions are met: (1) the water is not needed in WCA 2 or WCA 3 and (2) the Hillsboro Canal is not flowing to capacity (i.e., the tailwater stage at S-39 does not exceed 9.0 ft NGVD).

S-39A is a culvert located in the alignment in the L-36 borrow canal just south of the Hillsboro Canal. Control of water flow is effected by risers and flashboards. Together with S-38B this structure controls the seepage rate from WCA 2A to the L-36 borrow canal by regulating the water level in the borrow canal. Normally the structure is fully open and maintains a stage of 7.0 to 7.5 ft NGVD in the borrow canal. Runoff, pumped drainage, and seepage to the canal are discharged to the Hillsboro Canal by S-39A.

Deerfield Lock (G-56) is a flashboard controlled five-bay spillway and lock structure. A gated spillway has been constructed within the lock. Deerfield Lock is located in the alignment of the Hillsboro Canal about three-quarters of a mile west of I-95. It controls water surface elevations in the upper reach of the Hillsboro Canal, and it controls discharges to tidewater. In so far as is possible the headwater stage at Deerfield Lock is maintained at 7.7 ft NGVD. This is adequate to prevent saltwater intrusion into local groundwater.

Comments on Design and Historic Operation

There is no design storm for the Hillsboro Canal. It was built prior to the Project. The District assumed responsibility for the canal and Deerfield Lock from the Everglades Drainage District.

The Hillsboro Canal above Deerfield Lock will pass approximately 1600 cfs without any flooding occurring in the basin. This provides flood protection of approximately three-quarters of an inch of runoff per day; however, allowable runoff into the canal above Deerfield Lock is 1.3 inches of runoff per day (35 cfs per square mile). The total allowable inflow to the canal upstream of Deerfield Lock varies from 2500 to 2700 cfs depending on the drainage area assumed. A hydraulic analysis made in 1974 indicated that if all culverts and pumps discharging into the canal were operated at the allowable runoff discharge, the tailwater stage at S-39 would be approximately 11 ft NGVD. Stages above 9 ft NGVD cause flooding in pasturelands in the southwestern portion of the basin.

To pass the allowable discharge at a stage no higher than 9.0 ft NGVD would require enlarging the Hillsboro Canal from Powerline Road to the west end at S-39. It would also require a new structure (to replace the spillway at Deerfield Lock) capable of passing approximately 3000 cfs at a difference between headwater and tailwater stages of 0.5 feet.

Most inflows to the Hillsboro Canal are from Lake Worth Drainage District canals in Palm Beach County. Because some of the north-south flowing LWDD canals do not have divide structures between the Hillsboro Canal basin and the C-15 basin (nor between the C-15 basin and the C-16 basin), some interbasin transfer of water may occur. This is especially true in the western portions of the C-15 and C-16 basins. Land in the C-15 and C-16 basins between L-40 and the Florida Turnpike may, under some conditions, drain to the Hillsboro Canal by way of LWDD canals E-1 and E-3.

The stage held in the LWDD canals determines to some extent whether runoff in the basin enters the Hillsboro Canal upstream or downstream of Deerfield Lock. The drainage area upstream of Deerfield Lock may vary by as much as several square miles as the stages in the LWDD canals, especially E-3, vary. E-3 flows to the south one-half mile to the west of and parallel to Military Trail. It enters the Hillsboro Canal just downstream of Deerfield Lock. LWDD typically operates E-3 at a stage of 10 ft NGVD. At this stage, E-3 drains lands as far west as Florida's Turnpike, subtracting considerably from land that would otherwise drain to the upstream side of Deerfield Lock.

During severe storms the Hillsboro Canal develops flows to the east and to the west. The westward flow usually starts at U. S. Highway 441 or as far west as the LWDD canal E-1/2W approximately three miles west of U. S. Highway 441. The westward flow has a duration of 36 to 48 hours and causes flooding of pasturelands in the southwestern portion of the basin. The peak stage of the westward flow probably occurs one-half to three-quarters of a mile west of U. S. Highway 441. Owners of new developments in the southwestern portion of the basin are required to hold all of the runoff from their property for 48 hours. If the tailwater stage at S-39 exceeds 12.5 ft NGVD, the developers must also accept inflows of water from outside their property and hold it in their reservoirs.

