TECHNICAL MEMORANDUM

AN ATLAS OF THE EVERGLADES AGRICULTURAL AREA SURFACE WATER MANAGEMENT BASINS

By

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AN ATLAS OF THE EVERGLADES AGRICULTURAL AREA SURFACE WATER MANAGEMENT BASINS

EXECUTIVE SUMMARY

This atlas discusses the water management facilities of the primary drainage system of the surface water management basins of the Everglades Agricultural Area (EAA). The EAA comprises those lands south and southeast of Lake Okeechobee, Florida, that were originally part of the natural Everglades system, but have been drained and put into agricultural production. The EAA includes lands in four south Florida counties: Palm Beach, Martin, Hendry, and Glades.

The primary system of levees, canals, and water control structures in the EAA was designed and built by the U.S. Army Corps of Engineers (COE) under the Central and Southern Florida Project for Flood Control and Other Purposes (Project). The Project provides flood protection, water control, and agricultural water supply for the EAA; conveyance of water supply releases from Lake Okeechobee to Everglades National Park and to eastern Palm Beach, Broward and Dade counties for municipal and agricultural water supply and to maintain optimum groundwater levels to prevent saltwater intrusion; and conveyance of regulatory releases from the lake to the Water Conservation Areas. The South Florida Water Management District (District) manages the day to day operation and maintenance of the Project; however, the COE has final authority over the operation of the structures in the Project. The Project is dynamic with new structures being constructed and old structures and old water management practices being modified to meet the changing needs of southern Florida.

By text, maps, and tables of information the Project canals and water control structures of nine surface water management basins are described. The nine basins considered are the L-8, S-2, S-3, S-4, S-5A, S-6, S-7, S-8, and S-236 basins. The basins have a combined area of 1181 square miles and are served by 15 Project canals and 25 Project water control structures. The design level of flood protection for all basins is three-quarters of an inch of runoff per day except for the City of Clewiston which is allowed four inches of runoff per day.

The Project canals in the EAA provide the means by which water is conveyed from one place to another for purposes of flood control, drainage, agricultural and municipal water supply, and regulatory releases from Lake Okeechobee. The canals were sized to provide for conveyance of water at a rate of three quarters of an inch of runoff per day for flood protection or at a rate of 4.3 cfs per square mile of area served for agricultural water supply. The canals can pass regulatory discharges from Lake Okeechobee up to their design capacities for flood protection and water supply.

The Project water control structures in the EAA 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 periods of low natural flow. Some structures are usually closed to prevent water from passing from one basin to another, however, they can be opened to supply water from one basin or canal to another as necessary.

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

SUMMARY INFORMATION

BASIN	PROJECT CANALS	PROJECT CONTROL STRUCTURES	DESIGN LEVEL OF FLOOD PROTECTION	PRIMARY FUNCTIONS OF CANALS AND STRUCTURES
L-8	• L-8 BORROW CANAL • L-8 TIEBACK LEVEE BORROW CANAL • NORTH TIEBACK LEVEE BORROW CANAL	S-5A S-5AW S-5AS S-76 S-5AE CULVERT #10A	3/4 INCH OF RUNOFF PER DAY ACTUAL RATE DEPENDS ON CONDITIONS IN THE S-5A AND C-51 BASINS AND ON WATER LEVELS IN LAKE OKEECHOBEE AND WCA 1	• PROTECT THE AGRICULTURAL AREAS TO THE SW OF L-8 BY INTERCEPTING SURFACE WATER FLOWS ORIGINATING IN THE L-8 BASIN • FLOOD PROTECTION • WATER CONTROL • WATER SUPPLY TO THE L-8 BASIN AND EASTERN PALM BEACH COUNTY • TRANSFER WATER FROM WCA 1 TO LAKE OKEECHOBEE
S-5A	• L-10 /L-12 BORROW CANAL (WEST PALM BEACH CANAL) • L-13 BORROW CANAL (CROSS CANAL)	S-5A S-5AW S-5AS S-352 S-5AE S-5AX	3/4 INCH OF RUNOFF PER DAY	• FLOOD PROTECTION • WATER CONTROL • WATER SUPPLY TO THE S-5A BASIN AND EASTERN PALM BEACH COUNTY • REGULATORY RELEASES FROM LAKE OKEECHOBEE TO WCA 3
S-2	• L-14/L-15 BORROW CANAL (HILLSBORO CANAL) • L18/L-19 BORROW CANAL (NORTH NEW RIVER CANAL)	S-2 S-7 S-5AX S-150 S-6 S-351	3/4 INCH OF RUNOFF PER DAY	• FLOOD PROTECTION • WATER CONTROL • WATER SUPPLY TO THE S-2, S-6, AND S-7 BASINS AND EASTERN PALM BEACH AND BROWARD COUNTIES • REGULATORY RELEASES FROM LAKE OKEECHOBEE TO WCA 3, 1, 2A AND 3A
S-6	• L-14/L-15 BORROW CANAL (HILLSBORO CANAL) • L-6 BORROW CANAL	S-2 S-5AX S-6 S-351	3/4 INCH OF RUNOFF PER DAY	• FLOOD PROTECTION • WATER CONTROL • WATER SUPPLY TO THE S-6 BASIN AND EASTERN PALM BEACH AND BROWARD COUNTIES • REGULATORY RELEASES FROM LAKE OKEECHOBEE TO WCA 1
S-7	• L18/19 BORROW CANAL (NORTH NEW RIVER CANAL) • L-6 BORROW CANAL • L-5 BORROW CANAL	S-2 S-7 S-150 S-351	3/4 INCH OF RUNOFF PER DAY	• FLOOD PROTECTION • WATER CONTROL • WATER SUPPLY TO THE S-2, S-6, AND S-7 BASINS AND TO EASTERN PALM BEACH AND BROWARD COUNTIES • REGULATORY RELEASES FROM LAKE OKEECHOBEE TO WCA 2A AND 3A
S-3	• L23/L-24 BORROW CANAL (MIAMI CANAL)	S-3 S-8 S-354	3/4 INCH OF RUNOFF PER DAY	• FLOOD PROTECTION • WATER CONTROL • WATER SUPPLY TO THE S-3 AND S-8 BASINS, EASTERN DADE COUNTY, AND ENP • REGULATORY RELEASES FROM LAKE OKEECHOBEE TO WCA 3A
S-8	• L23/L-24 BORROW CANAL (MIAMI CANAL) • L-4 BORROW CANAL	S-3 S-8 S-354 G-88	3/4 INCH OF RUNOFF PER DAY	• FLOOD PROTECTION • WATER CONTROL • WATER SUPPLY TO THE S-8 BASIN, EASTERN DADE COUNTY AND ENP • REGULATORY RELEASES FROM LAKE OKEECHOBEE TO WCA 3A
S-236	• L-D2 BORROW CANAL	S-236 CULVERT #3	3/4 INCH OF RUNOFF PER DAY	• FLOOD PROTECTION • WATER CONTROL • INTERCEPT SEEPAGE THROUGH L-D2 •WATER SUPPLY
S-4	• C-21 • C-20 • L-D1/L-D3 BORROW CANAL	S-4 CULVERT #1 S-169 CULVERT #1A S-235 CULVERT #2 S-310	AGRICULTURAL LANDS: 3/4 INCH OF RUNOFF PER DAY CITY OF CLEWISTON: 4 INCHES OF RUNOFF PER DAY	• FLOOD PROTECTION • WATER CONTROL • INTERCEPT SEEPAGE THROUGH L-D1 AND L-D2 • WATER SUPPLY

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

An atlas of the water management facilities of the primary drainage system of the surface water management basins of the Evergaldes Agricultural Area is presented. The Everglades Agricultrual Area comprises those lands south and southeast of Lake Okeechobee, Florida that were originally part of the natural Everglades system, but have been drained and put into agricultural production. By text, maps, and tables of information the surface water management basins, structures, and water management practices of the Central and Southern Florida Project for Flood Control and Other Purposes are described and discussed. The 15 canals and 25 water control structures discussed provide flood protection and agricultural water supply to 1181 square miles. The design level of flood protection for all the basins is three quarters of an inch of runoff per day except for the City of Clewiston which is allowed four inches of runoff per day. Water can be supplied to the area at a design rate of 4.3 cfs per square mile of area served. In addition to flood protection for and water supply to the Everglades Agricultural Area, the canals and water control structures provide conveyance for regulatory releases from Lake Okeechobee to the Water Conservation Areas, for water supply releases to eastern Palm Beach, Broward, and Dade counties for municipal water supply and to prevent saltwater intrusion, and for water supply releases to Everglades National Park.

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AN ATLAS OF THE EVERGLADES AGRICULTURAL AREA SURFACE WATER MANAGEMENT BASINS

INTRODUCTION

This atlas discusses the water management facilities of the primary drainage system of the surface water management basins of the Everglades Agricultural Area (EAA). The EAA comprises those to lands south and southeast of Lake Okeechobee, Florida, that were originally part of the natural Everglades system, but have been drained and put into agricultural production. The EAA includes lands in four south Florida counties: Palm Beach, Martin, Hendry, and Glades.

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 primary system of levees, canals, and water control structures in the EAA was designed and built by the COE under the Central and Southern Florida Project for Flood Control and Other Purposes (Project). The District manages the day to day operation and maintenance of the Project and is the agency primarily responsible for permitting surface water drainage and water use in the EAA. The COE, however, has final authority over the operation of the structures in the Project.

The Project is dynamic. As the population of 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 and other parts have been rebuilt or modified. As the need has arisen, new water control structures, canals, and levees have been designed and constructed and new water management practices implemented. In some cases, the basins themselves have been redefined. As the COE cannot always participate in construction of new works, the District has occasionally designed and constructed additions or modifications to the Project, subject to COE approval.

The District has sponsored publication of this atlas so that up to date non-technical descriptions of the surface water management basins in the EAA are available to District personnel, to local governments or drainage districts within the EAA, and to other interested persons. Text, maps, and tables of information are used to define and locate basins within the EAA and to describe and discuss with regard to their operation and management the canals, levees, and control structures within each basin that are under the management of the District or the COE.

The current surface water management basins of the EAA and the associated Project structures were first defined in 1951 by the COE in their Partial Definite Report, Part 1, Agricultural and Conservation Areas (with Preliminary Information on Lake Okeechobee and Principal Outlets), Central and Southern Florida Project for Flood Control and Other Purposes. Further refinements in design parameters and basin boundaries were made in subsequent general design memorandums (GDMs). Based on the hydrology of the basins, the COE designed and constructed a system of canals, levees, and control structures for the EAA to provide flood protection, water control, and agricultural water supply for the EAA; to convey water from Lake Okeechobee to Everglades National Park for environmental benefit and to the eastern Palm Beach, Broward and Dade counties for municipal and agricultural water supply and to maintain optimum groundwater levels to prevent saltwater intrusion; and to convey regulatory releases from the lake to the Water Conservation Areas.

The Project canals and water control structures of nine surface water management basins are described in this atlas. The nine basins considered are the L-8, S-2, S-3, S-4, S-5A, S-6, S-7, S-8, and S-236 basins. The L-8, S-4 and S-236 basins are not strictly part of the EAA as most of the lands in the these basins were not originally Everglades and are characterized by sandy rather than organic soils. These basins are included in this atlas because they are closely tied to the EAA, Lake Okeechobee, or the Water Conservation Areas by hydrology and water management.

Following the basin descriptions is a bibliography of publications related to the surface water management basins in the EAA. 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 EAA, 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 is a discussion of the important concepts with which the reader should be familiar with 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 water control structures.

Using the Basin Descriptions

Surface water management basins (hereafter drainage basins) in the EAA are identified by the same designation as the major Project structure or canal located in that basin. For example, S-7 is a pumping station serving a basin in the south-central EAA. The basin is called the S-7 basin. On the other hand, the L-8 basin is named for the L-8 borrow canal which is the major Project canal in that basin.

The drainage basins in the EAA are shown in Figure 1. Map A (folded and placed in the pocket of the flyleaf) is a large map showing the basin boundaries, 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 EAA.

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 EAA; the purpose and general operation of canals in the basin; the alignment of these canals and the direction of water flow; 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**, Appendix 1); 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 the EAA. 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 EAA. 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 specified discharge under specified conditions of upstream and downstream water levels, this information is included as the design discharge, design headwater stage, and design tailwater 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 discharge 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 if considered relevant.

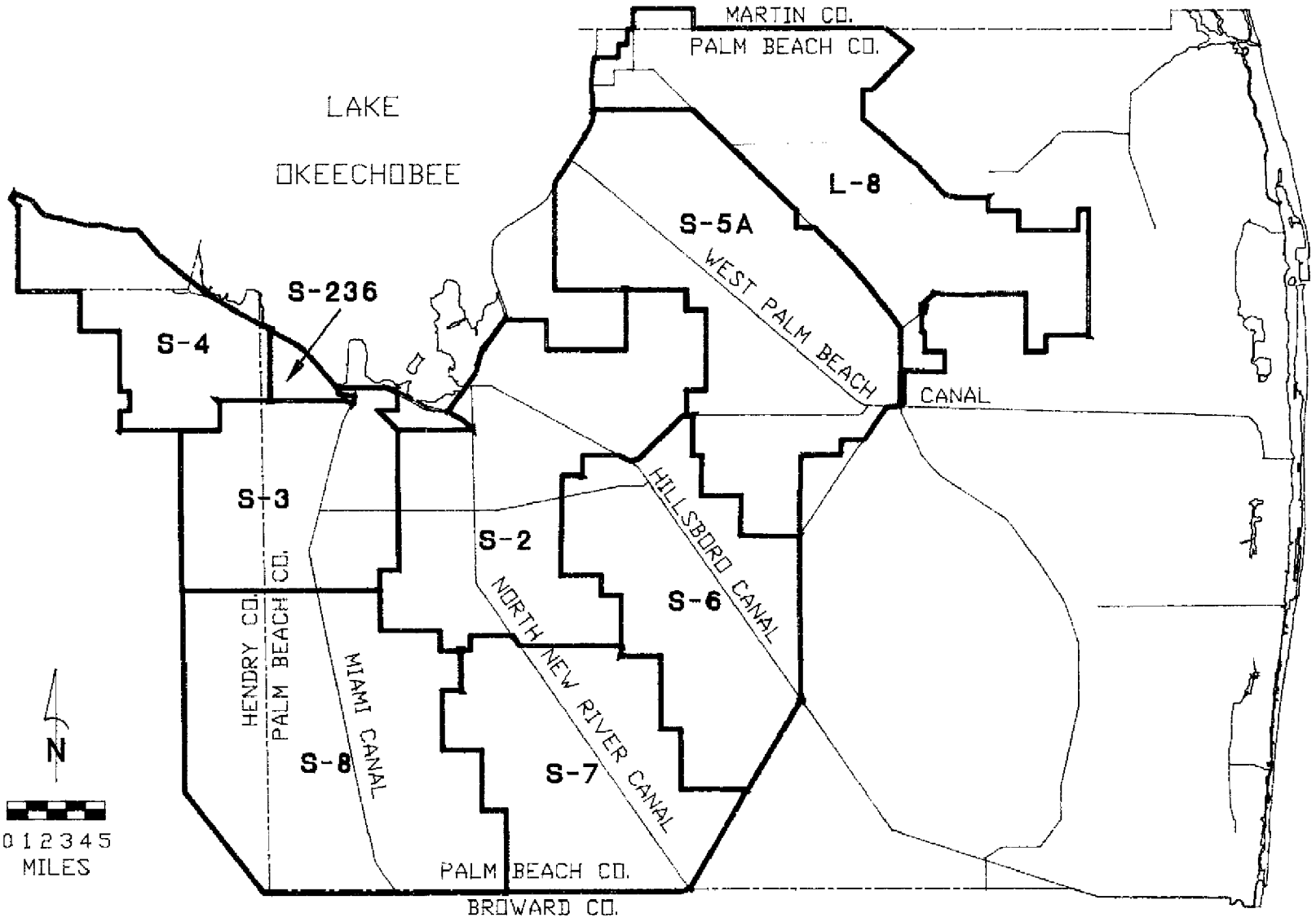


FIGURE 1. THE EVERGLADES AGRICULTURAL AREA DRAINAGE BASINS

L-8 BASIN

Description of the Basin

The L-8 drainage basin is 171.2 square miles in area and is located (Figure 2) in northwestern Palm Beach County (168.1 square miles) and southwestern Martin County (3.1 square miles). The basin boundary relative to local roads and landmarks is shown on Map A. A schematic map showing the L-8 basin boundary, canals, and water control structures is given in Figure 3.

The Project canals and water control structures in the L-8 basin have four primary functions: (1) to protect the agricultural areas to the southwest of the L-8 basin by intercepting surface water flows originating in the L-8 basin, (2) to remove excess water from the L-8 basin to storage in either Lake Okeechobee or Water Conservation Area 1 (WCA 1), (3) to supply water from Lake Okeechobee or WCA 1 to the L-8 basin for irrigation of agricultural lands, and (4) to transfer water from storage in WCA 1 to Lake Okeechobee. Excess water can be discharged from the L-8 basin in one of three ways: (1) to Lake Okeechobee by way of Culvert #10A; (2) to tidewater by way of S-5AE; and (3) to WCA 1 by way of either S-5AS, or S-5AW and S- 365A. Water is supplied to the L-8 basin from Lake Okeechobee by way of Culvert #10A, from WCA 1 by way of S-5AS, and from the S-5A basin by way of S-5AW. The L-8 borrow canal is used to transfer water from storage in WCA 1 to storage in Lake Okeechobee. These transfers are made by gravity flow from the WCA through S-5AS to the borrow canal and are subsequently discharged to the lake by way of Culvert #10 A. The conditions that make such a treansfer desirable and possible rarely occur.

The Project canals and water control structures in the basin have two secondary functions: (1) to supply water from the L-8 basin, WCA 1, or Lake Okeechobee to the City of West Palm Beach water supply system and (2) to accept discharges of excess water from the West Palm Beach water supply system. Water is supplied to the City of West Palm Beach municipal water supply system from the L-8 basin by way of a city owned and operated pump station located at the junction of the L-8 Tieback Levee borrow canal and the City of West Palm Beach's "M" Canal. A spillway adjacent to this pump station discharges excess water from the "M" Canal to the L-8 basin.

Occasionally the L-8 borrow canal is used to provide conveyance of regulatory releases from Lake Okeechobee to WCA 1 or tidewater. The releases are made to the L-8 borrow canal by way of Culvert #10A and subsequently are discharged to WCA 1 by way of S-5AS or S-5A. Regulatory releases by way of the L-8 borrow canal are rare occurrences. They are more likely to be made by way of the four agricultrual canals: The L-10/L-12 borrow (i.e., the West Palm Beach Canal), the Miami, the North New River, and the Hillsboro. West of the L-8 borrow canal the West Palm Beach Canal is known by its Project name, the L-10/L-12 borrow canal. East of the L-8 borrow canal, its Project name is C-51. Although the Project names for the West Palm Beach Canal are not as widely used as West Palm Beach Canal, they will be used in the discussion that follows to avoid any confusion as to the part of the West Palm Beach Canal being referenced.

Direction of flow in the canals in this basin depends on three factors: (1) the operation of the structures in the basin; (2) the location, intensity, and duration of

storms over the basin; and (3) the activities of growers in the basin with regard to irrigation and to pumping of excess water from their lands.

There are three Project canals in the L-8 basin: (1) the L-8 borrow canal, (2) the North Tieback Levee borrow canal, and (3) the L-8 Tieback Levee (also known as the South Tieback Levee) borrow canal. The borrow canals of the tieback levees are tributary to the L-8 borrow canal.

The L-8 borrow canal connects Lake Okeechobee to WCA 1. The connection to Lake Okeechobee is by way of Culvert #10A at the north end of the borrow canal, four miles south of Port Mayaca. The connection to WCA 1 is by way of S-5A and S-5AS at the south end of the borrow canal at the northern most tip of the WCA. Near the south end of the borrow canal, it intersects the L-10/L-12 borrow canal. The intersection of the L-8 borrow canal with the L-10/L-12 borrow canal is about two miles east of the intersection of U.S. Highway 441 and U.S. Highway 98. The connection of the L-8 borrow canal to WCA 1 is immediately south of the intersection.

The borrow canal of the North Tieback Levee drains a small portion of the L-8 basin south of Port Mayaca. It makes an open channel connection with the L-8 borrow canal just east of S-76 about three miles east of Lake Okeechobee. It is aligned north to south and extends about two miles to the north of the L-8 borrow canal.

The borrow canal of the L-8 Tieback Levee drains a small area in the southern L-8 basin and connects the L-8 borrow canal to the West Palm Beach water supply system. The canal's confluence with the L-8 borrow canal is four miles north of WCA 1. The borrow canal of the L-8 Tieback Levee extends about one and one-half miles to the northeast of this confluence. It is connected at its northern end to the "M" Canal of the West Palm Beach water supply system. The "M" Canal is aligned along the boundary between the L-8 and C-51 basins and connects the L-8 Tieback Levee borrow canal to the West Palm Beach water catchment area.

There are seven Project structures controlling flow in the L-8 basin: S-5A, S-5AE, S-5AS, S-5AW, S-76, Culvert #10A, and an unnamed weir (with a flapgate) in the L-8 Tieback Levee borrow canal at its intersection with the L-8 borrow canal. Design criteria for the Project control structures in the L-8 basin are given in Table 1.

S-5A, S-5AE, S-5AS, and S-5AW are located near the junction of the L-8 borrow canal with the L-10/L-12 borrow canal and C-51. They are operated in conjunction with one another to control flood runoff from the S-5A, L-8, and western C-51 basins, to implement numerous water supply operations, and to route regulatory releases from Lake Okeechobee to WCA 1.

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 agricultural flooding by removing excess water from the S-5A basin at a maximum design rate of three quarters of an inch of runoff per day; (2) to convey regulatory releases, discharged from Lake Okeechobee to either the L-8 or L-10-L-12 borrow canals, to WCA 1, and (3) to discharge, when capacity is available, flood flows from the L-8 basin and western portion of the C-51 basin to WCA 1.

S-5AE is a gated culvert located in the L-8 Tieback Levee at the west end of C-51. The gates are closed whenever flood conditions exist 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 are occasionally opened to discharge water from the C-51 basin to the S-5A basin if the tailwater (i.e., C-51 side) stage is greater than the headwater stage, and if S-5A has capacity available 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 can be opened to supply water to the C-51 basin from the L-8 and S-5A basins and Lake Okeechobee by way of Culvert #10A and the L-8 borrow canal and by way of S-352 and the L-10/L-12 borrow canals. See the S-5A basin description for information on the operation of S-352. S-5AE is operated for water supply only when there is enough water to do so. Water supply releases are not possible under some drought conditions.

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, S-5A, and C-51 basins. 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, for municipal water supply, and to maintain the optimum stages in the canals. The gates are opened to pass 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. Occasionally, S-5AS has been opened to transfer water from WCA 1 to Lake Okeechobee. Water discharged by gravity flow to the L-8 borrow canal subsequently is discharged to the lake by way of Culvert #10A. S-5AS also may be opened occasionally to pass regulatory discharges from Lake Okeechobee to WCA 1. The regulatory discharges may be by way of either the L-10/L-12 or L-8 borrow canals.

S-5AW is a gated culvert located in 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 flooding in the S-5A basin, 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 flow in these basins is then pumped to WCA 1 by S-5A. During periods of low natural flow, the gates can be opened to supply water, depending on availability, from the S-5A basin to the L-8 and C-51 basins or from the L-8 basin to the S-5A basin.

S-76 is a gated spillway located in the L-8 borrow canal approximately three miles east of Lake Okeechobee. The spillway is usually open. The structure can be operated to regulate flow to the west in the unlikely event (i.e., greater than a 1-10 year storm) that flood flows would overtop the levees along the L-8 borrow canal between S-76 and Lake Okeechobee.

Culvert #10A is a gated culvert in L-D9 at the connection of the L-8 borrow canal to Lake Okeechobee. It is operated and maintained by the U.S. Army Corps of Engineers. The structure has two primary functions: (1) to supply water for irrigation from the lake to the L-8 basin, and to a lesser extent to eastern Palm Beach County (via S-5AE and C-51), and (2) to provide gravity drainage to the lake when the canal stage is greater than the lake stage. Four of the five culverts of this structure have flap gates on the lake side. If these gates are closed, they open "automatically", when the canal stage is above the lake stage, to discharge water from the basin to the lake by gravity flow. The fifth (center) culvert has a slide gate,

also on the lake side. When closed, it remains so regardless of the relative stages of the canal and the lake. The flap gates and the slide gate are operated according to the stage in the lake. When the lake stage is less than 14.5 ft NGVD, the gates are normally fully opened. If the lake stage is above 14.5 ft NGVD, the gates are normally closed, and water supply to the basin is made from WCA 1. When the stage in the L-8 borrow canal is below 12.0 ft NGVD and the stage in WCA 1 is too low for water supply, the flap gates and the center gate will be opened as required to maintain a stage of 12.0 ft NGVD in the L-8 borrow canal. Culvert #10A has been used occasionally to transfer water, discharged from WCA 1 to the L-8 borrow canal, to Lake Okeechobee. In 1983, an extremely wet year, Culvert #10A was used to make regulatory release from Lake Okeechobee to the L-8 borrow canal.

The weir in the L-8 Tieback Levee borrow canal is located at that canal's confluence with the L-8 borrow canal. This structure is a sheet-pile weir with a crest elevation of 14.0 ft NGVD. A flap gate in the weir increases the amount of water that can flow from the L-8 borrow canal to the L-8 Tieback Levee borrow canal and permits water to flow to the L-8 Tieback Levee canal when the stage in the L-8 borrow canal is below 14.0 ft NGVD. This arrangement increases the availability of water in the L-8 Tieback Levee borrow canal for water supply to the City of West Palm Beach.

There is a non-Project structure affecting flow in the L-8 basin. The City of West Palm Beach owns and operates a pump station and a gated spillway at the junction of the "M" Canal and the L-8 Tieback Levee borrow canal. The spillway maintains a relatively high stage in the "M" Canal (over 20.0 ft NGVD) and allows for discharge of excess water from the "M" Canal to the L-8 Tieback Levee borrow canal. The spillway has a maximum discharge rate of about 400 cfs. The pump station is used to supply water from the L-8 basin (i.e., from the L-8 Tieback Levee borrow canal) to the West Palm Beach water supply system (i.e., to the "M" Canal). The pump station has a capacity of about 300 cfs.

Comments on Design and Historic Operation

Project Design

The design rate of water removal from the L-8 basin is three-quarters of an inch of runoff per day. In practice, the rate at which excess water is removed from the L-8 basin depends on conditions. Water can be removed by pumping at S-5A and by gravity flow to Lake Okeechobee by way of Culvert #10A and to tidewater by way of C-51. Note, however, that S-5A and C-51 must remove excess water from their respective basins before removing water from the L-8 basin and that discharge by way of Culvert #10A requires that the water level in the L-8 borrow canal be greater than in Lake Okeechobee. Under general flooding conditions in the L-8, S-5A, and C-51 basins and on Lake Okeechobee, it is possible for the discharge rate from the L-8 basin to be restricted and to be considerably less than three-quarters of an inch of runoff per day. As water levels in the S-5A and C-51 basins and on the lake recede, discharge from the L-8 basin is increased.

Permitted Discharge

The Corbett Wildlife Area, a large part of the basin, is permitted to discharge at a rate of one-quarter of an inch of runoff per day. Most other areas in the basin are permitted to discharge at a rate of one-inch of runoff per day. The average

permitted basin discharge is currently less than three-quarters of inch of runoff per day.

Backpumping to Lake Okeechobee

The U.S. Army Corps of Engineers is currently considering a plan to pump excess water from the L-8 basin to storage in Lake Okeechobee. The water in the L-8 basin is currently of good quality and presumably would not cause environmental problems in Lake Okeechobee. The plan calls for a pump station to be constructed at the outlet of the L-8 borrow canal to Lake Okeechobee. Most excess water in the basin would be discharged to the lake rather than to WCA 1 or to tide water.

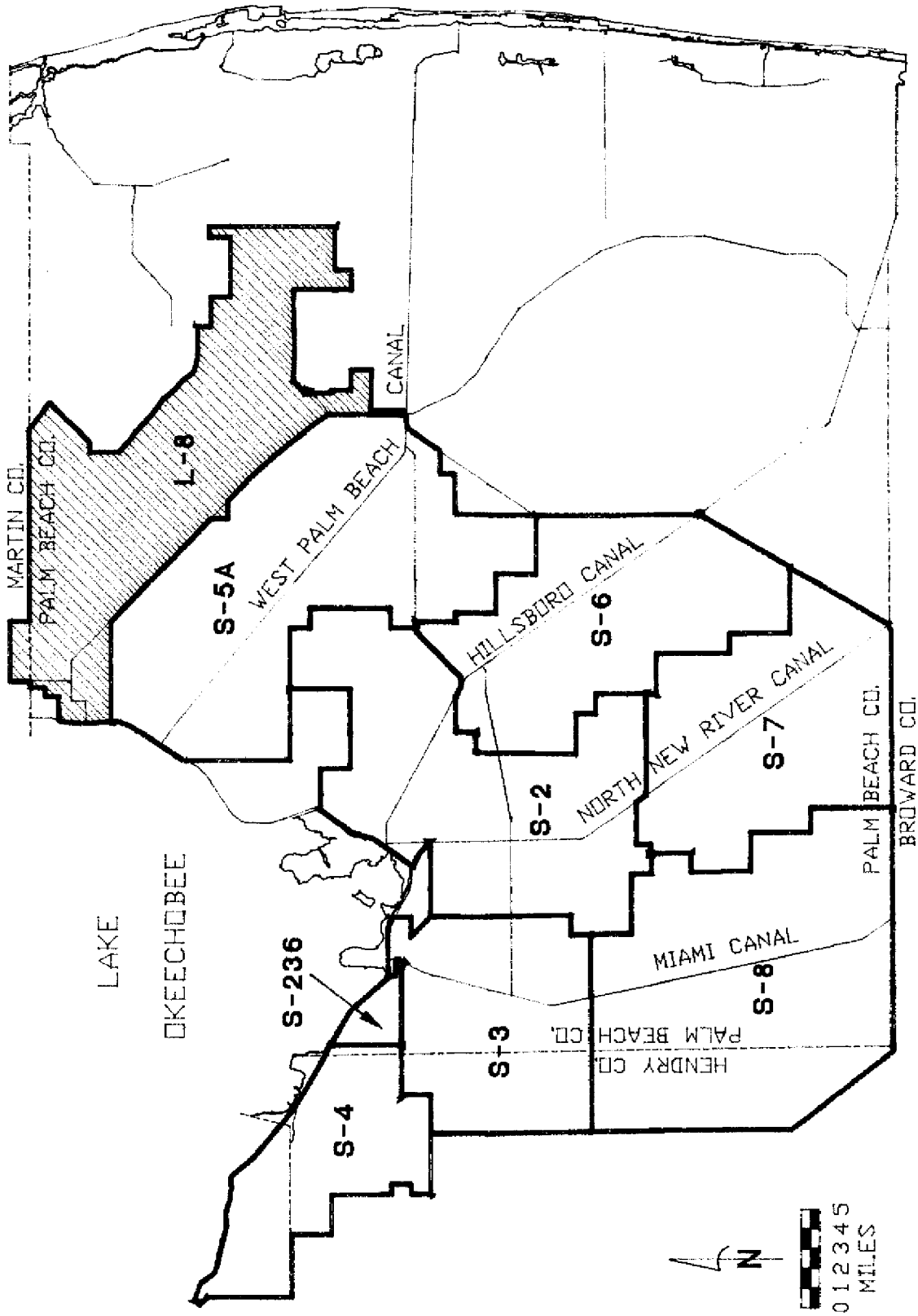


FIGURE 2. L-8 BASIN LOCATION MAP

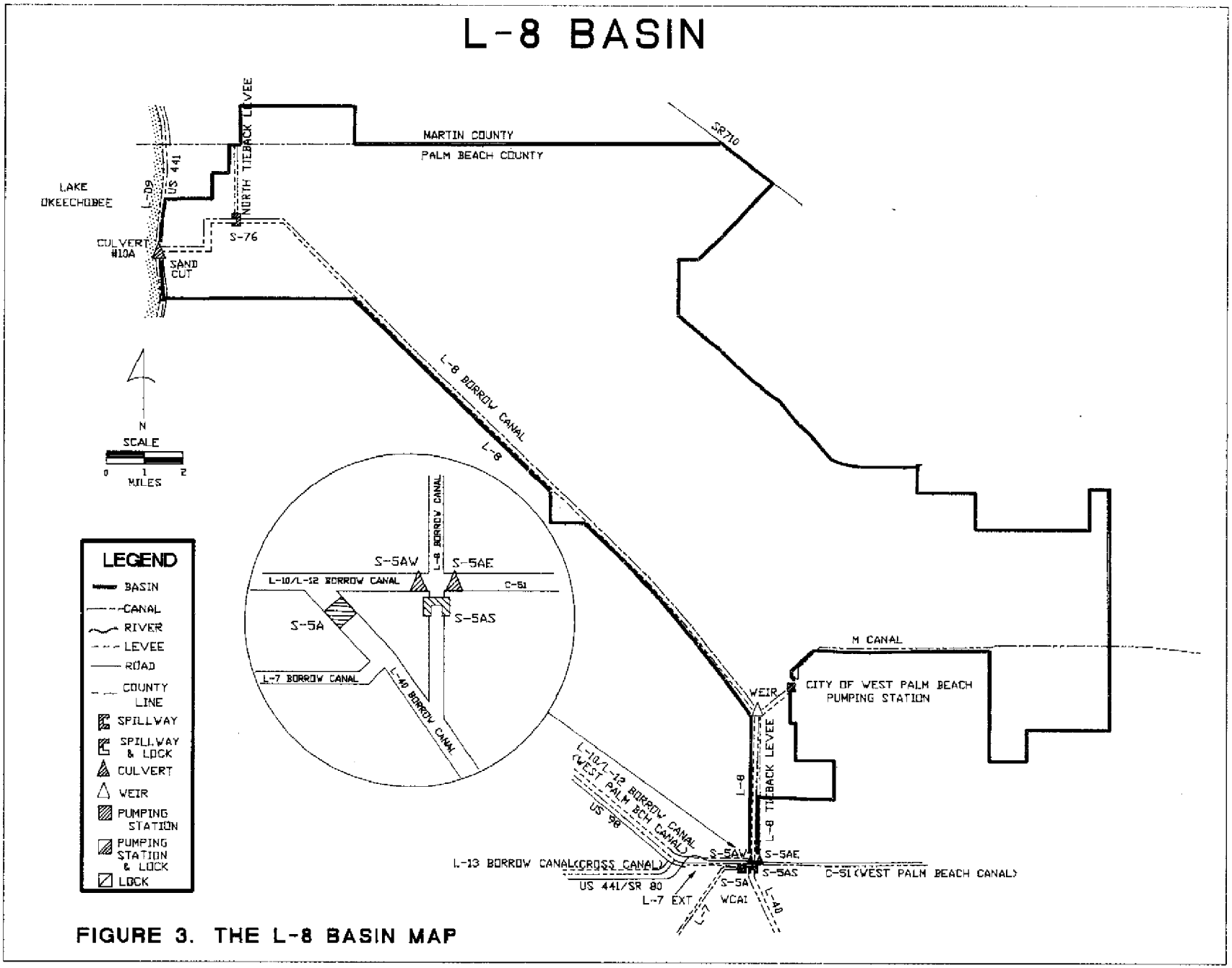


FIGURE 3. THE L-8 BASIN MAP

Table 1. L-8 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-5A	Pump Station 6 units-800 cfs each	13.0 (canal side)	24.1 (WCA 1 side)	11.5-12.0 in L-10/L-12 Borrow Canal	4800	HW = 14.26 TW = 18.54 Q(south) = 5235 Q(north) = 954	10/3/57 9/26/60 10/24/83 6/7/84
S-5AE	Gated Box Culvert 2-7ftx7ftx65ft Reinforced concrete box Invert elev = 1.0ft NGVD	11.5 (west side)	10.0 (east side)	Not used to control stage	700	HW = 19.34 TW = 16.38	9/27/60 10/23/83
S-5AS	Gated Spillway 2-Gates 19.3ft highx22.8ft wide Net crest lgth = 44.0ft Crest elev = 1.0ft NGVD	18.0 (canal side)	17.9 (WCA 1 side)	Not used to control stage	2000	HW = 19.34 TW = 16.3	9/27/60 10/3/85
S-5AW	Gated Box Culvert 2-7ftx7ftx80ft Reinforced concrete box Invert elev = -1.75 to 0.3ft NGVD	13.0 (west side)	11.5 (east side)	Not used to control stage	700		
S-76	Gated Spillway 3-Gates 7.5ft highx12.0ft wide Net crest lgth = 36ft Crest elev = 7.0ftNGVD	20.3 (east side)	19.6 (west side)		1000	HW = 20.03 TW = 17.86	10/1/60 10/17/60
Culvert # 10A	Gated Culvert 5-120inx185ft CMP Invert elev = 5.5ft NGVD	19.0 (lake side)	15.6 (canal side)	Stage ≤ 12.0 in L-8 borrow canal at S-5A	1000		

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

S-5A BASIN

Description of the Basin

The S-5A drainage basin is 194.3 square miles in area and is located (Figure 4) in northwestern Palm Beach County. The basin boundary relative to local roads and landmarks is shown on Map A. A schematic map showing the S-5A basin boundary, canals, and control structures is given in Figure 5.