Peak discharges and headwater stages in the basin occurred during the April 25, 1979 storm. The peak discharge at Deerfield Lock was 3700 cfs with an average flow for the day of 3030 cfs. Discharges above 3000 cfs cause flooding in the Boca Raton area and in the area west of U. S. Highway 441. The peak headwater stage at Deerfield Lock was 10.86 ft NGVD with an average for the day of 8.79 ft NGVD. The average tailwater stage on April 25 was 5.51 ft NGVD, and on April 26, it was 6.95 ft NGVD.

Peak tailwater stages occurred during the October 15, 1965 storm. Peak stage at the west end of the Hillsboro Canal at S-39 was 12.39 ft NGVD. At Deerfield Lock, the peak tailwater stage was 9.2 ft NGVD.

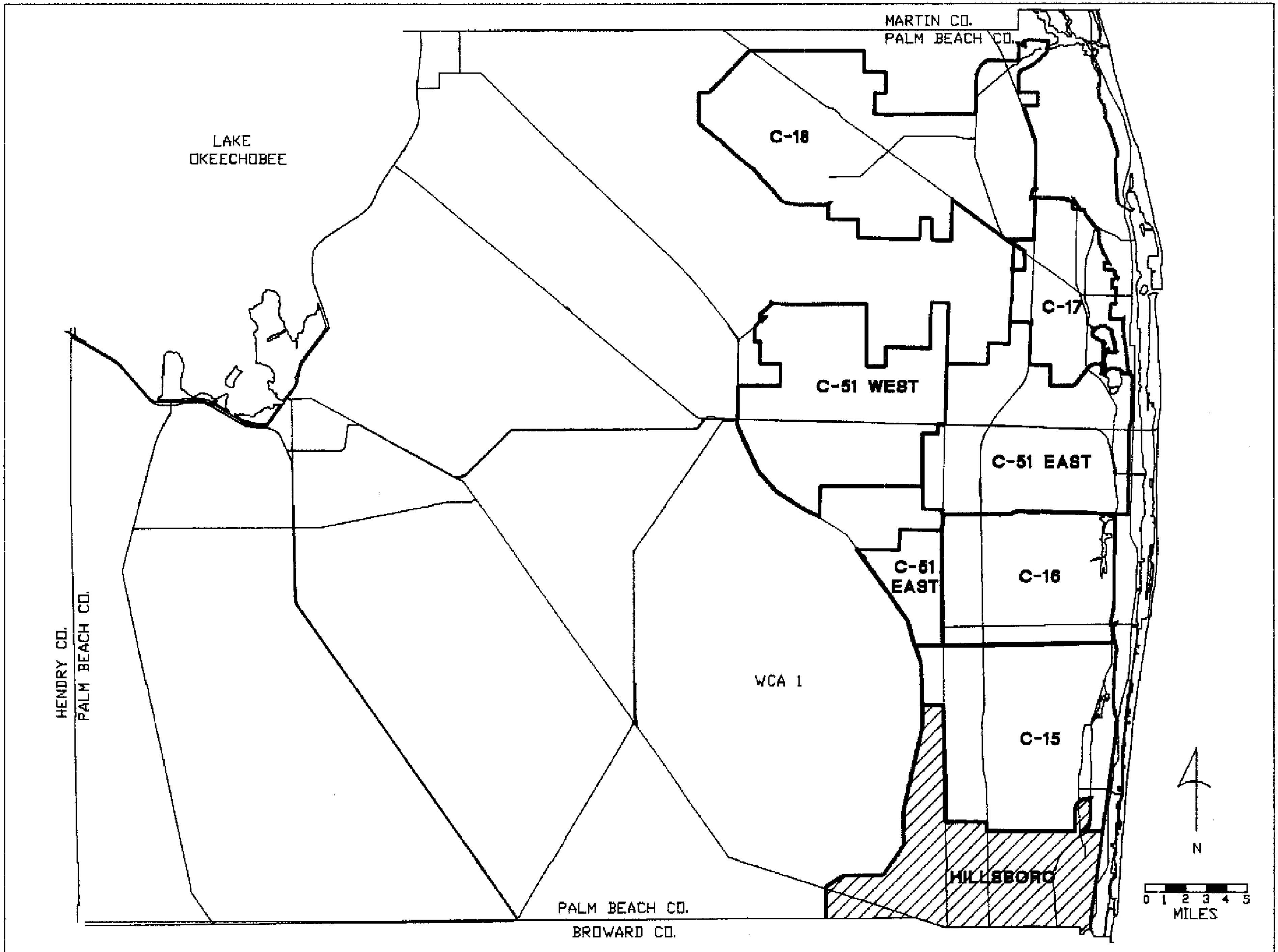

FIGURE 14 HILLSBORO BASIN LOCATION MAP

HILLSBORO CANAL BASIN

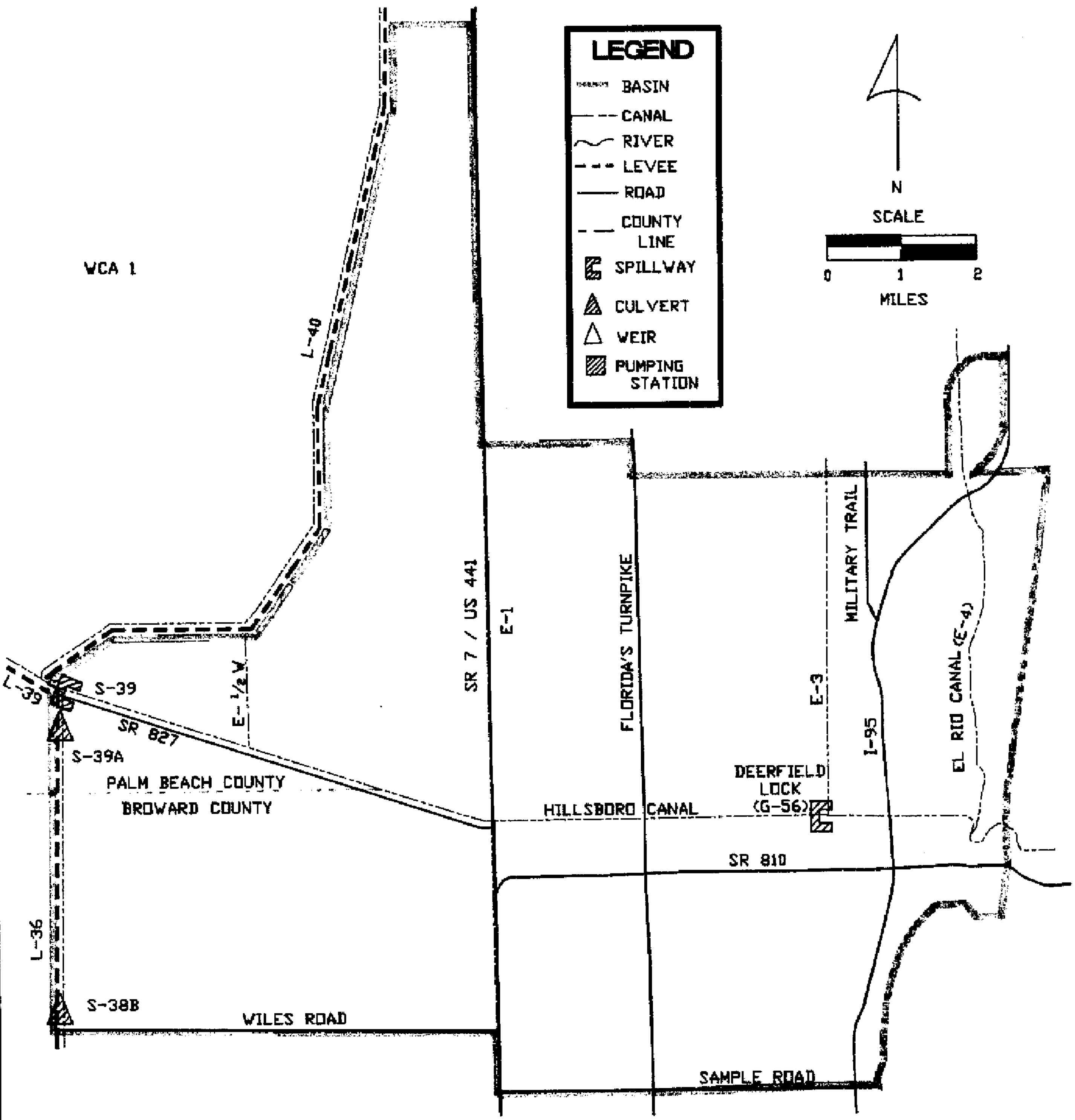

FIGURE 15. THE HILLSBORO CANAL BASIN

TABLE 6. Hillsboro Canal Basin Structures - Design Criteria

Structure	Type	Design HW Stage (ft NGVD)	Design TW Stage (ft NGVD)	Optimum Stage (ft NGVD)	Design Discharge (cfs)	Peak Stage (ft NGVD) Peak Discharge (cfs)	Date of Peak
Deerfield Lock (G-56) Stage divide	Flashboard lgth = 65ft. (5-bays) Crest elev = 1.0ft NGVD Lock width = 25ft Crest elev = -5.0 ft.	4.0	3.5	HW = 7.7	1600	HW = 10.86 TW = 9.2 Q = 3700	4/25/79 10/15/65 4/25/79
S-39 Water supply and regulatory releases to Hillsboro Canal from WCA-1	Spillway Tainter Gate 16ft x 9.2ft Weir lgth = 15ft. Crest elev = 2.5ft NGVD	11.0	9.0	TW = 9.0 max. HW = WCA 1 Regulation schedule	800	TW = 12.39	10/15/65
S-39A Stage divide	Culvert 3-72in x 54ft. CMP with riser and boards			HW = 7.0-7.5			
S-38B Divide C-14 and Hillsborto Basins	Gated Culvert 1-65in x 72ft. CMP Invert elev = 0ft NGVD	9.0	7.65				

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

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APPENDIX 1 - BASIC CONCEPTS

Runoff and Drainage - Several things can happen to rain after it falls to earth. At the beginning of a rain event, the rain will most likely seep into, or "infiltrate", the soil. As soil becomes saturated, however, the rain will tend to pool on the surface of the ground in puddles or ponds. These detention areas have only a limited storage volume, and when their capacity is exceeded, the excess water will flow downhill to the nearest stream or canal. That part of the rainfall that "runs off" of the soil surface to enter local streams is termed "surface runoff". Of the water that is detained on the surface, some will evaporate and the balance will eventually seep into the ground.

Water seeping into the ground enters a reservoir of subsurface water known as groundwater. Since, in south Florida, many soils are very sandy and underlying rock strata tend to be very porous, water flows easily between surface water and groundwater. The surface of the groundwater is known as the "water table". When the water table level is higher than local surface water levels, water will enter the surface water from groundwater. When the water table is lower than the local surface water level, flow is from surface water to groundwater. In general, groundwater supplements stream flow during periods of low rainfall, and surface water recharges groundwater storage during periods of high rainfall. Although subsurface flow from groundwater to surface water is important to the long term supply of water to a canal or stream (it is sometimes referred to as "base flow"), it does not make significant contributions, if at all, to streamflow during storm events with high rainfall.

In the context of these basin descriptions, the term drainage is used to refer to the total surface and subsurface flows entering a canal from its drainage basin. It may be useful to keep in mind, however, that during a rain event (especially one severe enough to cause flooding), it is surface runoff that is the important contributor to this flow, and at times between rain events, subsurface flow from groundwater to surface water is most important.