The Project canals and water control structures in the S-5A basin have four primary functions: (1) to remove excess water from the S-5A basin to storage in Water Conservation Area 1 (WCA 1), and under some flood conditions, to storage in Lake Okeechobee; (2) to prevent over drainage of the S-5A basin; (3) to supply water from WCA 1, Lake Okeechobee, or the L-8 basin to the S-5A basin for irrigation; and (4) to provide conveyance for regulatory releases from the Lake Okeechobee to WCA 1 and for water supply releases from the lake to the C-51 basin for municipal and agricultural use and to maintain the optimum canal water level to prevent saltwater intrusion. Excess water is usually discharged from the basin to WCA 1 by way of S-5A. Under some very rare conditions, water can be discharged from the basin to Lake Okeechobee by way of S-352. Regulatory releases from Lake Okeechobee can be made to the L-10/L-12 borrow canal (i.e., the West Palm Beach Canal) by way of S-352. On the rare occasions such releases are made, they are passed to WCA 1 by way of S-5A or S-5AS. Water is supplied to the basin from Lake Okeechobee by way of S-352, from WCA 1 by way of S-5AS and S-5AW, and from the L-8 borrow canal by way of S-5AW. It is possible, though unlikely, to transfer water from WCA 1 to Lake Okeechobee by way of the L-10/L-12 borrow canal. Under the rare circumstances that would make such a transfer possible and desireable, the L-8 borrow canal more likely would be used to make the transfer.

Direction of flow in the canals in this basin depends on three factors: (1) the operation of the structures in the basin; (2) the location, intensity, and duration of storms over the basin; and (3) the activities of growers in the basin with regard to irrigation and to pumping of excess water from their lands.

There are two Project canals in the S-5A basin: the L-10/L-12 and L-13 borrow canals. The L-10/L-12 borrow canal is the Project name given to the West Palm Beach Canal west of L-8. East of L-8, the West Palm Beach Canal is known by its Project name C-51. Although the Project names for the West Palm Beach Canal are not as widely used as West Palm Beach Canal, they will be used in the discussion that follows to avoid any confusion as to the part of the West Palm Beach Canal being referenced. The L-13 borrow canal is the Project name for a part of an otherwise non-Project canal, the Cross Canal (or sometimes, the Ocean Canal). Only that part of the Cross Canal in the S-5A basin is part of the Project. Since the whole of the Cross Canal is of interest here, it will be referred to as such, remembering that it is only in part a Project canal.

The L-10/L-12 borrow canal connects Lake Okeechobee to WCA 1. The connection of the borrow canal to Lake Okeechobee is by way of S-352 at the north end of the canal at the town of Canal Point. The connection of the canal to WCA 1 is by way of S-5A and S-5AS at the south end of the canal at the northern most tip of the WCA. The borrow canal is also connected to two Project canals at its southern end: C-51 and the L-8 borrow canal. The junction of the L-10/L-12 borrow canal, the

L-8 borrow canal, and C-51 is about two miles east of the intersection of U.S. Highway 441 with U.S. Highway 98.

The L-13 borrow canal is the eastern reach of the Cross Canal which extends east to west connecting the L-10/L-12 borrow canal (S-5A basin) to the Hillsboro Canal (S-2 and S-6 basins). The Cross Canal makes an open channel connection with the L-10/L-12 borrow canal near the intersection of U.S. Highway 441 and U.S. Highway 98 and an open channel connection with the Hillsboro Canal at the U.S. 441 crossing of the Hillsboro Canal. There is a gated culvert, S-5AX, in the Cross Canal at the boundary between the S-5A basin and S-2 and S-6 basins. The L-13 borrow canal extends from the L-10/L-12 borrow canal to S-5AX. When the gates on S-5AX are closed, it acts as a divide between the basins. Since this structure is usually open, the Hillsboro Canal and the L-10/L-12 borrow canals are usually connected by an open channel, and the actual boundary between the S-5A basin and the S-2 and S-6 basins may vary from that shown on Map A. The drainage boundary between the S-5A basin and the S-2 and S-6 basins depends on the operation of the S-2, S-6, and S-5A pump stations. See the S-2 and S-6 basin descriptions for information on the operation of their respective structures.

There are six Project control structures regulating flow in the S-5A basin: S-5A, S-5AE, S-5AS, S-5AW, S-5AX, and S-352. Design criteria for the Project control structures in the S-5A basin are given in Table 2.

S-5A, S-5AE, S-5AS, and S-5AW are located near the junction of the L-10/L-12 borrow canal with the L-8 borrow canal and C-51. They are operated in conjunction with one another to control flood runoff from the S-5A, L-8, and western C-51 basins, to implement numerous water supply operations, and to route regulatory releases from Lake Okeechobee to WCA 1.

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 agricultural flooding by removing excess water from the S-5A basin at a maximum design rate of three quarters of an inch of runoff per day; (2) to convey regulatory releases, discharged from Lake Okeechobee to either the L-8 or L-10/L-12 borrow canals, to WCA 1, and (3) to discharge, when capacity is available, flood flows from the L-8 basin and western portion of the C-51 basin to WCA 1.

S-5AE is a gated culvert located in the L-8 Tieback Levee at the west end of C-51. The gates are closed whenever flood conditions exist 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 are occasionally opened to discharge water from the C-51 basin to the S-5A basin if the tailwater (i.e., C-51 side) stage is greater than the headwater stage, and if S-5A has capacity available 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 can be opened to supply water to the C-51 basin from the L-8 and S-5A basins and Lake Okeechobee by way of Culvert #10A and the L-8 borrow canal and by way of S-352 and the L-10/L-12 borrow canal. S-5AE is operated for water supply only when there is enough water. Water supply releases are not possible under some drought conditions.

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, S-5A, and

C-51 basins. 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, for municipal water supply, and to maintain the optimum stages in the canals. The gates are opened to pass 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. Occasionally, S-5AS has been opened to transfer water from WCA 1 to Lake Okeechobee. Water discharged by gravity flow to the L-8 borrow canal subsequently is discharged to the lake by way of Culvert #10A. S-5AS also may be opened occasionally to pass regulatory discharges from Lake Okeechobee to WCA 1. The regulatory discharges may be by way of either the L-10/L-12 or the L-8 borrow canals.

S-5AW is a gated culvert located in the 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 flooding in the S-5A basin, 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 flow is then pumped to WCA 1 by S-5A. During periods of low natural flow, the gates can be opened to supply water, depending on availability, from the S-5A basin to the L-8 and C-51 basins or from the L-8 basin to the S-5A basin.

S-5AX is a gated culvert located in the Cross Canal at the boundary between the S-5A basin and the S-2 and S-6 basins. The gates are normally open. They are closed only to prevent water from passing from one basin to another when the additional flows would create flooding, or would exacerbate an existing flood condition, in the receiving basin.

S-352 is a gated spillway located in L-D9 at the connection of the L-10/L-12 borrow canal to Lake Okeechobee. The primary functions of the structure are to prevent a hurricane surge on the lake from entering the canal and to make water supply releases. The gates are often closed, but may be opened for any of three reasons: (1) to supply water to the S-5A basin when the stage at S-5A is below 11.0 ft NGVD and to the C-51 basin when the stage at S-155 is below 8.0 ft NGVD; (2) to discharge flood flows from the S-5A basin to Lake Okeechobee when the stage in the lake is below 11.0 ft NGVD; and (3) to make regulatory releases from Lake Okeechobee to WCA 1 by way of the L-10/L-12 borrow canal. The last two cases are rare occurrences.

Comments on Design and Historic Operation

Project Design

Design of the canals and water control structures in the S-5A basin was based on two primary considerations: flood control and water supply. For flood control the design removal rate was determined to be three-quarters of an inch of runoff per day for the drainage area. For water supply, the canals and structures were designed to deliver water at a maximum rate of 4.3 cubic feet per second for each square mile of area served.

The design removal rate is less than the rate at which it is possible for individual growers to pump to the canals in the EAA, and the capacity of the Project canals and water control structures is less than the total of the possible grower discharges. The design removal rate and the capacities of the canals and structures are adequate,

however, because of three factors: (1) not all the land in the EAA is in production at one time, (2) much of the EAA is planted to water-tolerant crops (e.g., sugarcane), and (3) the canals in the EAA have some storage capacity.

Water supply to the basin was intended for irrigation and to maintain water levels in the basin as high as possible to minimize soil subsidence and oxidation. The COE recognized that the optimum water level in the L-10/L-12 borrow canal would have to be lowered over time as subsidence in the basin occurred. The intake elevation for the pumps at S-5A was determined taking into consideration the anticipated lowering of the optimum water level.

Lake Okeechobee Regulatory Releases

Although lake regulation was not a factor in the original design, it was anticipated that, with no local inflows to the L-10/L-12 borrow canal, lake regulatory releases would be made up to the capacity of the borrow canal. There are six principal outlets for regulatory releases from Lake Okeechobee: the Caloosahatchee River (C-43), the St. Lucie Canal (C-44), and the four agricultural canals, the L-10/L-12 borrow, the Miami, the North New River , and the Hillsboro. The levees and discharge structures for Lake Okeechobee were designed assuming releases would be made by way of all six outlets during a major storm event. Regulatory releases from the lake to these canals are made in accordance with the Lake Okeechobee regulation schedule (Figure 6)

Although the St. Lucie Canal and the Caloosahatchee River can pass the largest discharges from the lake, they are not the preferred outlets from the lake since water released in this way is lost to the ocean and, in some cases, damages the estuaries of the St. Lucie and Caloosahatchee Rivers. To the extent possible, regulatory releases are made to the agricultural canals. Water released to these canals is stored in the WCAs and is kept in the system. This affords additional opportunity for using the water, and it limits the amount of freshwater that enters the estuaries of the Caloosahatchee and St. Lucie Rivers. However, this is not a common practice and little of the regulatory discharge from Lake Okeechobee is handled in this way.

There are three reasons that regulatory releases to the agricultural canals are rare.

1. Most significantly, regulatory releases to the agricultural canals cannot be made if to do so would compromise agricultural water control in any of the basins the canals pass through. In the case of the L-10/L-12 borrow canal, only the S-5A basin is of concern. In general, it is required that weather conditions in the S-5A basin be dry and that water levels in the L-10/L-12 borrow canal be low enough not to restrict local inflows. As a rule of thumb, the canal water level must be below 11.0 ft NGVD. With no local inflows, however, the water level at the outlet structure, S-352, can be allowed to rise as high as 13.5 ft NGVD during regulatory discharge.
2. Although COE and District policy does not explicitly restrict regulatory releases to the WCAs when the WCAs are over schedule, such releases usually are not made if it is perceived the releases would be harmful to the environment in the receiving WCA, e.g., by drowning deer in WCA 3A or by compromising the WCA 2A drawdown.
3. Regulatory releases to the agricultural canals cost more to make than do releases to the St. Lucie Canal or the Caloosahatchee River since water discharged to the agricultural canals must be pumped to the receiving WCA.

The wet weather conditions that cause Lake Okeechobee to go over schedule also are likely to create wet conditions in the EAA basins, with water levels over 11.0 ft NGVD, and to cause the WCAs to go over schedule. These factors combine to make regulatory releases by way of the agricultural canals rare events.

S-352

The original structure, Hurricane Gate Structure 5, controlling discharges from the lake to the L-10/L-12 borrow canal has been replaced by a gated spillway, S-352. The old hurricane gate, for the last few years of its long service, could not be operated as designed and could pass only limited discharges. The new structure allows regulatory and water supply discharges up to the capacity of the L-10/L-12 borrow canal.

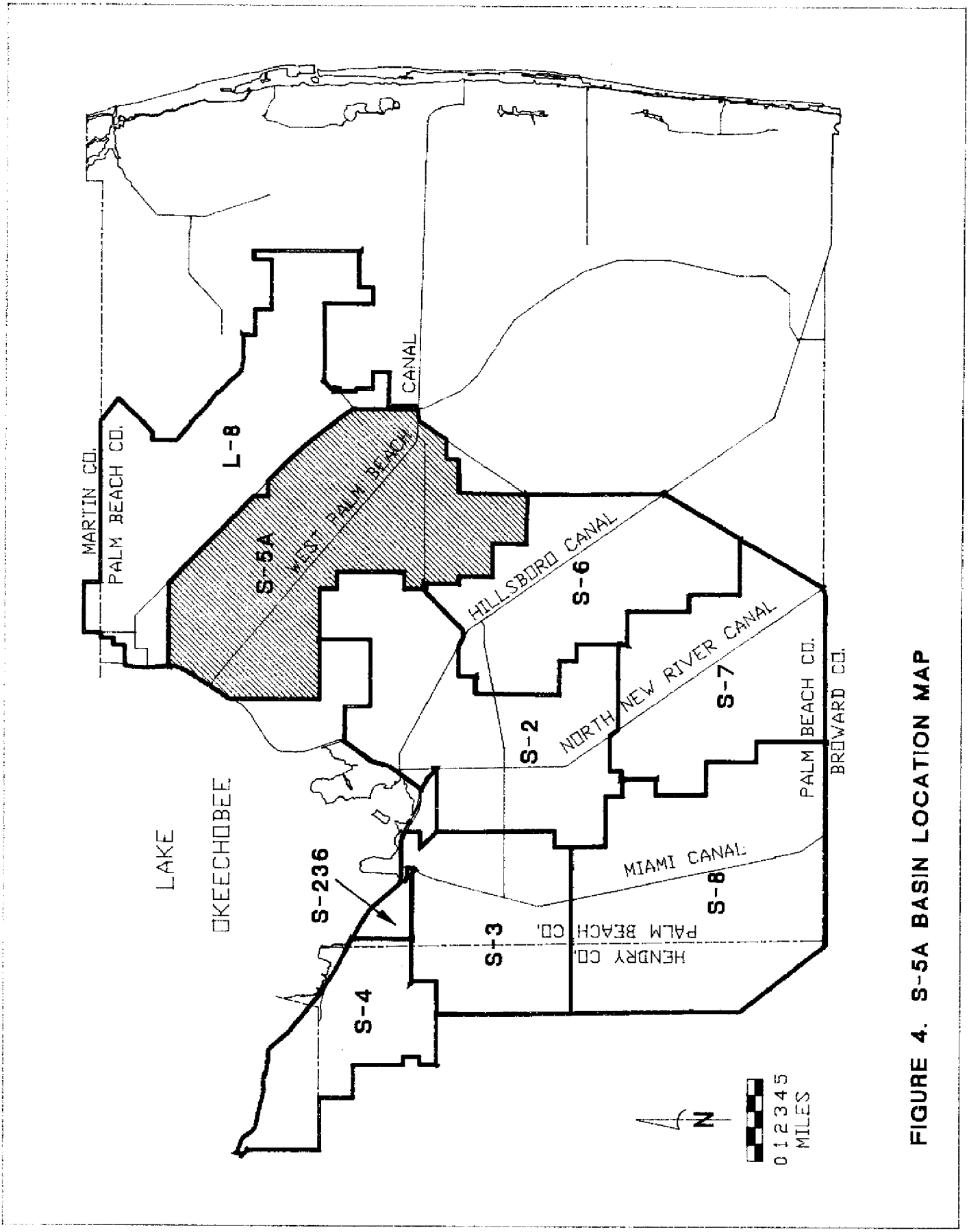


FIGURE 4. S-5A BASIN LOCATION MAP

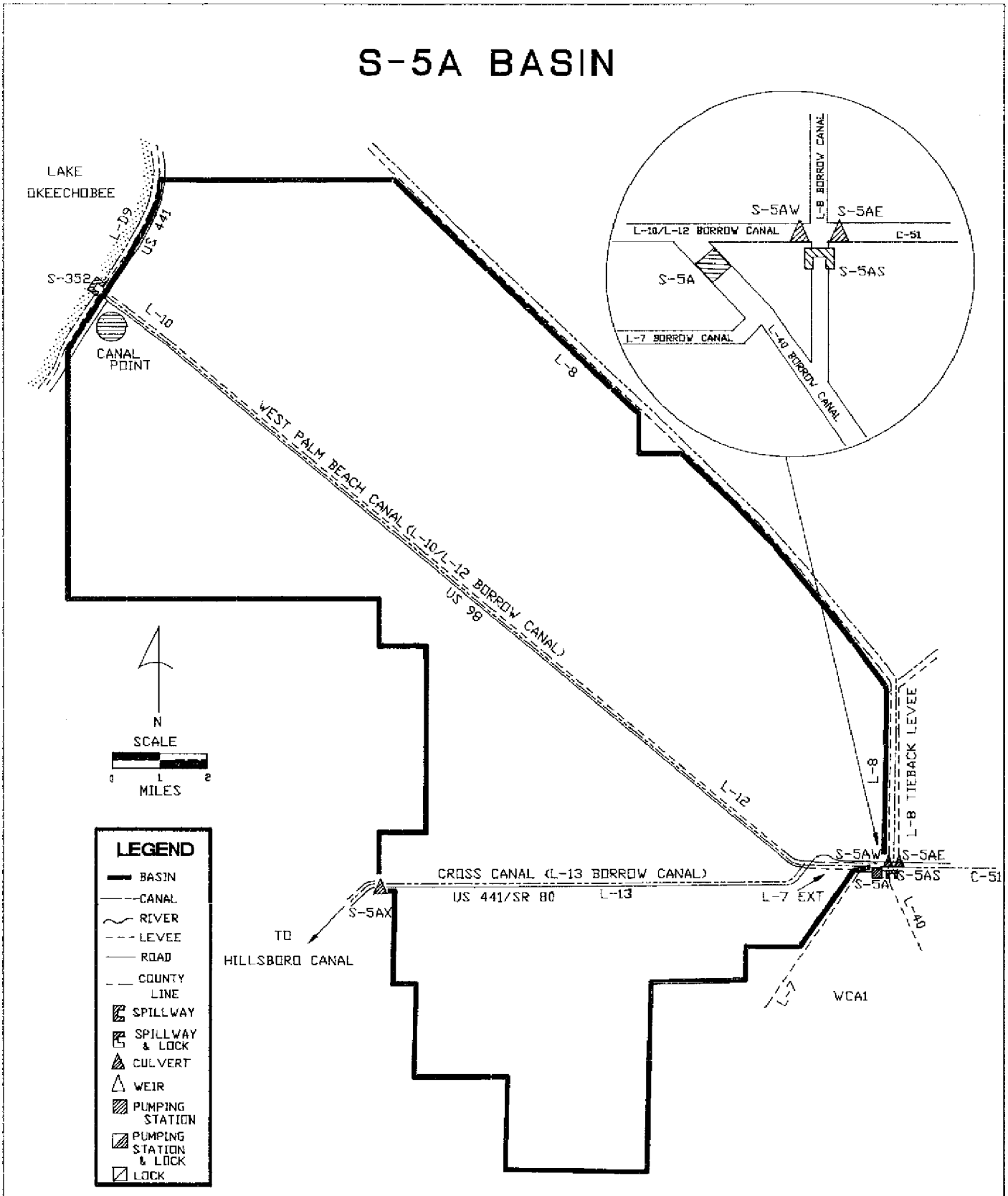
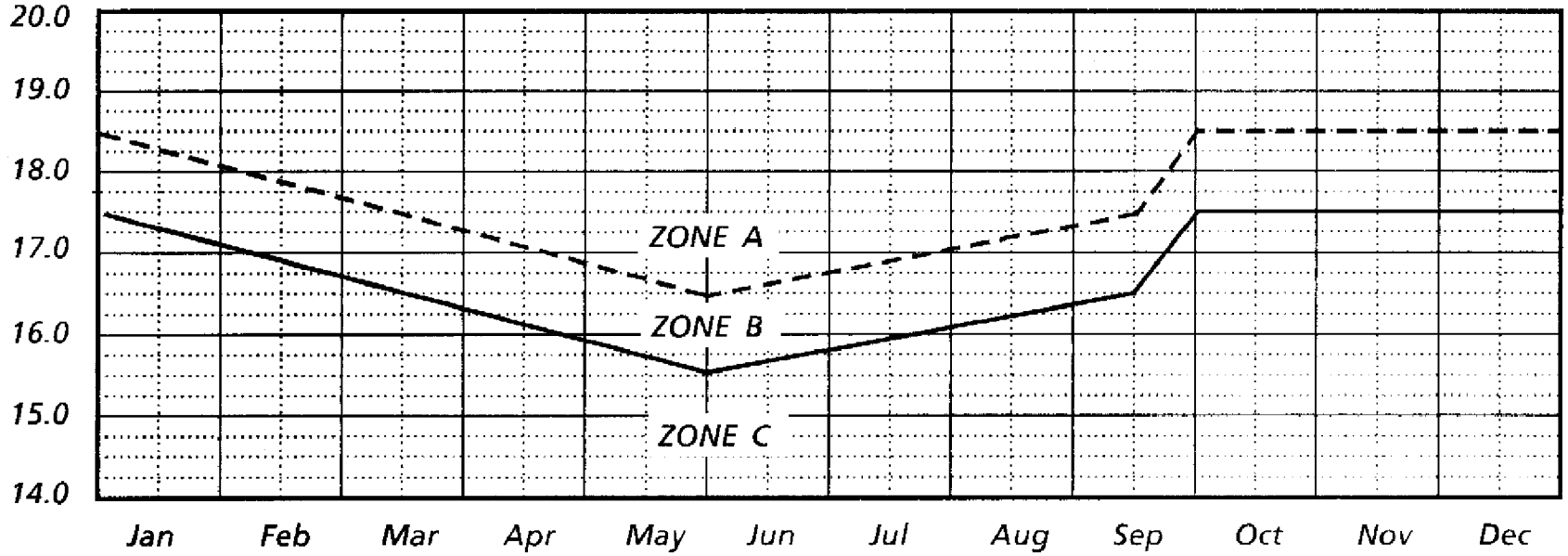


FIGURE 5. THE S-5A BASIN MAP



Releases Through Outlets As Indicated

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to Conservation Areas for Regulation After Removal of Local Runoff	Up to maximum capacity (9300 CFS at S-77) Without Local Flooding	Up to maximum Discharge at S-80C
B*		Up to 4500 CFS at S-77	Up to 2500 CFS at S-80**
C	No Regulatory Discharge	No Regulatory Discharge	No Regulatory Discharge
	First Priority	Second Priority	Third Priority

* Release Through Various Outlets May Be Modified to Minimize Damages or Obtain Additional Benefits.
** Except When Exceeded by Local Inflow.

Central and Southern Florida
INTERIM REGULATION SCHEDULE--LAKE OKEECHOBEE
Department of the Army, Jacksonville District
Corps of Engineers, Jacksonville, Florida
Dated 10 May 1978

Figure 6. CURRENT LAKE OKECHOBEE REGULATION SCHEDULE

TABLE 2 S-5A 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-5A	Pump Station 6 units - 800 cfs each	13.0 (canal side)	24.1 (WCA 1 side)	11.5-12.0 in L-10/L-12 Borrow Canal	4800	HW = 14.26 TW = 18.54 Q(south) = 5235 Q(north) = 954	10/3/57 9/26/60 10/24/83 6/7/84
S-5AE	Gated Box Culvert 2-7ftx 7ftx 65ft Reinforced Concrete Box Invert elev = 1.0ft NGVD	11.5 (west side)	10.0 (east side)	Not used to control stage	700	HW = 19.34 TW = 16.38	9/27/60 10/23/83
S-5AS	Gated Spillway 2-Gates 19.3ft high x 22.8ft wide Net crest lgth = 44.0ft crest elev = 1.0ft NGVD	18.0 (canal side)	17.9 (WCA 1 side)	Not used to control stage	2000	HW = 18.34 TW = 16.3	9/27/60 1/3/85
S-5AW	Gated Box Culvert 2-7ftx 7ftx 80ft Reinforced Concrete Box Invert elev = 1.075 to 0.3ftNGVD	13.0 (west side)	11.5 (east side)	Closed during flooding	700		
S-5AX	Gated Culvert 4-72in x 68ft CMP Invert elev = 5.5ft NGVD			Closed during flooding Divide between S-5A and S-2/S-6 Basins	600		
S-352*	Gated Spillway 2-Gates 6.3 ft highx23.0 ft wide Net crest lgth = 46.0 ft Crest elev = 5.2 ft NGVD	Water Supply 10.5 Regulatory Releases 24.8 (lake side)	Water Supply 10.0 Regulatory Releases 13.5 (canal side)	Not used to control stage Regulatory Releases 1250	Water Supply 900 Regulatory Releases 1250	HW = 18.99 TW = 18.70 Q(east) = 1610 Q(west) = 1760	3/10/83 10/12/47 10/2/59 6/15/42

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

*S-352 has only recently replaced Hurricane Gate Structure 5 (HGS-5). The peak discharges and stages given are for HGS-5.

S-2 Basin

Description of the Basin

The S-2 drainage basin is 165.7 square miles in area and is located in west-central Palm Beach County (Figure 7). The basin boundary relative to local roads and landmarks is shown on Map A. A schematic map showing the basin boundary, canals, and water control structures is given in Figure 8.

The Project canals and water control structures affecting flow in the S-2 basin have four primary functions: (1) to remove excess water from the S-2 basin to storage in the Water Conservation Areas (WCAs), and under some flood conditions, to storage in Lake Okeechobee; (2) to prevent overdrainage of the S-2 basin; (3) to supply water from Lake Okeechobee to the S-2, S-6, and S-7 basins as needed for irrigation; and (4) to provide conveyance for regulatory releases from Lake Okeechobee to be passed to storage in the WCAs and for water supply releases from the lake to be passed to eastern Palm Beach and Broward counties. Pump stations S-2, S-6, and S-7 remove excess water from the S-2 basin and discharge it to Lake Okeechobee, WCA 1, and WCA 2A, respectively. Under some rare flood conditions, S-351 may discharge to Lake Okeechobee. S-150 allows gravity discharge to WCA 3A from the S-2 basin by way of the North New River Canal. Regulatory releases from Lake Okeechobee are made to the Hillsboro and North New River canals by way of S-351. On the rare occasions such releases are made, they are passed to WCA 1 by way of S-6, to WCA 2A by way of S-7, and to WCA 3A by way of S-150. Water supply releases from Lake Okeechobee are made to the Hillsboro and North New River Canals by way of S-351 and S-2. These releases are passed to the WCAs, and subsequently to eastern Palm Beach and Broward counties, by way of S-6 and S-7.

There are two Project canals in the S-2 basin: the Hillsboro Canal and the North New River Canal. Two other, non-Project canals are important in the basin. These are the Bolles Canal and the Cross Canal. The Cross Canal is tributary to the Hillsboro Canal and the Bolles Canal is tributary to both the Hillsboro and the North New River canals.

The Hillsboro Canal connects Lake Okeechobee to WCA 1. The connection to Lake Okeechobee is by way of S-2 at the north end of the canal at South Bay west of Belle Glade. The connection to WCA 1 is by way of S-6 at the intersection of L-6 and L-7 on the west side of WCA 1.

The North New River Canal connects Lake Okeechobee to WCAs 2A and 3A. The connection to Lake Okeechobee is by way of S-2 at the north end of the canal at South Bay west of Belle Glade. The connection with WCA 2A is by way of S-7 at the intersection of L-5 and L-6, just east of U.S. Highway 27 on the Palm Beach-Broward County line. The connection with WCA 3A is by way of S-150 just west of S-7.

The Project name for that part of the Hillsboro Canal within the EAA is the L-14/L-15 borrow canal. Similarly the Project name for that part of the North New River Canal within the EAA is the L-18/L-19 borrow canal. Since the Hillsboro Canal and the North New River Canal are the more familiar names for these canals, and since no confusion should result from their use in the context of this Atlas, they are the names that will be used.

The Cross Canal extends east to west connecting the L-10/L-12 borrow canal (i.e., the West Palm Beach Canal) in the S-5A basin to the Hillsboro Canal. It makes an open channel connection with the L10/L-12 borrow canal near the intersection of U.S. Highway 441 and U.S. Highway 98, and an open channel connection with the Hillsboro Canal at the U.S. 441 crossing of the Hillsboro Canal. The part of the Cross Canal in the S-5A basin is a Project canal also known as the L-13 borrow canal. In this atlas, the distinction will not be made, the entire canal from the Hillsboro Canal to the L-10/L-12 borrow canal being referred to as the Cross Canal.

The Bolles Canal extends east to west connecting the Hillsboro Canal to the North New River and the Miami canals. It makes an open channel connection with the Hillsboro Canal about one and one-half miles southeast of the U.S. Highway 441 crossing of the Hillsboro Canal, it makes an open channel connection with the North New River Canal at the intersection of State Road 827 and U.S. Highway 27, and it is connected to the Miami Canal by way of three uncontrolled 72 inch culverts about three miles north of the Seaboard Coast Line Railway crossing of the Miami Canal.

There are six Project control structures affecting flow in the S-2 basin: S-2, S-5AX, S-6, S-7, S-150, and S-351. Design criteria for these Project control structures are given in Table 3.

S-2 is a pump station located at the connection of the North New River and Hillsboro canals to Lake Okeechobee about two miles west of the town of Belle Glade. Pumping is initiated when the S-6 and S-7 pump stations can not maintain the stage in the Hillsboro or the North New River canals below 13.5 ft NGVD or when flooding occurs in the basin. Flooding is most likely to occur along the Bolles Canal or the Cross Canal (see **Comments on Design and Historic Operation**). The stage in the Hillsboro or North New River canals is not to be drawn down below 10.0 ft NGVD. S-351 is closed when pumping is under way. S-2 is used to augment water supply releases from Lake Okeechobee when the lake stage is too low for an adequate discharge through S-351. Water supply releases through S-2 are by syphoning through the pumps.

S-5AX is a gated culvert located in the Cross Canal at the boundary between the S-5A basin and the S-2 and S-6 basins. The gates are normally open. They are closed only to prevent water from passing from one basin to another when the additional flows would create flooding, or would exacerbate an existing flood condition, in the receiving basin.

S-6 is a pump station located at the point where the Hillsboro Canal enters WCA 1. Pumping from the Hillsboro Canal to WCA 1 is initiated when the stage at any point in the Hillsboro Canal exceeds 12.5 ft NGVD. The stage in the canal is not to be drawn down below 10.0 ft NGVD. Pumping also may be initiated upon request by the U. S. Army Corps of Engineers to provide regulatory discharge from Lake Okeechobee to WCA 1 by way of S-351 and the Hillsboro Canal, when the entire capacity of S-6 is not needed for removal of water from the S-6 and S-2 basins.

S-7 is a pump station and gated spillway located at the point where the North New River Canal enters WCA 2A just east of U.S. Highway 27 at the Palm Beach-Broward County line. Water is discharged from the North New River Canal to WCA 2A when the stage at any point in the canal exceeds 12.5 ft NGVD. Discharge is by gravity flow through the gated spillway if the stage in WCA 2A is low enough to permit a discharge adequate to maintain the optimum stage in the North New River Canal and by pumping otherwise. Normally, the headwater stage (i.e., canal side) at

S-7 is drawn down to and held at 10.0 ft NGVD. It is not to be drawn down below 8.7 ft NGVD to prevent possible damage to the pumps. Pumping also may be initiated upon request by the U. S. Army Corps of Engineers to provide regulatory discharge from Lake Okeechobee to WCA 2A by way of S-351 and the North New River Canal when the capacity of S-7 is not needed for removal of water from the S-7 and S-2 basins.

S-150 is a gated culvert located in L-5 just west of S-7. It can be used to pass water by gravity flow from the North New River Canal (i.e., from the S-7 and S-6 basins) to WCA 3A unless this interferes with the supply of water to WCA 2A by way of S-7. Discharge through S-150 also may be initiated upon request by the U. S. Army Corps of Engineers, to provide regulatory discharge from Lake Okeechobee to WCA 3A by way of S-351 and the North New River Canal when the capacity of S-150 is not needed for removal of excess water from the S-7 basin.

S-351 is a gated spillway located in L-D2 at the connection of the Hillsboro and the North New River canals to Lake Okeechobee. The primary functions of the structure are to prevent a hurricane surge on the lake from entering the canals and to make water supply releases. The gates are often closed, but may be opened for any of four reasons: (1) to supply water from Lake Okeechobee to the S-2, S-6, and S-7 basins when dry season water levels in the Hillsboro and North New River canals are below 11.0 ft NGVD; (2) to supply water from the lake to eastern Palm Beach and Broward counties; (3) to make regulatory releases from Lake Okeechobee to storage in the WCA 2A; and (4) to discharge flood flows from the S-2 basin to Lake Okeechobee if the lake stage is below 11.0 ft NGVD. In general, cases 2 and 3 are implemented only when the water levels in the Hillsboro and North New River canals are below 11.0 ft NGVD. Cases 3 and 4 are rare occurrances.

Comments on Design and Historic Operation

Project Design

Design of the canals and water control structures in the S-2 basin was based on two primary considerations: flood control and water supply. For flood control the design removal rate was determined to be three-quarters of an inch of runoff per day for the drainage area. For water supply, the canals and structures were designed to deliver water at a maximum rate of 4.3 cubic feet per second for each square mile of area served.

The design removal rate is less than the rate at which it is possible for individual growers to pump to the canals in the EAA, and the capacity of the Project canals and water control structures is less than the total of the possible grower discharges. The design removal rate and the capacities of the canals and structures are adequate, however, because of three factors: (1) not all the land in the EAA is in production at one time, (2) much of the EAA is planted to water-tolerant crops (e.g., sugarcane), and (3) the canals in the EAA have some storage capacity.

Water supply to the basin was intended for irrigation and to maintain water levels in the basin as high as possible to minimize soil subsidence and oxidation. The COE recognized that the optimum water level in the Hillsboro and North New River canals would have to be lowered over time as subsidence in the basin occurred. The intake elevation for the pumps at S-2 was determined taking into consideration the anticipated lowering of the optimum water level.

Lake Okeechobee Regulatory Releases

Although lake regulation was not a factor in the original design, it was anticipated that, with no local inflows to the Hillsboro or North New River canals, lake regulatory releases would be made up to the combined capacities of the canals. There are six principal outlets for regulatory releases from Lake Okeechobee: the Caloosahatchee River (C-43), the St. Lucie Canal (C-44), and the four agricultural canals, the L-10/L-12 borrow, the Miami, the North New River, and the Hillsboro. The levees and discharge structures for Lake Okeechobee were designed assuming releases would be made by way of all six outlets during a major storm event. Regulatory releases from the lake to these canals are made in accordance with the Lake Okeechobee regulation schedule (Figure 6).

Although the St. Lucie Canal and the Caloosahatchee River can pass the largest discharges from the lake, they are not the preferred outlets from the lake since water released in this way is lost to the ocean and, in some cases, damages the estuaries of the St. Lucie and Caloosahatchee Rivers. To the extent possible, regulatory releases are made to the agricultural canals. Water released to these canals is stored in the WCAs and is kept in the system. This affords additional opportunity for using the water, and it limits the amount of freshwater that enters the estuaries of the Caloosahatchee and St. Lucie Rivers. However, this is not a common practice and little of the regulatory discharge from Lake Okeechobee is handled in this way.

There are three reasons that regulatory releases to the agricultural canals are rare.

1. Most significantly, regulatory releases to the agricultural canals cannot be made if to do so would compromise agricultural water control in any of the basins the canals pass through. In the case of the Hillsboro and North New River canals, the S-2, S-6, and S-7 basins are of concern. In general, it is required that weather conditions in the S-2, S-6, and S-7 basins be dry and that water levels in the Hillsboro and North New River canals be low enough not to restrict local inflows. As a rule of thumb, the canal water level must be below 11.0 ft NGVD. With no local inflows, however, the water level at the outlet structure, S-351, can be allowed to rise as high as 13.5 ft NGVD during regulatory discharge.
2. Although COE and District policy does not explicitly restrict regulatory releases to the WCAs when the WCAs are over schedule, such releases usually are not made if it is perceived the releases would be harmful to the environment in the receiving WCA, e.g., by drowning deer in WCA 3A or by compromising the WCA 2A drawdown.
3. Regulatory releases to the agricultural canals cost more to make than do releases to the St. Lucie Canal or the Caloosahatchee River since water discharged to the agricultural canals must be pumped to the receiving WCA.

The wet weather conditions that cause Lake Okeechobee to go over schedule also are likely to create wet conditions in the EAA basins, with water levels over 11.0 ft NGVD, and to cause the WCAs to go over schedule. These factors combine to make regulatory releases by way of the agricultural canals rare events.

S-351

The original structure, Hurricane Gate Structure 4, controlling discharges from the lake to the Hillsboro and North New River Canals has been replaced by a gated spillway, S-351. The old hurricane gate, for the last few years of its long service, could not be operated as designed and could pass only limited discharges. The new structure allows regulatory and water supply discharges up to the combined capacities of the Hillsboro and North New River canals.

S-2 Basin Boundary

The S-2 basin is that portion of the EAA draining to the Hillsboro and the North New River canals from which pump station S-2 was designed to pump excess water at a maximum rate of three-quarters of an inch of runoff per day. At any given time however, the actual drainage basin may differ significantly from the design basin. There are three reasons for this:

1. Because of environmental problems in Lake Okeechobee resulting from inflow of nutrient rich water to the lake, the current District water management plan for the EAA discourages discharge of water to Lake Okeechobee from the EAA. Consequently, S-2 is operated only when necessary to prevent flooding in the S-2 basin. Normal (non-flood) drainage from the S-2 basin is to the south to the S-6 and S-7 basins by way of the Hillsboro and the North New River canals, and on to the WCAs by way of S-6, S-7, and S-150. This water management plan is known as the Interim Action Plan (IAP) and was originally implemented under the Lake Okeechobee Temporary Operating Permit (LOTOP) from the Florida Department of Environmental Regulation (FDER). FDER has since granted the District permission to continue the plan on a permanent basis under the Lake Okeechobee Operating Permit (LOOP).

2. The North New River Canal is interconnected to the Miami Canal and to the Hillsboro Canal by the Bolles Canal. These are open channel connections. Although water flow in the Bolles Canal is restricted by its shallow depth, small cross sectional area, and by culverts in its alignment (at Duda Road, at a farm road on the boundary between the S-2 and S-3 basins, and at the confluence with the Miami Canal), there may be interbasin flow of water between the S-2 and S-3 basins and between the S-2 and S-6 basins. As a result, the boundaries between these basins may vary.