Runoff from an area is influenced by several factors: how much rain has fallen recently, the depth to the water table, and how the land in the area is used. The amount of recent rain, and the depth to the water table dictate how much water is in the soil. The degree to which the soil is saturated, in turn, determines how much of the falling rain may infiltrate the soil, and thus, how much of the rain will run off to local streams.

Land use has a large impact on the amount of surface runoff entering local streams and canals. For example, most of the surface area in an urban area (e.g., roofs, roads, and parking lots) is impervious to water. Almost all the rain impacting these areas becomes surface runoff. Some water may be detained and will evaporate, but the percentage of rainfall that enters local canals or streams by surface flow in an urban area can be quite high. As a result, urban areas are subject to high stream flows (flooding) during rain events.

A vegetated area intercepts and retains a large part of the rainfall, and subsequent surface runoff from a rain event. This intercepted water has additional opportunity to evaporate or seep into the ground. In general, a smaller percentage of the rain falling on a vegetated area will enter local streams and canals as surface runoff than a comparable urban area. As a result, stream flows in vegetated areas are moderated compared to urban areas.

Drainage Basin - If rains falls over a large enough area, some of the runoff from that storm will likely enter one stream, and some of it will enter another stream. It is said that those streams "drain" different basins, that they are in different "drainage basins". The drainage basin of a stream is all the land that contributes runoff to the stream or its tributaries. It is usually specified to be the land draining to the stream upstream of a given point, such as the mouth of the stream. The boundary between drainage basins is termed a "divide". Runoff is divided along the boundary, runoff on one side of the boundary flowing to one stream, and runoff on the other side of the boundary flowing to another stream.