3. The Hillsboro Canal is interconnected to the L-10/L12 borrow canal (i.e., the West Palm Beach Canal) by the Cross Canal. There is a gated culvert, S-5AX, in the Cross Canal at the boundary between the S-5A basin and the S-2 and S-6 basins. When the gates on this culvert are closed, it acts as a divide between the basins. Since this structure is usually open, the Hillsboro Canal and the L-10/L-12 borrow canal are usually connected by an open channel, and the actual boundary between the S-5A, S-2, and S-6 basins may vary from that shown in Map A.

The extent to which the boundaries vary between the S-2 and S-3 basins, the S-2 and S-5A basins, the S-2 and S-6 basins, and the S-2 and S-7 basins depends on the operation of the structures in the S-2, S-3, S-5A, S-6, S-7, and S-8 basins. See the S-3, S-5A, and S-8 basin descriptions for information on the operation of their respective control structures. The design basin boundaries are probably most closely realized for the S-2, S-3, S-5A, S-6, S-7, and S-8 basins when all pump stations are operating to capacity.

With operation under the IAP, the hump in the Hillsboro Canal restricts flow to the south from the S-2 basin to the S-6 basin. Because of this, flood flows to the

south to the S-6 basin may create high stages in the part of the Hillsboro Canal in the S-2 basin and in the Bolles and Cross canals. Flooding is most likely to occur along the Bolles and Cross canals because of their relatively low levees and their distance from the Project pump stations.

Special Drainage Districts

The S-2 basin is smaller than the basin S-2 was designed to drain. Four areas now drained to Lake Okeechobee by special drainage districts[1] were originally included in the S-2 basin:

1. The South Shore basin.
2. The East Shore basin.
3. The 715 Farms basin.
4. The East Beach basin.

Boles and Cross Canals General Design Memorandum

At the time of publication of this Atlas, the Corps of Engineers is preparing a General Design Memorandum (GDM) on the Bolles and Cross Canals. The GDM will propose a scope of work to reduce flooding along the canals. The work will probably include increasing the conveyance of the canals and increasing the size of the levees that border the canals.

[1]These districts are the so-called "298 Districts". The 298 refers to the Florida statute permitting these districts.

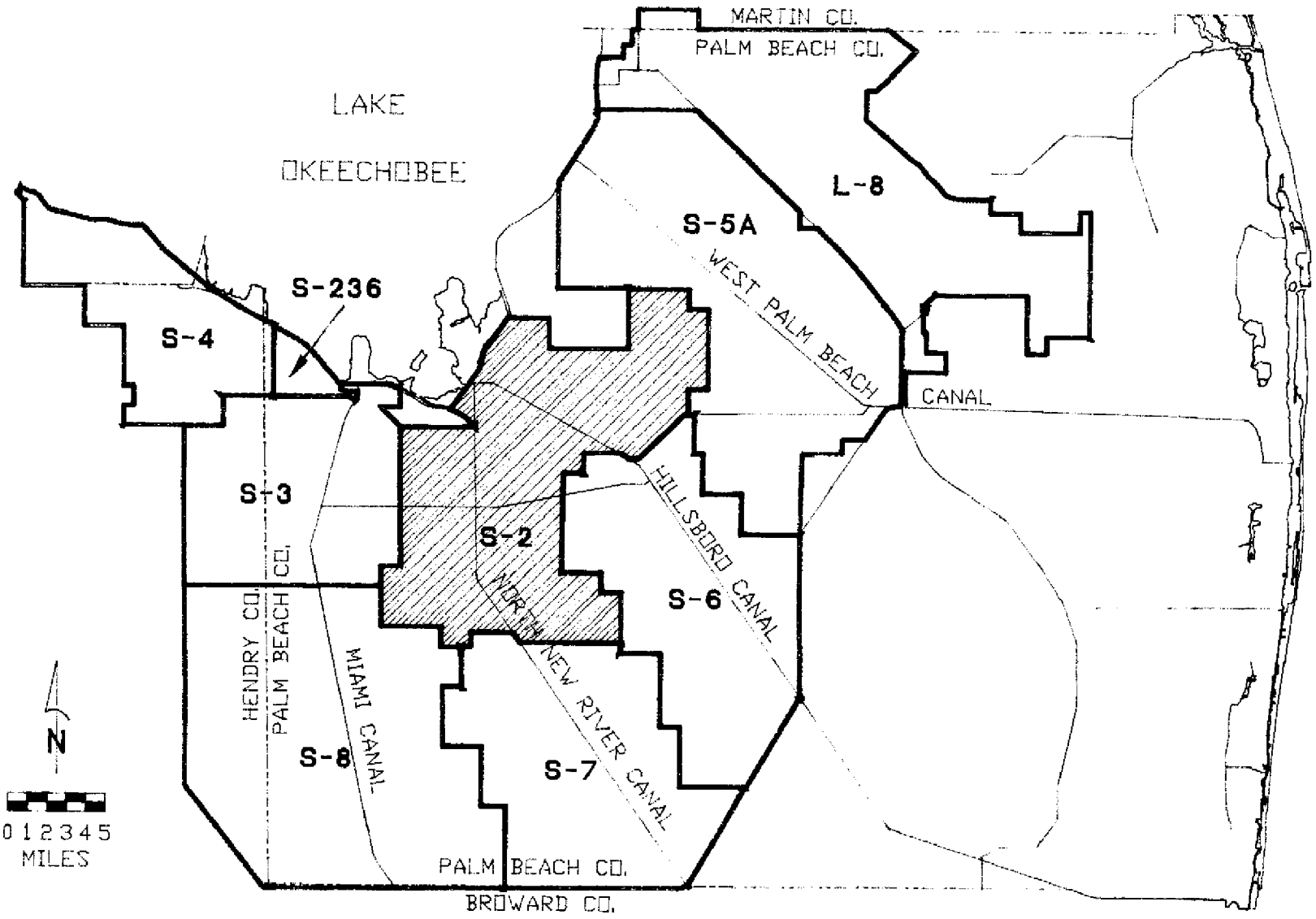


FIGURE 7. S-2 BASIN LOCATION MAP

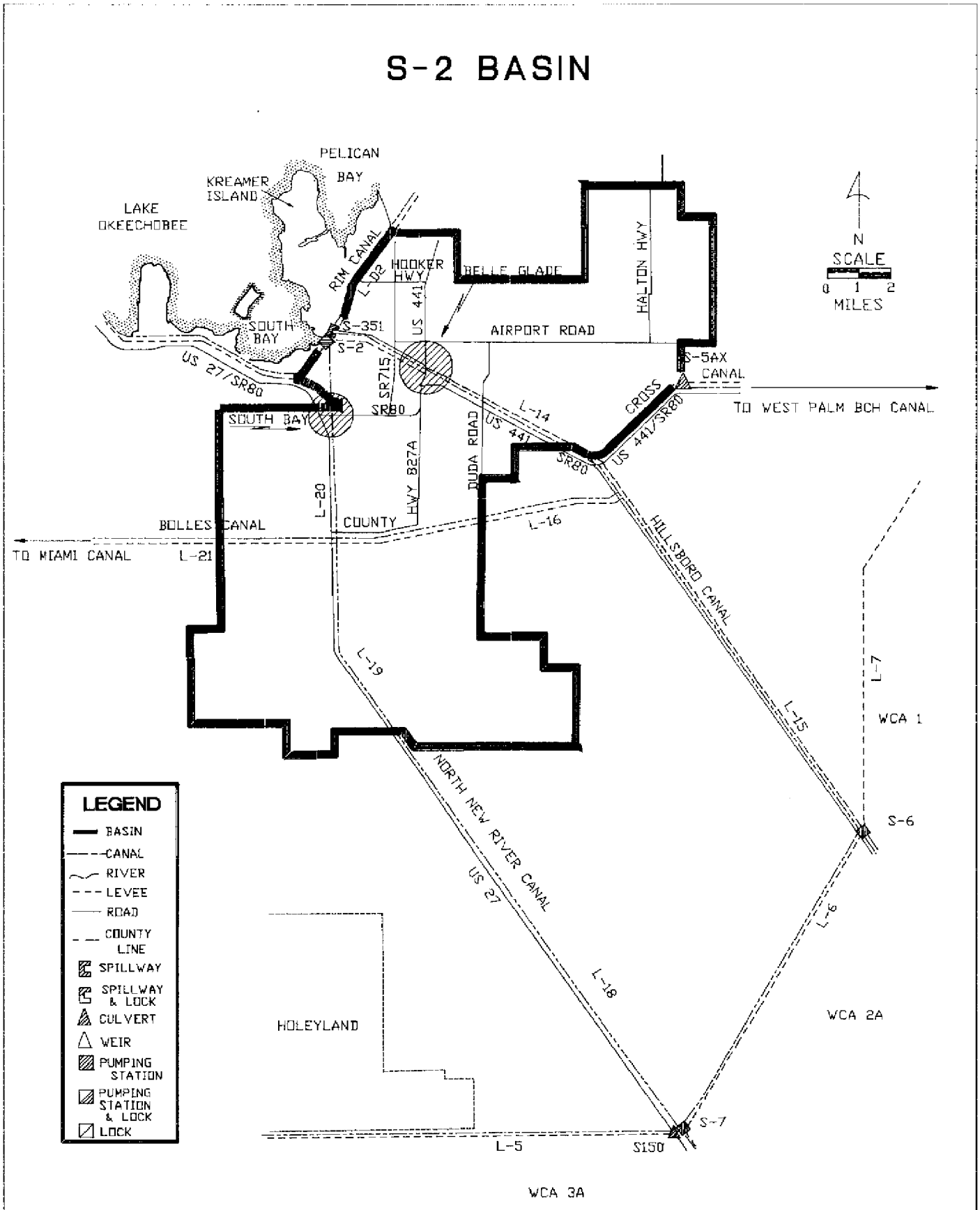


FIGURE 6. THE S-2 BASIN MAP

TABLE 3 S-2 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-2*	Pump Station 4 Units - 900 cfs each	13.0 (canal side)	19.2 (lake side)	10.0-12.5 in Hillsboro and North New River Canals	3600	Lake = 18.52 Canal = 14.09 Q(north) = 3440 Q(south) = 4900	3/9/83 9/28/62 3/15/85 8/19/81
S-5AX	Gated Culvert 4-72in x 68ft CMP Invert elev = 5.5ft NGVD			Closed during flooding. Divide between S-2/S-6 Basins	600		
S-6	Pump Station 3 units - 975 cfs each	12.5 (EAA side)	20.8 (WCA 1 side)	10.0-12.5 in Hillsboro Canal	2925	HW = 14.74 TW = 17.90 Q = 2920	12/25/57 10/20/60 6/9/66
S-7	Pump Station 3 units-830cfs each Gated Box Culvert 1-14.7ftx13.3ftx43ft Reinforced ConcreteBox Invert elev = 1.75ft NGVD	13.0 (pumped discharge) (EAA side)	18.3 (Pumped discharge) (WCA 2A side)	10.0-12.5 in North New River Canal	2490 400	HW = 14.09 TW = 15.5 Q = 2790 (pump)	10/31/61 11/15/69 8/20/81
S-150	Gated Culvert 5-84in x92ft CMP Invert elev = 3.0ft NGVD	11.0 (EAA side)	10.0 (WCA 3A side)	Not used to control stage	1000	HW = 14.09 TW = 12.28 Q = 1575	10/31/61 7/16/68 3/30/82
S-351**	Gated Spillway 3-gates 20ft widex7.5ft high Net Crest lgth = 60ft Crest elev = 4.5ft NGVD	Water Supply 10.5 Regulatory Releases 24.5 (lake side)	Water Supply 10.0 Regulatory Releases 13.5 (canal side)	10.0-12.5 in Hillsboro and North New River Canals	Water Supply 1500 Regulatory Releases 2400	Lake = 18.52 Canal = 14.09 Q(north) = 3440 Q(south) = 4900	3/9/83 9/28/62 3/15/85 8/19/81

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

*The peak discharges given for S-2 and S-351 are the combined discharges for the structures.
**S-351 replaced Hurricane Gate Structure 4 which was at the same location and served a similar function.

S-6 Basin

Description of the Basin

The S-6 drainage basin is 132.8 square miles in area and is located in central Palm Beach County (Figure 9). 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 10.

The Project canals and water control structures in the S-6 basin have four primary functions: (1) to remove excess water from the S-6 basin to storage in Water Conservation Area 1 (WCA 1); (2) to prevent overdrainage of the S-6 basin; (3) to supply water from Lake Okeechobee to the S-6 basin as needed for irrigation; and (4) to provide conveyance for regulatory releases from Lake Okeechobee to be passed to storage in WCA 1 and for water supply releases to be passed to eastern Palm Beach and Broward counties. Pump station S-6 removes excess water from the S-6 basin and discharges it to WCA 1. Regulatory releases from Lake Okeechobee are made to the Hillsboro Canal by way of S-351. On the rare occasions such releases are made, they are passed to WCA 1 by way of S-6. Water supply releases from Lake Okeechobee are made to the Hillsboro Canal by way of S-351 and S-2. These releases are passed to WCA 1, and subsequently to eastern Palm Beach and Broward counties, by way of S-6.

There are two Project canals in the S-6 basin: the Hillsboro Canal and the L-6 borrow canal. Two other, non-Project canals, are important in this basin. These are the Cross Canal and the Bolles Canal. The Cross Canal, the Bolles Canal, and the L-6 borrow canal are tributary to the Hillsboro Canal.

The Hillsboro Canal connects Lake Okeechobee to WCA 1. The connection to Lake Okeechobee is by way of S-2 at the north end of the canal at South Bay west of Belle Glade. The connection to WCA 1 is by way of S-6 at the intersection of L-6 and L-7 on the west side of WCA 2A. The Project name for that part of the Hillsboro Canal within the EAA is the L-14/L-15 borrow canal. Since the Hillsboro Canal is the more familiar name for this canal, and since no confusion should result from its use in the contex of this atlas, it is the name that will be used here.

The Cross Canal extends east to west connecting the L-10/L-12 borrow canal (i.e., West Palm Beach Canal) in the S-5A basin to the Hillsboro Canal. It makes an open channel connection with the L-10/L-12 borrow canal near the intersection of U.S. Highway 441 and U.S. Highway 98 and an open channel connection with the Hillsboro Canal at the U.S. 441 crossing of the Hillsboro Canal. The part of the Cross Canal in the S-5A basin is a Project canal and is known as the L-13 borrow canal. In this atlas, the distinction will not be made, the entire canal from the Hillsboro Canal to the L-10/L-12 borrow canal being referred to as the Cross Canal.

The Bolles Canal extends east to west connecting the Hillsboro Canal to the North New River and Miami canals. It makes an open channel connection with the Hillsboro canal about one and one-half miles southeast of the U.S. Highway 441 crossing of the HIllsboro Canal, it makes an open channel connection with the North New River Canal at the intersection of State Road 827 and U.S. Highway 27, and it is connected to the Miami Canal by way of three uncontrolled 72 inch culverts about three miles north of the Seaboard Coast Line Railway crossing of the Miami Canal.

The L-6 borrow canal is aligned southwest to northeast along the southeastern boundary of the basin. It connects the Hillsboro Canal to the North New River Canal. It makes open channel connections with the Hillsboro Canal and the North New River canals at the points where those canals are crossed by L-6.

There are four Project control structures affecting flows in the S-6 basin: S-2, S-5AX, S-6, and S-351. Design criteria for these Project control structures are given in Table 4.

S-2 is a pump station located at the connection of the North New River and Hillsboro canals to Lake Okeechobee about two miles west of the town of Belle Glade. Pumping is initiated when the S-6 and S-7 pumping stations can not maintain the stage in the Hillsboro or North New River canals below 13.5 ft NGVD or when flooding occurs in the basin. Flooding is most likely to occur along the Bolles Canal or the Cross Canal (see **Comments on Design and Historic Operation**). The stage in the Hillsboro or the North New River canals is not to be drawn down below 10.0 ft NGVD. S-351 is closed when pumping is under way. S-2 is used to augment water supply releases from Lake Okeechobee when the lake stage is too low for an adequate discharge through S-351. Water Supply releases through S-2 are by syphoning through the pumps.

S-5AX is a gated culvert located in the Cross Canal at the boundary between the S-5A basin and the S-2 and S-6 basins. The gates are normally open. They are closed only to prevent water from passing from one basin to another when the additional flows would create flooding, or would exacerbate an existing flood condtion, in the receiving basin.

S-6 is a pump station located at the point where the Hillsboro Canal enters WCA 1. Pumping from the Hillsboro Canal to WCA 1 is initiated when the stage at any point in the Hillsboro Canal exceeds 12.5 ft NGVD. The stage in the canal is not to be drawn down below 10.0 ft NGVD. Pumping also may be initiated upon request by the U. S. Army Corps of Engineers to provide regulatory discharge from Lake Okeechobee to WCA 1 by way of S-351 and the Hillsboro Canal, when the entire capacity of S-6 is not needed for removal of water from the S-6 and S-2 basins.

S-351 is a gated spillway located in L-D2 at the connection of the Hillsboro and North New River canals to Lake Okeechobee. The primary functions of the structure are to prevent a hurricane surge on the lake from entering the canals and to make water supply releases. The gates are normally closed, but may be opened for any of four reasons: (1) to supply water for irrigation to the S-2, S-6, and S-7 basins when dry season water levels in the North New River and Hillsboro canals are below 11.0 ft NGVD; (2) to supply water from the lake to eastern Palm Beach and Broward counties; (3) to make regulatory releases from Lake Okeechobee to storage in the WCA 2A and 3A.; and (4) to discharge flood flows from the S-2 basin to Lake Okeechobee if the lake stage is below 11.0 ft NGVD. In general, cases 2 and 3 are implemented only when the water levels in the Hillsboro and North New River canals are below 11.0 ft nGVD. Cases 3 and 4 are rare occurrances.

Comments on Design and Historic Operation

Project Design

Design of the canals and water control structures in the S-6 basin was based on two primary considerations: flood control and water supply. For flood control the

design removal rate was determined to be three-quarters of an inch of runoff per day for the drainage area. For water supply, the canals and structures were designed to deliver water at a maximum rate of 4.3 cubic feet per second for each square mile of area served.

The design removal rate is less than the rate at which it is possible for individual growers to pump to the canals in the EAA, and the capacity of the Project canals and water control structures is less than the total of the possible grower discharges. The design removal rate and the capacities of the canals and structures are adequate, however, because of three factors: (1) not all the land in the EAA is in production at one time, (2) much of the EAA is planted to water-tolerant crops (e.g., sugarcane), and (3) the canals in the EAA have some storage capacity.

Water supply to the basin was intended for irrigation and to maintain water levels in the basin as high as possible to minimize soil subsidence and oxidation. The COE recognized that the optimum water level in the Hillsboro Canal would have to be lowered over time as subsidence in the basin occurred. The intake elevation for the pumps at S-6 was determined taking into consideration the anticipated lowering of the optimum water level.

Lake Okeechobee Regulatory Releases

Although lake regulation was not a factor in the original design, it was anticipated that, with no local inflows to the Hillsboro Canal, lake regulatory releases would be made up to the design capacity of the canal. There are six principal outlets for regulatory releases from Lake Okeechobee: the Caloosahatchee River (C-43), the St. Lucie Canal (C-44), and the four agricultural canals, the L-10/L-12 borrow, the Miami, the North New River, and the Hillsboro. The levees and discharge structures for Lake Okeechobee were designed assuming releases would be made by way of all six outlets during a major storm event. Regulatory releases from the lake to these canals are made in accordance with the Lake Okeechobee regulation schedule (Figure 6).