Water Surface Elevations - A water surface elevation in a canal is the distance from the water's surface to some reference elevation or "datum". In the District, all elevations are relative to the National Geodetic Vertical Datum (NGVD). Water surface elevations are measured in feet (ft). Water surface elevations may also be referred to as "stages".

Important water surface elevations are the headwater (upstream) stage, and the tailwater (downstream) stage at the control structures (see **Control Structures**). The difference between these stages will affect the flow through or over the structure. Gravity flow is always from the highest to lowest elevation and, in general, flow increases as the difference in elevation increases. Note that in some basins, pumps are used to move water from lower to higher elevations.

Water surface elevations anywhere else in the canal are also important. Obviously, if the stage exceeds the elevation of the top of the canal, flooding will result. Not as obvious is the fact that the stage in the canal largely determines the water table elevation of the local groundwater (see **Runoff and Drainage**). The stage in the lower reaches (near the ocean) in some canals is maintained at levels high enough to prevent intrusions of saltwater into the local groundwater. In other areas, stages are maintained that keep water table elevations low enough to prevent drainage problems in low lying areas.

Control Structures - The structures referred to in the basin descriptions are devices (e.g., weirs, spillways, and culverts) placed in the canals to control water surface elevations (stage divide), amount of flow (stage divide or water supply structure), or direction of flow (divide structure) in the canals. A structure may have more than one function. In general, a stage divide controls water surface elevation upstream of the structure, and it controls water flow (or discharge) downstream of the structure. A divide structure is usually located at or near a basin boundary. It prevents water in one basin from entering the other basin. A water supply structure is also usually located near a basin boundary. It is used to pass water from one canal to another (i.e., from one basin to another).

Hydraulic Analysis - A set of water surface elevations taken along the length of a canal is known as the hydraulic profile of the canal. The elevations always increase upstream. This, in the simplest sense, says that water runs downhill, but it has more important implications for design of canals and structures. The water surface elevations are a function of the size and shape of the canal, the amount and location of inflow to the canal, the roughness and slope of the canal, and the downstream water surface elevation of the canal (often determined by some control structure). Canals are designed to pass a certain amount of flow without over-topping their banks. Designing a canal and its structures consists of selecting values for the factors listed above for which none of the water surface elevations of the resulting hydraulic profile exceed the elevation of the banks of the canal for the design discharge. Since the design discharge is given, and to a large extent the slope of the canal is determined by the topography of the basin, it is the size and shape of the canal, and the downstream water surface elevation (to be maintained by some structure), that are varied to achieve a successful design. (The downstream structure must also be large enough to pass the design discharge.) Because the factors that determine the water surface elevations are either known or can be reasonably estimated, it is possible to calculate the hydraulic profile of a proposed canal design. In this way an appropriate design can be selected. Similarly, calculation of the hydraulic profile, can be used to determine the flood protection provided by a canal constructed without regard to a specific design storm, or for a canal that has been modified with regard to its design specifications. For example, increasing the cross-sectional area of a canal will, in general, allow the canal to pass a given flow at stages lower than before enlargement (i.e., the hydraulic profile is lowered). Hydraulic analysis may determine for this canal that the flood protection has increased, that is, the canal can now pass the runoff from a storm more severe than the design storm.

Design Storm - The design storm for a basin is the most severe storm for which the canals and structures in the basin will accommodate that storm's runoff without flooding occurring in the basin. Sometimes a basin is described as having "flood protection" up to a certain design storm.

A severe storm is described by the frequency with which it may occur. On a long term average a storm of given intensity may occur, for example, once in every ten years (i.e., the storm has a ten percent chance of occurring in any given year). This is written as 1-10 years, and is read as one in ten years. It must be emphasized, however, that a storm of a given intensity can occur at any time regardless of the frequency assigned to it. For example, two severe storms, of an intensity that occurs on average only once in every one hundred years (1-100 year storm), occurred in northern Palm Beach County within three months of each other in the early 1980s.

The Army Corps of Engineers specifies a Standard Project Storm (SPS) for south Florida. The rainfall amounts for the SPS are those for a 1-100 year storm increased by 25 percent. The storm is assumed to occur during the hurricane, or wet season, when water tables are high and soils are wet. These conditions will maximize the runoff from the storm. The runoff from the SPS is designated the Standard Project Flood (SPF). The capacity of a canal and its structures may be given as a percentage of the SPF (e.g., 40 percent SPF). The storm that would generate this amount of runoff is given by its recurrence interval (e.g., 1-10 years). Note that it is implicitly assumed that these storms occur for antecedent weather conditions that will maximize the runoff from the storm in the basin of interest.