Although the St. Lucie Canal and the Caloosahatchee River can pass the largest discharges from the lake, they are not the preferred outlets from the lake since water released in this way is lost to the ocean and, in some cases, damages the estuaries of the St. Lucie and Caloosahatchee Rivers. To the extent possible, regulatory releases are made to the agricultural canals. Water released to these canals is stored in the WCAs and is kept in the system. This affords additional opportunity for using the water, and it limits the amount of freshwater that enters the estuaries of the Caloosahatchee and St. Lucie Rivers. However, this is not a common practice and little of the regulatory discharge from Lake Okeechobee is handled in this way.

There are three reasons that regulatory releases to the agricultural canals are rare.

1. Most significantly, regulatory releases to the agricultural canals cannot be made if to do so would compromise agricultural water control in any of the basins the canals pass through. In the case of the Hillsboro Canal, which must be considered with the North New River Canal, the S-2, S-6, and S-7 basins are of concern. In general, it is required that weather conditions in the S-2, S-6, and S-7 basins be dry and that water levels in the Hillsboro and North New River Canals be low enough not to restrict local inflows. As a rule of thumb, the canal water level must be below 11.0 ft NGVD. With no local inflows, however, the water level at the

outlet structure, S-351, can be allowed to rise as high as 13.5 ft NGVD during regulatory discharge.

2. Although COE and District policy does not explicitly restrict regulatory releases to the WCAs when the WCAs are over schedule, such releases usually are not made if it is perceived the releases would be harmful to the environment in the receiving WCA, e.g., by drowning deer in WCA 3A or by compromising the WCA 2A drawdown.

3. Regulatory releases to the agricultural canals cost more to make than do releases to the St. Lucie Canal or the Caloosahatchee River since water discharged to the agricultural canals must be pumped to the receiving WCA.

The wet weather conditions that cause Lake Okeechobee to go over schedule also are likely to create wet conditions in the EAA basins, with water levels over 11.0 ft NGVD, and to cause the WCAs to go over schedule. These factors combine to make regulatory releases by way of the agricultural canals rare events.

S-351

The original structure, Hurricane Gate Structure 4, controlling discharges from the lake to the Hillsboro and North New River canals has been replaced by a gated spillway, S-351. The old hurricane gate, for the last few years of its long service, could not be operated as designed and could pass only limited discharges. The new structure allows regulatory and water supply discharges up to the combined capacities of the Hillsboro and North New River canals.

S-6 Basin Boundary

The S-6 basin is that portion of the EAA draining to the Hillsboro Canal from which pump station S-6 was designed to pump excess water at a maximum rate of three-quarters of an inch of runoff per day. At any given time, however, the actual drainage basin may differ significantly from the design basin. There are four reasons for this:

1. Because of environmental problems in Lake Okeechobee resulting from inflow of nutrient rich water to the lake, the current District water management plan for the EAA discourages discharge of water to Lake Okeechobee from the EAA. Consequently, S-2 (located at the north end of the Hillsboro Canal) is operated only when necessary to prevent flooding in the S-2 basin. Normal (non-flood) drainage from the portion of the S-2 basin that drains to the Hillsboro Canal is to WCA 1 by way of S-6. This water management plan is known as the Interim Action Plan (IAP) and was originally implemented under the Lake Okeechobee Temporary Operating Permit (LOTOP) from the Florida Department of Environmental Regulation (FDER). FDER has since granted the District permission to continue the plan on a permanent basis under the Lake Okeechobee Operating Permit (LOOP).

2. The Hillsboro Canal is interconnected to the North New River and Miami canals by the Bolles Canal. These are open channel connections. Although water flow in the Bolles Canal is restricted by its shallow depth, small cross-sectional area, and by culverts in its alignment (at Duda Road, at a farm road on the boundary between the S-2 and S-3 basins, and at the confluence with the Miami Canal), there may be interbasin transfer of water between the S-2 and S-6 basins and between the S-2 and S-3 basins. As a result, the boundaries between these basins may vary.

3. The Hillsboro Canal is interconnected to the L-10/L-12 borrow canal (i.e., West Plam Beach Canal) in the S-5A basin by the Cross Canal. There is a gated culvert, S-5AX, in the Cross Canal at the boundary between the S-5A basin and S-2

and S-6 basins. When the gates on this culvert are closed, it acts as a divide between the basins. Since this structure is usually open, however, the Hillsboro Canal and the L-10/L-12 borrow canal are usually connected by an open channel and the actual boundary between the S-5A, S-2, and S-6 basins may vary from that shown in Map A as interbasin flow of water occurs.

4. The Hillsboro Canal is interconnected to the North New River Canal by the L-6 borrow canal. Since this is an open channel connection, there may be interbasin transfer of water between the S-6 and S-7 basins. As a result, the boundary between these basins may vary.

The extent to which the boundaries vary between the S-6 and S-2 basins, between the S-6 and S-5A basins, and between the S-6 and S-7 basins depends on the operation of the structures in the S-2, S-3, S-5A, S-6, S-7, and S-8 basins. See the S-3, S-5A, S-7, and S-8 basin descriptions for information on the operation of their respective pump stations. The design basin boundaries are probably most closely realized for the S-2, S-3, S-5A, S-6, S-7, and S-8 basins when all pump stations are operating to capacity.

With operation under the IAP, the hump in the Hillsboro Canal restricts flow to the south from the S-2 basin to the S-6 basin. Because of this, flood flows southward to the S-6 basin may create high stages in the part of the Hillsboro Canal in the S-2 basin and the Bolles and Cross canals. Flooding is most likely to occur along the Bolles and Cross canals because of their relatively low levees and their distance from the Project pump station.

Bolles and Cross Canals General Design Memorandum

At the time of publication of this Atlas, the Corps of Engineers is preparing a General Design Memorandum (GDM) on the Bolles and Cross Canals. The GDM will propose a scope of work to reduce flooding along the canals. The work will probably include increasing the conveyance of the canals and increasing the size of the levees that border the canals.

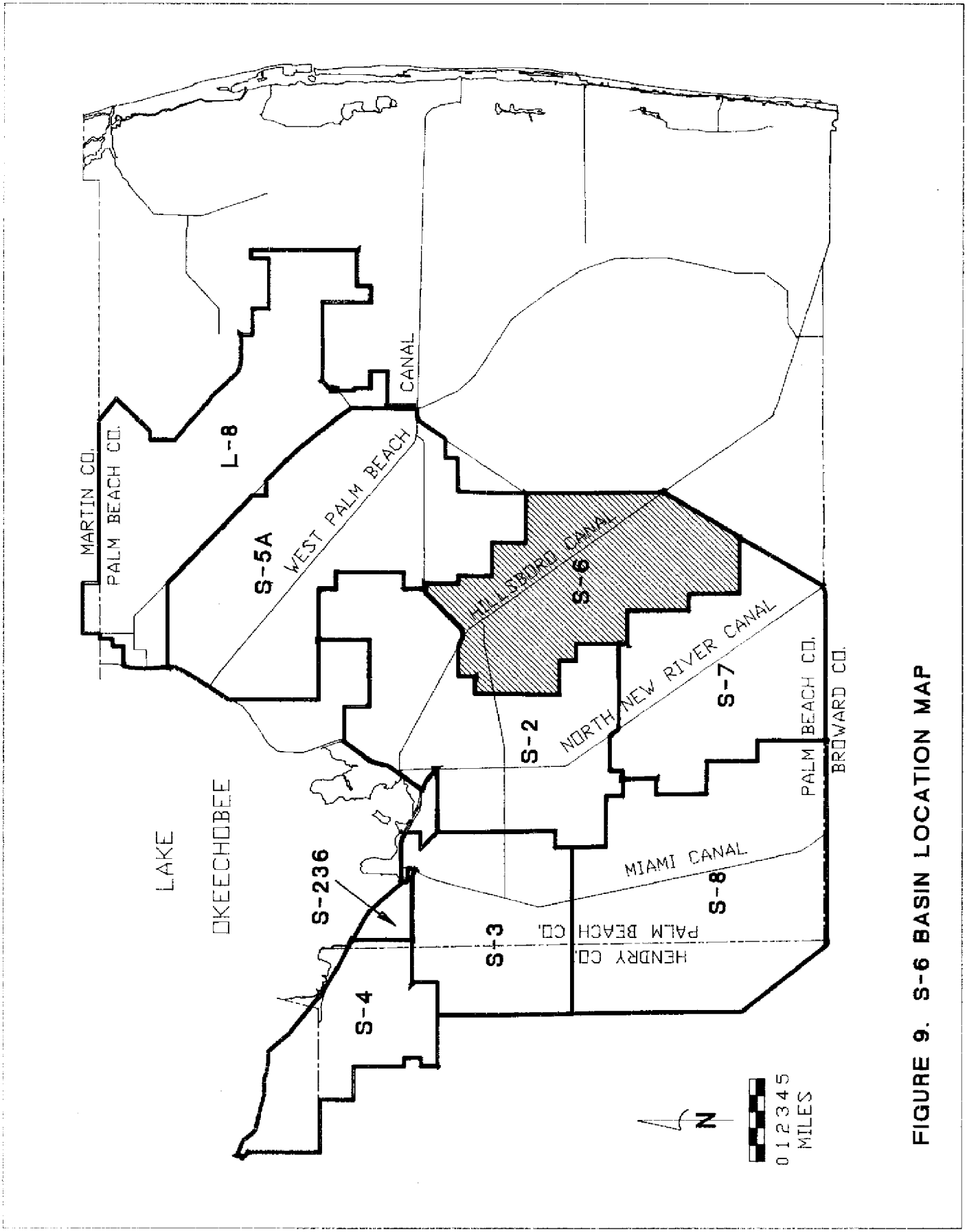


FIGURE 9. S-6 BASIN LOCATION MAP

S-6 BASIN

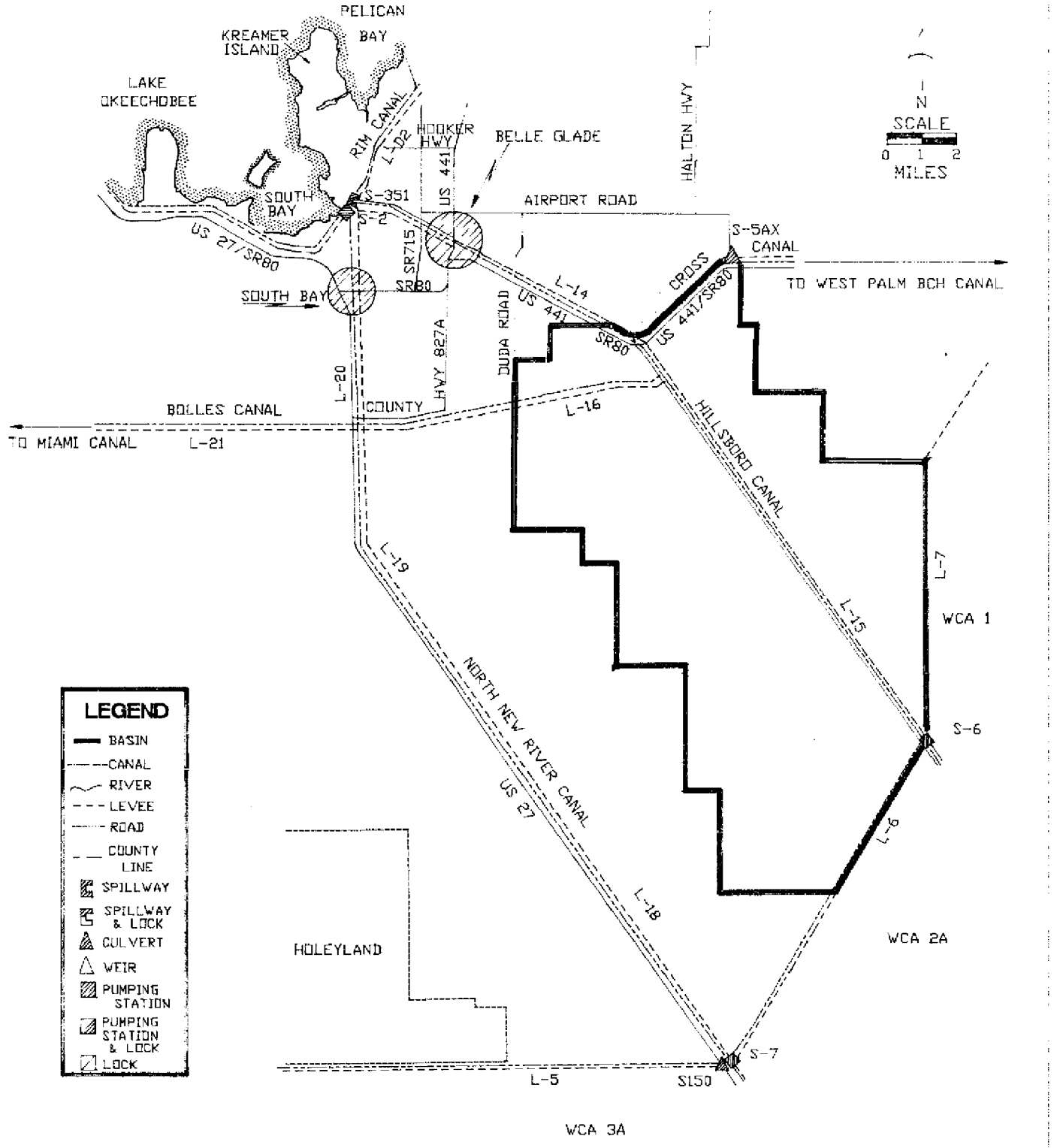


FIGURE 10. THE S-6 BASIN MAP

TABLE 4 S-6 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-2*	Pump Station 4 units-900 cfs each	13.0 (canal side)	19.2 (lake side)	10.0-12.5 in Hillsboro and North New River Canals	3600	Lake = 18.52 Canal = 14.09 Q(north) = 3440 Q(south) = 4900	3/9/83 9/28/62 3/15/85 8/19/81
S-5AX	Gated Culvert 4-72in x 68ft CMP Invert elev = 5.5ft NGVD			Closed During flooding Divide between S-5A and S-2/S-6 Basins	600		
S-6	Pump Station 3 units -9.75 cfs	12.5 (EAA side)	20.8 (WCA 1 side)	10.0 -12.5 in Hillsboro Canal	2925	HW = 14.74 TW = 17.90 Q = 2920	12/25/57 10/20/60 6/9/66
S-351**	Gated Spillway 3 gates 20ft wide x 7.5ft high Net Crest lgth = 60ft Crest elev = 4.5ft NGVD	Water Supply 10.5 Regulatory Releases 24.5 (lake side)	Water Supply 10.0 Regulatory Releases 13.5 (canal side)	10.0-12.5 in Hillsboro and North New River Canals	Water Supply 1500 Regulatory Releases 2400	Lake = 18.52 Canal = 14.09 Q(north) = 3440 Q(south) = 4900	3/9/83 9/28/62 3/15/85 8/19/81

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

*The peak discharges given for S-2 and S-351 are the combined discharges for the structures.
**S-351 replaced Hurricane Gate Gtructure 4 which was at the same location and served a similar function.

S-7 BASIN

Description of the Basin

The S-7 drainage basin is 131.3 square miles in area and is located in south-central Palm Beach County (Figure 11). 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 12.

The Project canals and water control structures in the S-7 basin have four functions: (1) to remove excess water from the S-7 basin to storage in Water Conservation Areas (WCAs) 2A and 3A; (2) to prevent overdrainage of the S-6 basin; (3) to supply water from Lake Okeechobee to the S-7 basin as needed for irrigation; and (4) to provide conveyance for regulatory releases from Lake Okeechobee to be passed to storage in WCAs 2A and 3A and for water supply releases to be passed to eastern Broward County. Pump station S-7 removes excess water from the S-7 basin and discharges it to WCA 2A. S-150 also removes excess water from the basin, but discharge is by gravity flow to WCA 3A. Regulatory releases from Lake Okeechobee are made to the North New River Canal by way of S-351. On the rare occasions such releases are made, they are passed to WCA 2A by way of S-7 and to WCA 3A by way of S-150. Water supply releases from Lake Okeechobee are made to the North New River Canal by way of S-351 and S-2. These releases are passed to WCA 2A, and subsequently to eastern Broward County, by way of S-7.

There are three Project canals in the S-7 basin: the North New River Canal , the L-6 borrow canal, and the L-5 borrow canal.

The North New River Canal connects Lake Okeechobee to WCAs 2A and 3A. The connection to Lake Okeechobee is by way of S-2 at the north end of the canal at South Bay west of Belle Glade. The connection with WCA 2A is by way of S-7 at the intersection of L-5 and L-6, just east of U. S. Highway 27 on the Palm Beach-Broward County line. The connection with WCA 3A is by way of S-150 just west of S-7.

The L-6 borrow canal is aligned southwest to northeast along the southeastern boundary of the basin. It connects the Hillsboro Canal to the North New River Canal. It makes open channel connections with the Hillsboro and North New River canals at the intersections of L-6 and L-7, and L-6 and L-5, respectively.

The L-5 borrow canal is aligned east-west along the southern boundary of the basin. It makes an open channel connection with the North New River Canal at the intersection of L-5 and L-6. The borrow canal extends to the west approximately six miles. It does not connect to the Miami Canal.

There are four Project control structures affecting flow in the S-7 basin: S-2, S-7, S-150, and S-351. Design criteria for these Project control structures are given in Table 5.

S-2 is a pump station located at the connection of the North New River and Hillsboro canals to Lake Okeechobee about two miles west of the town of Belle Glade. Pumping is initiated when the S-6 and S-7 pumping stations can not maintain the stage in the Hillsboro or North New River canals below 13.5 ft NGVD or when flooding occurs in the basin. Flooding is most likely to occur along the Bolles Canal or the Cross Canal (see **Comments on Design and Historic Operation**). The stage in

the Hillsboro or North New River canals is not to be drawn down below 10.0 ft NGVD. S-351 is closed when pumping is under way. S-2 is used to augment water supply releases from Lake Okeechobee when the lake stage is too low for an adequate discharge through S-351. Water supply releases through S-2 are by syphoning through the pumps.

S-7 is a pump station and gated spillway located at the point where the North New River Canal enters WCA 2A just east of U.S. Highway 27 at the Palm Beach-Broward County line. Water is discharged from the North New River Canal to WCA 2A when the stage at any point in the canal exceeds 12.5 ft NGVD. Discharge is by gravity flow through the gated spillway if the stage in WCA 2A is low enough to permit a discharge adequate to maintain the optimum stage in the North New River Canal and by pumping otherwise. Normally, the headwater stage (i.e., canal side) at S-7 is drawn down to and held at 10.0 ft NGVD. It is not to be drawn down below 8.7 ft NGVD to prevent possible damage to the pumps. Pumping is also initiated upon request by the U. S. Army Corps of Engineers to provide regulatory discharge from Lake Okeechobee to WCA 2A by way of S-351 and the North New River Canal when the capacity of S-7 is not needed for removal of water from the S-7 basin.