A severe storm of a certain frequency may not generate the same amount of runoff in different basins of the same size even when antecedent weather conditions or water table elevations for the basins are similar. Land use in the basins will also affect the relative amounts of surface runoff to be expected from the basins (see **Runoff and Drainage**). Urban areas will have relatively more surface runoff than will more vegetated areas.

The amount of runoff to be expected per unit area for design storms at various recurrence intervals, antecedent conditions, and land use can be found in the Army Corps of Engineers' General Design Memorandum (GDM) for the Project. The runoff calculated to occur for a given set of storm frequency, antecedent conditions, and land use is the design discharge. It should be noted that land use in Palm Beach County has changed considerably since the GDM was written.

APPENDIX 2 - GLOSSARY

Designations Given to District Works

C-XXX The letter C followed by a number, designates a Central and Southern Florida Flood Control Project canal. For example, C-111 reads as "Canal 111".

G-XXX The letter G followed by a number, designates a Central and Southern Florida Flood Control Project structure (see **Control Structures,** under **Basic Concepts**). For example, G-72 reads as "Control Structure 72". G structures were built by the District.

L-XXX The letter L followed by a number, designates a Central and Southern Florida Flood Control Project levee. For example, L-38E reads as "Levee 38 east".

S-XXX The letter S followed by a number, designates a Central and Southern Florida Flood Control Project control structure (see **Control Structures,** under **Basic Concepts**). For example, S-26 reads as "Control Structure 26". S structures were built by the U.S. Army Corps of Engineers.

Terms

District

This refers to the South Florida Water Management District (formerly the Central and South Florida Flood Control District), the agency which operates and maintains the Project.

Free Digging Contract

This refers to an agreement between the District and an outside party whereby that party excavates a canal (or a portion of a canal). The outside party receives the excavated material as payment for the excavation. The material is generally used as fill for residential and commercial development.

General Design Memorandums

This is a document prepared by the U.S. Army Corps of Engineers that reports all work done preliminary to preparation of the final design of a project. In the General Design Memorandum for the Central and Southern Florida Flood Control Project:

- the basins are delineated.
- a design storm is specified and the resulting runoff is estimated for each basin.
- the flood protection to be afforded each basin is identified.
- the size of canals, and the size and number of control structure is determined.

The final design of the canals and structures is given in the Detailed Design Memorandum.

1-XXX Year

This designates the recurrence interval for a design storm (see **Design Storm**, under **Basic Concepts**). For example, "1-100 year storm" reads as one in one-hundred year storm.

Project

This refers to the Central and South Florida Flood Control Project. The Project has been responsible for the construction of most of the major canals and structures in south Florida.

Regulation Schedule

A regulation schedule specifies the level of water to be held in a reservoir (e.g., a WCA) as a function of the time of year.

Regulatory Release

A regulatory release is water discharged from a reservoir (e.g., a WCA) to lower the water level in the reservoir to the regulation schedule.

Water Conservation Areas

The five Water Conservation Areas (WCAs 1, 2A, 2B, 3A, and 3B) are located in western Dade and Broward Counties and in central Palm Beach County. Only WCA 1 borders on basins described in this publication (Figure 1). The WCAs are remnants of the original everglades in South Florida. Water is impounded in the WCAs by Project levees, and water flow into and out of the WCAs is regulated by various Project control structures. The WCAs are managed to store water and to provide viable wetlands habitat. Water is stored in the WCAs according to a set of regulation schedules, one for each WCA. A regulation schedule specifies the level of water to be held in the WCA at any time during the year. When the water level in a WCA exceeds its schedule, water is released from the WCA through the structures on its periphery. These are called regulatory releases. If the water level in a WCA is below the regulation schedule, releases from the WCA are restricted. During periods of low natural flow, water stored in WCA 1 can be supplied to the C-51 basin and to the Hillsboro Canal basin.

ABBREVIATIONS

cfs : cubic feet per second

ft : Feet

GDM : General Design Memorandum

NGVD : National Geodetic Datum (see **Control Structures**, under **Basic Concepts)**

SPF : Standard Project Flood (see **Design Storm**, under **Basic Concepts)**

SPS : Standard Project Storm (see **Design Storm**,under **Basic Concepts)**

WCA : Water Conservation Area