S-150 is a gated culvert located in L-5 just west of S-7. It can be used to pass water by gravity flow from the North New River Canal (i.e., from the S-7 and S-6 basins) to WCA 3A unless this interferes with the supply of water to WCA 2A by way of S-7. Discharge through S-150 also may be initiated upon request by the U. S. Army Corps of Engineers to provide regulatory discharge from Lake Okeechobee to WCA 3A by way of S-351 and the North New River Canal when the capacity of S-150 is not needed for removal of excess water from the S-7 basin.

S-351 is a gated spillway located in L-D2 at the connection of the Hillsboro North New River canals to Lake Okeechobee. The primary functions of the structure are to prevent a hurricane surge on the lake from entering the canals and to make water supply releases. The gates are often closed, but may be opened for any of four reasons: (1) to supply water from Lake Okeechobee to the S-2, S-6, and S-7 basins when dry season water levels in the North New River and Hillsboro canals are below 11.0 ft NGVD; (2) to supply water from the lake to eastern Palm Beach and Broward counties; (3) to make regulatory releases from Lake Okeechobee to storage in the WCAs 2A and 3A; and (4) to discharge flood flows from the S-2 basin to Lake Okeechobee if the lake stage is below 11.0 ft NGVD. In general, cases 2 and 3 are implemented only when the water levels in the Hillsboro and North New River canals are below 11.0 ft NGVD. Cases 3 and 4 are rare occurrences.

Comments on Design and Historic Operation

Project Design

Design of the canals and water control structures in the S-7 basin was based on two primary considerations: flood control and water supply. For flood control the design removal rate was determined to be three-quarters of an inch of runoff per day for the drainage area. For water supply, the canals and structures were designed to deliver water at a maximum rate of 4.3 cubic feet per second for each square mile of area served.

The design removal rate is less than the rate at which it is possible for individual growers to pump to the canals in the EAA, and the capacity of the Project canals and water control structures is less than the total of the possible grower discharges. The

design removal rate and the capacities of the canals and structures are adequate, however, because of three factors: (1) not all the land in the EAA is in production at one time, (2) much of the EAA is planted to water-tolerant crops (e.g., sugarcane), and (3) the canals in the EAA have some storage capacity.

Water supply to the basin was intended for irrigation and to maintain water levels in the basin as high as possible to minimize soil subsidence and oxidation. The COE recognized that the optimum water level in the Hillsboro Canal would have to be lowered over time as subsidence in the basin occurred. The intake elevation for the pumps at S-7 was determined taking into consideration the anticipated lowering of the optimum water level.

Lake Okeechobee Regulatory Releases

Although lake regulation was not a factor in the original design, it was anticipated that, with no local inflows to the North New River Canal, lake regulatory releases would be made up to the design capacity of the canal. There are six principal outlets for regulatory releases from Lake Okeechobee: the Caloosahatchee River (C-43), the St. Lucie Canal (C-44), and the four agricultural canals, the L-10/L-12 borrow, the Miami, the North New River, and the Hillsboro. The levees and discharge structures for Lake Okeechobee were designed assuming releases would be made by way of all six outlets during a major storm event. Regulatory releases from the lake to these canals are made in accordance with the Lake Okeechobee regulation schedule (Figure 6).

Although the St. Lucie Canal and the Caloosahatchee River can pass the largest discharges from the lake, they are not the preferred outlets from the lake since water released in this way is lost to the ocean and, in some cases, damages the estuaries of the St. Lucie and Caloosahatchee Rivers. To the extent possible, regulatory releases are made to the agricultural canals. Water released to these canals is stored in the WCAs and is kept in the system. This affords additional opportunity for using the water, and it limits the amount of freshwater that enters the estuaries of the Caloosahatchee and St. Lucie Rivers. However, this is not a common practice and little of the regulatory discharge from Lake Okeechobee is handled in this way.

There are three reasons that regulatory releases to the agricultural canals are rare.

1. Most significantly, regulatory releases to the agricultural canals cannot be made if to do so would compromise agricultural water control in any of the basins the canals pass through. In the case of the North New River Canal, which must be considered with the Hillsboro Canal, the S-2, S-6, and S-7 basins are of concern. In general, it is required that weather conditions in the S-2, S-6, and S-7 basins be dry and that water levels in the Hillsboro and North New River Canals be low enough not to restrict local inflows. As a rule of thumb, the canal water level must be below 11.0 ft NGVD. With no local inflows, however, the water level at the outlet structure, S-351, can be allowed to rise as high as 13.5 ft NGVD during regulatory discharge.
2. Although COE and District policy does not explicitly restrict regulatory releases to the WCAs when the WCAs are over schedule, such releases usually are not made if it is perceived the releases would be harmful to the environment in the receiving WCA, e.g., by drowning deer in WCA 3A or by compromising the WCA 2A drawdown.

3. Regulatory releases to the agricultural canals cost more to make than do releases to the St. Lucie Canal or the Caloosahatchee River since water discharged to the agricultural canals must be pumped to the receiving WCA.

The wet weather conditions that cause Lake Okeechobee to go over schedule also are likely to create wet conditions in the EAA basins, with water levels over 11.0 ft NGVD, and to cause the WCAs to go over schedule. These factors combine to make regulatory releases by way of the agricultural canals rare events.

S-351

The original structure, Hurricane Gate Structure 4, controlling discharges from the lake to the Hillsboro and North New River canals has been replaced by a gated spillway, S-351. The old hurricane gate, for the last few years of its long service, could not be operated as designed and could pass only limited discharges. The new structure allows regulatory and water supply discharges up to the combined capacities of the Hillsboro and North New River canals.

S-7 Basin Boundary

The S-7 basin is that portion of the EAA draining to the North New River Canal from which pump station S-7 was designed to pump excess water at a maximum rate of three-quarters of an inch of runoff per day. At any given time, however, the actual drainage basin may differ significantly from the design basin. There are two reasons for this:

1. Because of environmental problems in Lake Okeechobee resulting from inflow of nutrient rich water to the lake, the current District water management plan for the EAA discourages discharge of water to Lake Okeechobee from the EAA. As a result, S-2 (located at the north end of the North New River Canal) is operated only when necessary to prevent flooding in the S-2 basin. Normal (non-flood) drainage from the portion of the S-2 basin that drains to the North New River Canal is to the S-7 basin by way of the North New River Canal, and then to WCA 2A by way of S-7 and WCA 3A by way of S-150. This water management plan is known as the Interim Action Plan (IAP) and was originally implemented under the Lake Okeechobee Temporary Operating Permit (LOTOP) from the Florida Department of Environmental Regulation (FDER). FDER has since granted the District permission to continue the plan on a permanent basis under the Lake Okeechobee Operating Permit (LOOP).
2. The North New River Canal is interconnected to the Hillsboro Canal by the L-6 borrow canal. Since this is an open channel connection, there may be interbasin transfer of water between the S-7 and S-6 basins. As a result, the boundary between these basins may vary.

The extent to which the boundaries vary between the S-7 and S-2 basins and between the S-7 and S-6 basins depends on the operation of the structures in the S-2, S-3, S-6, S-7, and S-8 basins. See the S-3, S-6, and S-8 basin descriptions for information on the operation of their respective pump stations. The design basin boundaries are probably most closely realized for the S-2, S-3, S-6, S-7, and S-8 basins when all pump stations are operating to capacity.

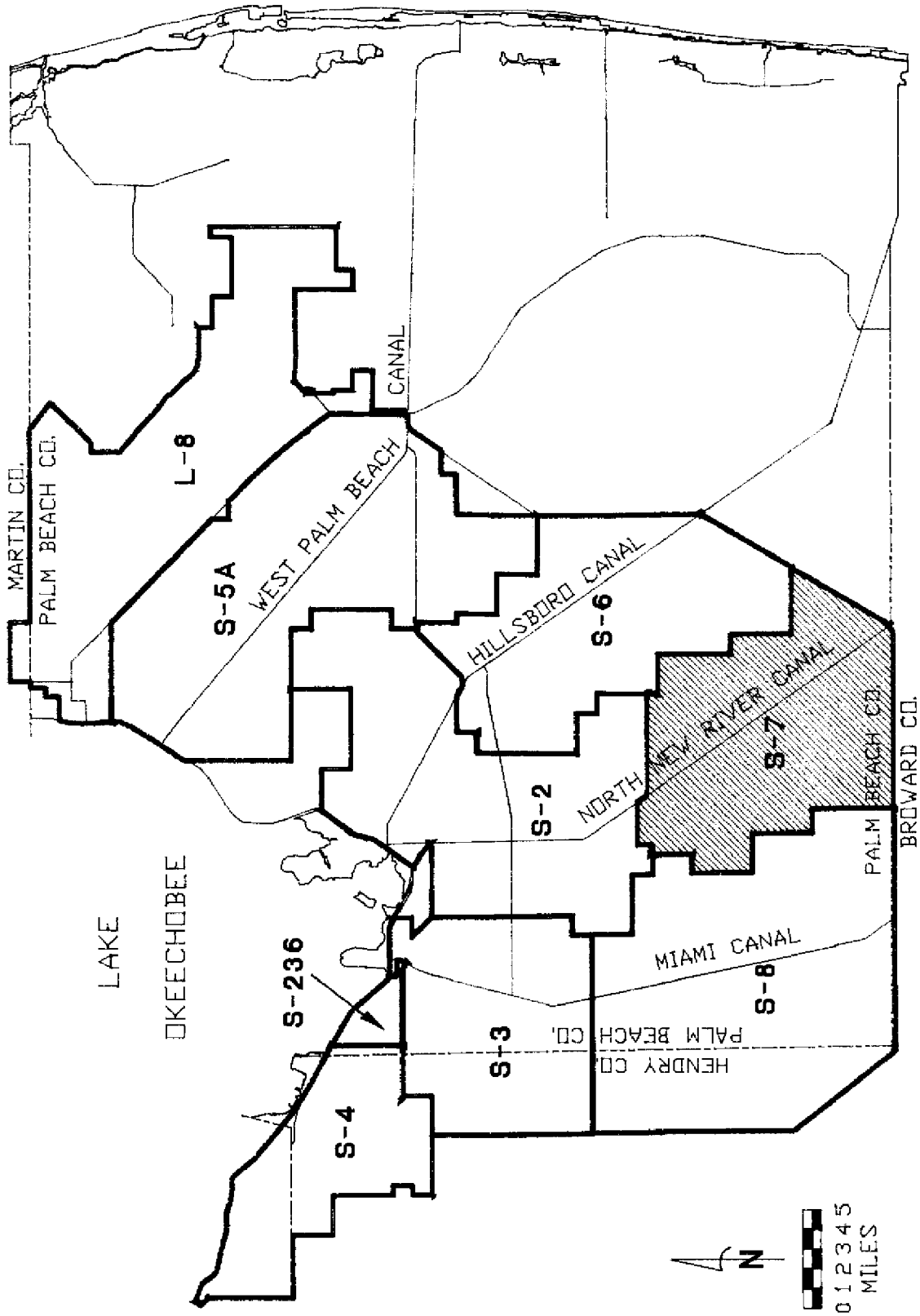


FIGURE 11. S-7 BASIN LOCATION MAP

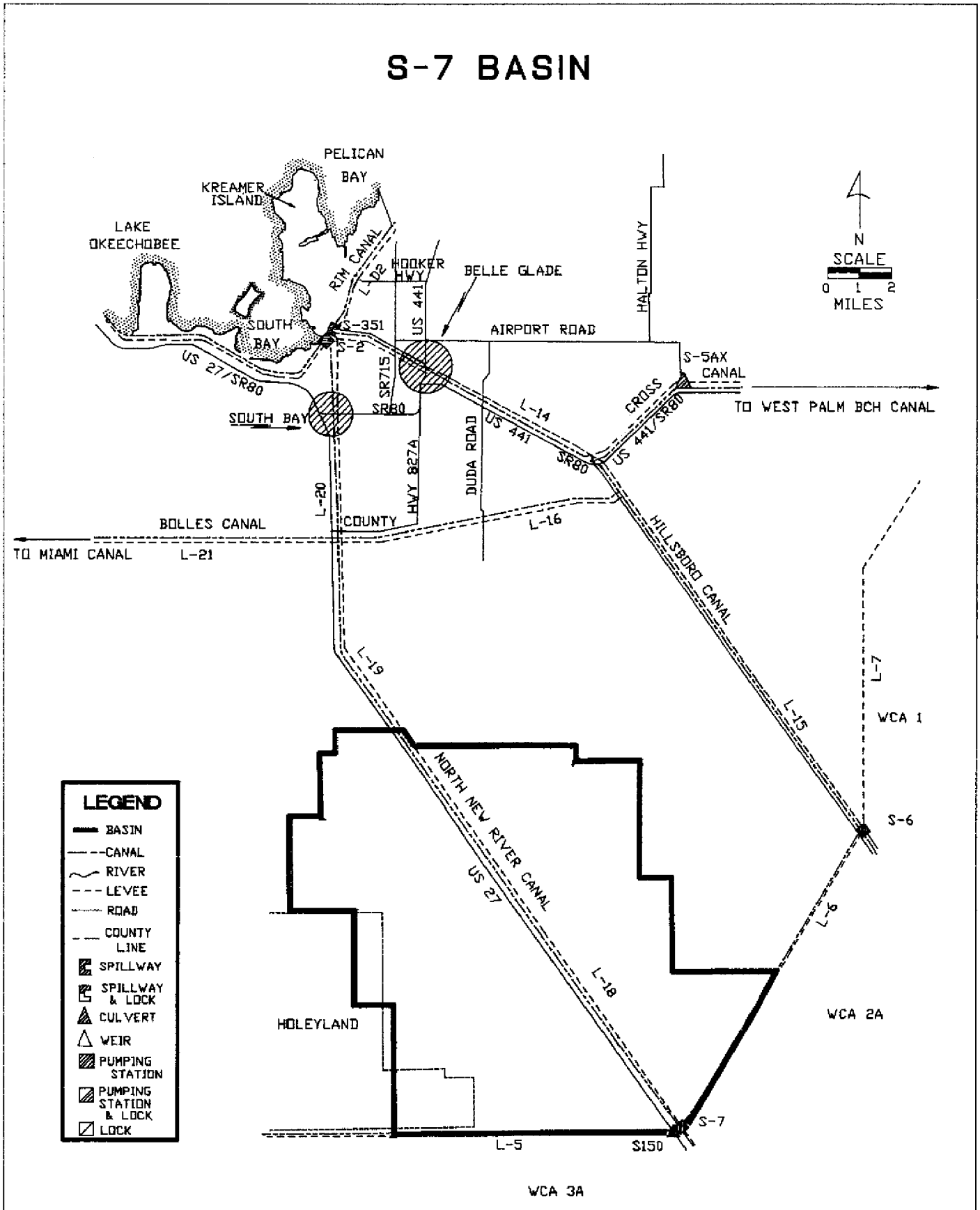


FIGURE 12. THE S-7 BASIN MAP

TABLE 5 S-7 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-2*	Pump Station 4 units-900 cfs each	13.0 (canal side)	19.2 (lake side)	10.0-12.5 in Hillsboro and North New River Canals	3600	Lake = 18.52 Canal = 14.09 Q(north) = 3440 Q(south) = 4900	3/9/63 9/28/62 3/15/85 8/19/81
S-7	Pump Station 3 units-830 cfs each Gated Box Culvert 1-14.7ftx13.3ftx43ft Reinforced concrete box Invert elev = 1.75ft NGVD	13.0 (Pumped Discharge) (EAA Side)	18.3 (Pumped Discharge) (WCA 2A side	10.0-12.5 in North New River Canals	2490 400	HW = 14.09 TW = 15.5 Q = 2790 (pump)	10/31/61 11/15/69 8/20/81
S-150	Gated Culvert 5-84in x92ft CMP Invert elev = 3.0ft NGVD	11.0 (EAA Side)	10.0 (WCA 3A side	Not used to control stage	1000	HW = 14.09 TW = 12.28 Q = 1575	10/31/61 7/16/68 3/30/82
S-351**	Gated Spillway 3-gates 20ft wide x7.5ft high Net crest lgth = 60ft Crest elev = 4.5ft NGVD	Water Supply 10.5 Regulatory Releases 24.5 (lake side)	Water Supply 10.0 Regulatory Releases 13.5 (canal side)	10.0-12.5 in Hillsboro and North New River Canals	Water Supply 1500 Regulatory Releases 2400	Lake = 18.52 Canal = 14.09 Q(north) = 3440 Q(south) = 4900	3/9/63 9/28/62 3/15/85 8/19/81

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

*The peak discharges given for S-2 and S-351 are the combined discharges for the structures.

**S-351 replaced Hurricane Gate Structure 4 which was at the same location and served a similar function.

S-3 Basin

Description of the Basin

The S-3 drainage basin is 101.0 square miles in area and is located (Figure 13) in west-central Palm Beach County (66.2 square miles) and east-central Hendry County (34.8 square miles). 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 14.

The Project canals and water control structures affecting flow in the S-3 basin have five primary functions: (1) to remove excess water from the S-3 basin to storage in Water Conservation Area 3A (WCA 3A) , and under some flood conditions to storage in Lake Okeechobee; (2) to prevent over drainage of the S-3 basin; (3) to supply water from Lake Okeechobee to the S-3 and S-8 basins as needed for irrigation; (4) to provide conveyance for regulatory releases from Lake Okeechobee to be passed to storage in WCA 3A and for water supply releases from the lake to be passed to eastern Dade County and Everglades National Park; and (5) to receive discharges of excess water from the L-1 borrow canal (i.e., northeast Hendry County) when these discharges will not jeopardize flood control in the S-3 or S-8 basins. Pump stations S-3 and S-8 remove excess water from the S-3 basin and discharge it to Lake Okeechobee and WCA 3A respectively. Regulatory releases from Lake Okeechobee can be made to the Miami Canal by way of S-354. On the rare occasions such releases are made, they are passed to WCA 3A by way of S-8. Water supply releases from Lake Okeechobee are made to the Miami Canal by way of S-354 and S-3. These releases are passed to WCA 3A, and subsequently to eastern Dade County and Everglades National Park, by way of S-8. Discharges from the L-1 borrow canal are made to the L-1E canal and subsequently to the Miami Canal.

The Miami Canal is the only Project canal in the S-3 basin. Two non-Project canas are important to the primary system in the basin. One is the Bolles Canal, built prior to the Project by the Everglades Drainage District, and the other is the L-1E canal built by the District from 1982 to 1987.

The Miami Canal connects Lake Okeechobee to WCA 3A. The connection to Lake Okeechobee is by way of S-3 at the north end of the canal at the town of Lake Harbor. The connection to WCA 3A is by way of S-8, 15 miles west of U.S. Highway 27 on the Broward-Palm Beach County line.

The Bolles Canal extends east to west connecting the Miami Canal to the North New River and Hillsboro canals. It makes an open channel connection with the Hillsboro Canal about one and one-half miles southeast of the U.S. Highway 441 crossing of the Hillsboro Canal, it makes an open channel connection with the North New River Canal at the intersection of State Road 827 and U.S. Highway 27, and it is connected to the Miami Canal by way of three uncontrolled 72 inch culverts about three miles north of the Seaboard Coast Line Railway crossing of the Miami Canal.

The L-1E canal extends east to west connecting the L-1 borrow canal to the Miami Canal. It makes an open-channel connection to the Miami Canal about three miles south of Lake Harbor, and it connects to the L-1 borrow canal by way of G-136 at the northeasternmost corner of the borrow canal.

There are four Project control structures affecting flow in the S-3 basin: S-3, S-8, S-354, and G-136. Design criteria for these structures are given in Table 6.

S-3 is a pump station located at the connection of the Miami Canal to Lake Okeechobee just north of the town of Lake Harbor. Pumping is initiated when the S-8 pumping station cannot maintain the stage in the Miami Canal below 13.5 ft NGVD or if flooding occurs in the basin. The stage in the canal is not to be drawn down below 10.0 ft NGVD. S-354 is closed when pumping is underway. S-3 is used to augment water supply releases from Lake Okeechobee when the lake stage is too low for an adequate discharge through S-354. Water supply releases through S-3 are by syphoning through the pumps.

S-8 is a pump station and gated spillway located at the point where the Miami Canal enters WCA 3A, 15 miles west of U.S. Highway 27 at the Palm Beach-Broward County line. Water is discharged from the Miami Canal to WCA 3A when the stage at any point in the canal exceeds 12.5 ft NGVD. Discharge is by gravity flow through the gated spillway if the stage in WCA 3A is low enough to permit a discharge adequate to maintain the optimum stage in the Miami Canal; otherwise, discharage is by pumping. The headwater stage (i.e., the north side) is not to be drawn down below 9.5 ft NGVD. Pumping at S-8 may be initiated by request of the U. S. Army Corps of Engineers to provide regulatory discharge from Lake Okeechobee by way of S-354 and the Miami Canal when the capacity of S-8 is not needed for removal of water from the basin.

S-354 is a gated spillway[2] located in L-D2 at the connection of the Miami Canal to Lake Okeechobee. The primary functions of the structure are to prevent a hurricane surge on the lake from entering the Miami Canal and to make water supply releases. The gates are often closed, but may be opened for any of four reasons: (1) to supply water for irrigation to the S-3 and the S-8 basins when dry season water levels in the Miami Canal fall below 11.0 ft NGVD; (2) to supply water from Lake Okeechobee to eastern Dade County and Everglades National Park; (3) to make regulatory releases from the lake to storage in WCA 3A; and (4) to discharge flood flows from the S-3 basin when Lake Okeechobee is below 11.0 ft. In general, cases 2 and 3 are implemented only when the water level in the Miami Canal is below 11.0 ft NGVD. cases 3 and 4 are rare occurrences.

G-136 is a culvert in the alignment of the L-1E canal at the intersection of that canal with the L-1 borrow canal. Control of water flow is by riser and stoplogs. Normally, all stoplogs are in place and the structure is closed. If the tailwater stage (i.e., L-1E borrow canal side) is below 15.7 ft NGVD, and if S-3 is not pumping, G-136 may be opened when the headwater stage is above 14.0 ft NGVD or when the stage in Montura Ranch Estates reservoir must be lowered. The structure is opened by removing all stoplogs down to a crest elevation of 13.0 ft NGVD.

[2]At the time of publication, S-354 is under construction. The scheduled completion date is July 1990. The structure will replace Hurricane Gate Structure 3, which is already out of service.

Comments on Design and Historic Operation

Project Design

Design of the canals and water control structures in the S-3 basin was based on two primary considerations: flood control and water supply. For flood control the design removal rate was determined to be three quarters of an inch of runoff per day for the drainage area. For water supply, the canals and structures were designed to deliver water at a maximum rate of 4.3 cubic feet per second for each square mile of area served.

The design removal rate is less than the rate at which it is possible for individual growers to pump to the canals in the EAA, and the capacity of the Project canals and water control structures is less than the total of the possible grower discharges. The design removal rate and the capacities of the canals and structures are adequate, however, because of three factors: (1) not all the land in the EAA is in production at one time, (2) much of the EAA is planted to water-tolerant crops (e.g., sugarcane), and (3) the canals in the EAA have some storage capacity.

Water supply to the basin was intended for irrigation and to maintain water levels in the basin as high as possible to minimize soil subsidence and oxidation. The COE recognized that the optimum water level in the Miami Canal would have to be lowered over time as subsidence in the basin occurred. The intake elevation for the pumps at S-3 was determined taking into consideration the anticipated lowering of the optimum water level.

Lake Okeechobee Regulatory Releases

Although lake regulation was not a factor in the original design, it was anticipated that, with no local inflows to the Miami Canal, lake regulatory releases would be made up to the capacity of the canal. There are six principal outlets for regulatory releases from Lake Okeechobee: the Caloosahatchee River (C-43), the St. Lucie Canal (C-44), and the four agricultural canals, the L-10/L-12 borrow, the Miami , the North New River, and the Hillsboro. The levees and discharge structures for Lake Okeechobee were designed assuming releases would be made by way of all six outlets during a major storm event. Regulatory releases from the lake to these canals are made in accordance with the Lake Okeechobee regulation schedule (Figure 6).

Although the St. Lucie Canal and the Caloosahatchee River can pass the largest discharges from the lake, they are not the preferred outlets from the lake since water released in this way is lost to the ocean and, in some cases, damages the estuaries of the St. Lucie and Caloosahatchee Rivers. To the extent possible, regulatory releases are made to the agricultural canals. Water released to these canals is stored in the WCAs and is kept in the system. This affords additional opportunity for using the water, and it limits the amount of freshwater that enters the estuaries of the Caloosahatchee and St. Lucie Rivers. However, this is not a common practice and little of the regulatory discharge from Lake Okeechobee is handled in this way.

There are three reasons that regulatory releases to the agricultural canals are rare.

1. Most significantly, regulatory releases to the agricultural canals cannot be made if to do so would compromise agricultural water control in any of the basins the canals pass through. In the case of the Miami Canal, the S-3 and S-8 basins are of concern. In general, it is required that weather conditions in the S-3 and S-8 basins be dry and that water levels in the Miami Canal be low enough not to restrict local inflows. As a rule of thumb, the canal water level must be below 11.0 ft NGVD. With no local inflows, however, the water level at the outlet structure, S-354, can be allowed to rise as high as 13.5 ft NGVD during regulatory discharge.
2. Although COE and District policy does not explicitly restrict regulatory releases to the WCAs when the WCAs are over schedule, such releases usually are not made if it is perceived the releases would be harmful to the environment in the receiving WCA, e.g., by drowning deer in WCA 3A or by compromising the WCA 2A drawdown.
3. Regulatory releases to the agricultural canals cost more to make than do releases to the St. Lucie Canal or the Caloosahatchee River since water discharged to the agricultural canals must be pumped to the receiving WCA.

The wet weather conditions that cause Lake Okeechobee to go over schedule also are likely to create wet conditions in the EAA basins, with water levels over 11.0 ft NGVD, and to cause the WCAs to go over schedule. These factors combine to make regulatory releases by way of the agricultural canals rare events.

S-354

The original structure, Hurricane Gate Structure 3, controlling discharges from the lake to the Miami Canal has been replaced by a gated spillway, S-354. The old hurricane gate, for the last few years of its long service, could not be operated as designed and could pass only limited discharges. The new structure allows regulatory and water supply discharges up to the capacity of the Miami Canal.

S-3 Basin Boundary

The S-3 basin is that portion of the EAA draining to the Miami Canal that the pump station S-3 was designed to pump excess water from at a maximum rate of three-quarters of an inch of runoff per day. At any given time however, the actual drainage basin may differ significantly from the design basin. There are two reasons for this:

1. Because of environmental problems in Lake Okeechobee resulting from inflows of nutrient rich water to the lake, the current District water management plan for the EAA discourages discharge of water to Lake Okeechobee from the EAA. Consequently, S-3 is operated only when necessary to prevent flooding in the S-3 basin. Normal (non-flood) drainage from the S-3 basin is to the south to the S-8 basin by way of the Miami Canal, and then to WCA 3A by way of S-8. This water management plan is known as the Interim Action Plan (IAP) and was originally implemented under the Lake Okeechobee Temporary Operating Permit (LOTOP) from the Florida Department of Environmental Regulation (FDER). FDER has since granted the District permission to continue the plan on a permanent basis under the Lake Okeechobee Operating Permit (LOOP).
2. The Miami Canal is interconnected to the North New River Canal and to the Hillsboro Canal by the Bolles Canal. These are open channel connections. Although water flow in the Bolles Canal is restricted by its shallow depth, small cross-sectional area, and by culverts in its alignment (at Duda Road, at a farm road

on the boundary between the S-2 and S-3 basins, and at the confluence with the Miami Canal), there may be interbasin transfer of water between the S-3 and S-2 basins and between the S-2 and S-6 basins. As a result, the boundaries between these basins may vary.

The extent to which the boundaries vary between the S-3 and S-2 basins, and the S-3 and S-8 basins depends on the operation of the structures in the S-2, S-3, S-6, S-7, and S-8 basins. See the S-2, S-6, and S-7 basin descriptions for information on the operation of their respective pump stations. The design basin boundaries are probably most closely realized for the S-2, S-3, S-6, S-7, and S-8 basins when all pump stations are operating to capacity.

Bolles and Cross Canals General Design Memorandum

At the time of publication of this Atlas, the Corps of Engineers is preparing a General Design Memorandum (GDM) on the Bolles and Cross Canals. The GDM will propose a scope of work to reduce flooding along the canals. The work will probably include increasing the conveyance of the canals and increasing the size of the levees that border the canals.

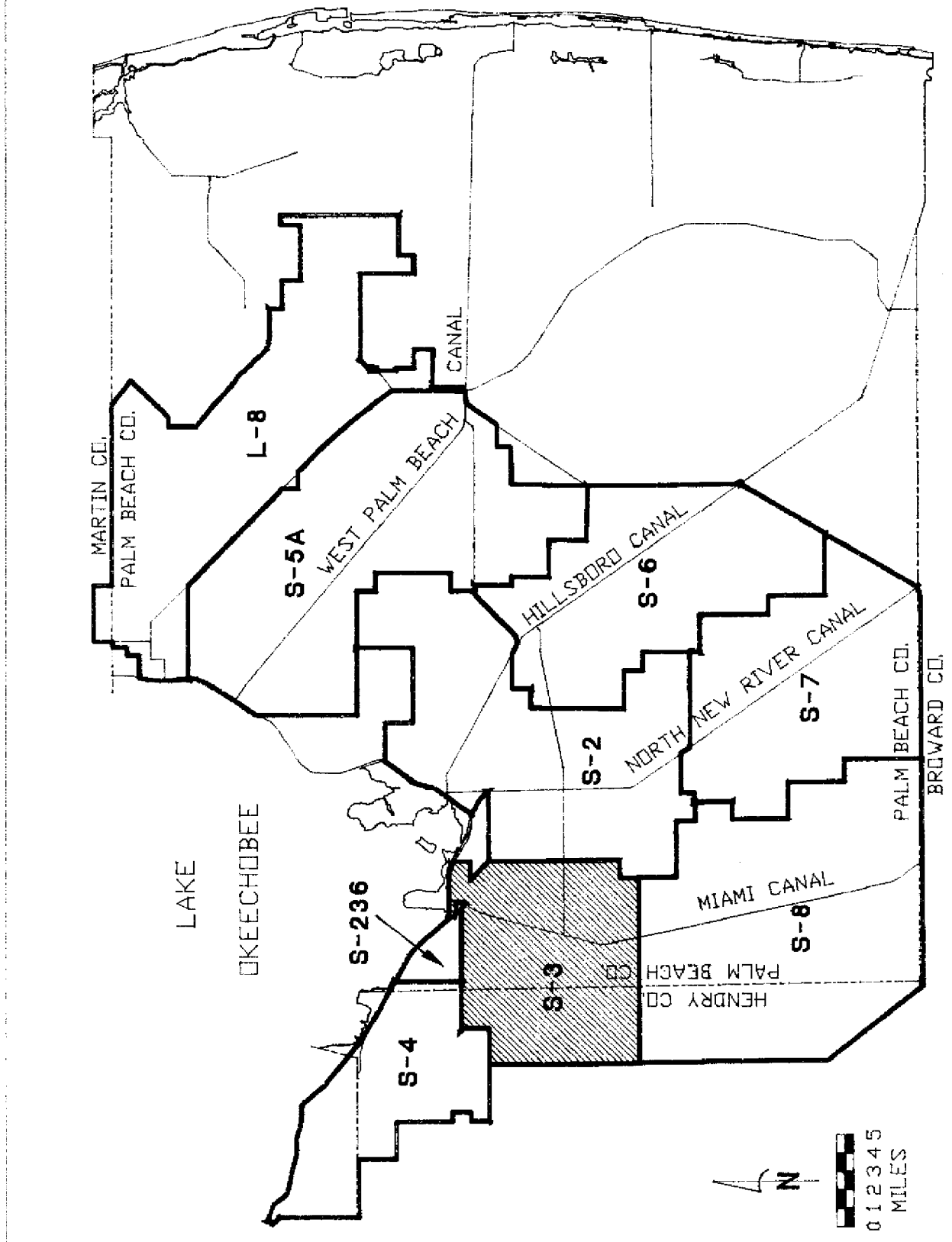


FIGURE 13. S-3 BASIN LOCATION MAP

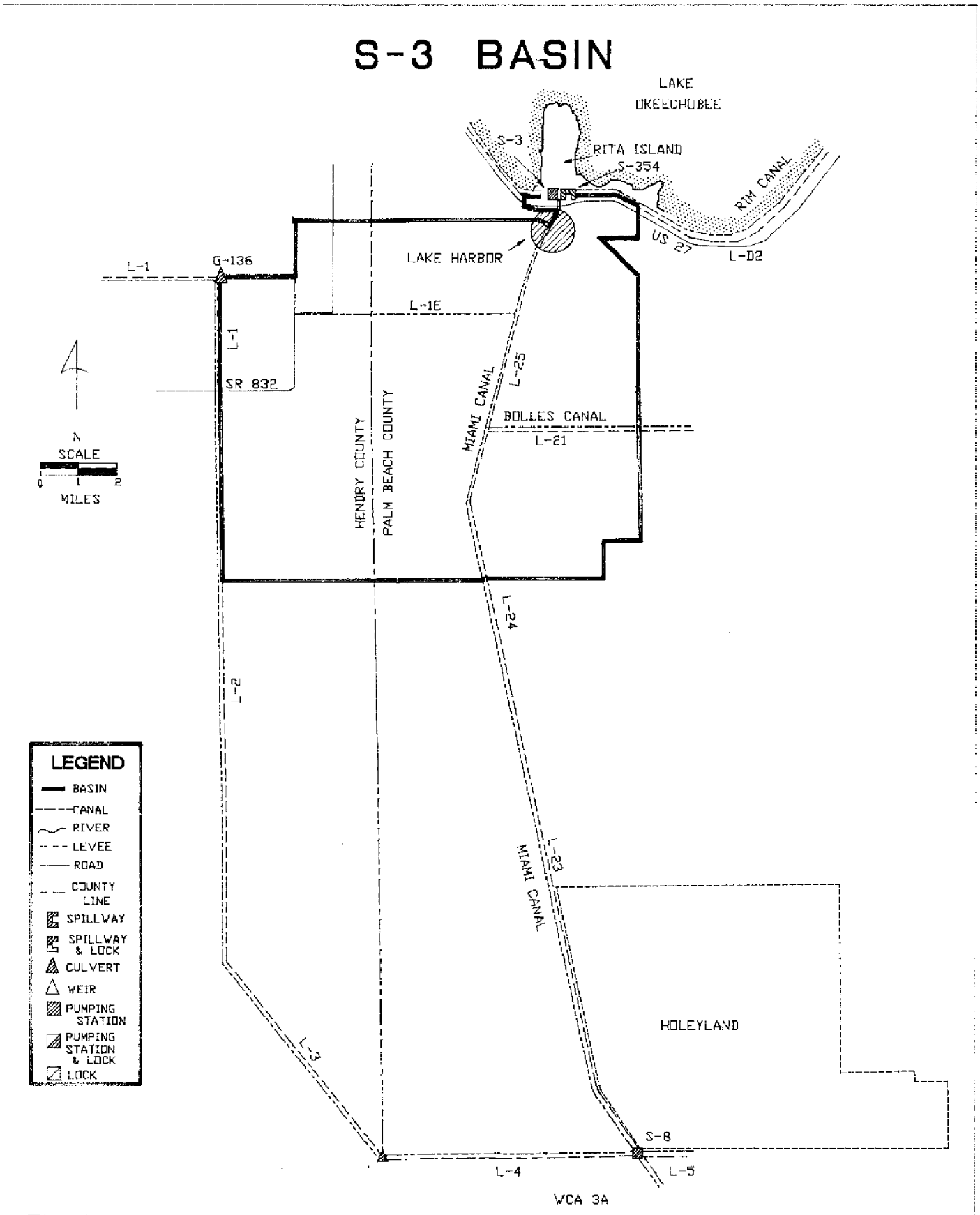


FIGURE 14. THE S-3 BASIN MAP

TABLE 6 S-3 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-3*	Pump Station 3 units -890 cfs each	13.0 (canal side)	19.4 (lake side)	10.0-12.5 in Miami Canal	2580	Lake = 18.38 Canal = 14.92 Q(north) = 2280 Q(south) = 2790	3/9/83 10/2/65 3/24/66 3/26/70
S-8	Pump Station 4 units-1040 cfs each Gated Box Culvert 1-16.5x14.4ftx78.5ft Reinforced Concrete Box Invert elev = 1.0ft NGVD	12.0 (Pumped Discharge) 12.0 (Gravity Discharge) (EAA side)	16.5 (Pumped Discharge) 11.0 (Gravity Discharge) (WCA 3A side)	10.0-12.5 in Miami Canal	4170 (Pumped Discharge) 500 (Gravity Discharge	HW = 13.05 TW = 14.69 Q = 4240 (pump) Q = 1252 (SPW)	2/15/66 7/11/66 10/22/69 1/18/77
S-354**	Gated Spillway 2-Gates 8.3ft highx23.0ft wide Net crest lgth = 46.0 ft Crest elev = 3.2 ft	Water Supply 10.5 Regulatory Releases 24.8 (lake Side)	Water Supply 10.0 Regulatory Releases 24.8 (canal side)	Not used to control stage	Water Supply 1450 Regulatory Releases 2000	Lake = 18.38 Canal = 14.92 Q(north) = 2280 Q(south) = 2790	3/9/83 10/2/65 3/24/66 3/26/70
G-136	Culvert with riser and stoplogs 3-84 in x 80 ft CMP invert elev = 8.0 ft NGVD				850		

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

*The peak discharges given for S-3 and S-354 are the combined discharges for the structures.

**S-354 will replace Hurricane Gate Structure 3 (HGS-3) by the end of 1990. HGS-3 was at the same location and served a similar function as S-354.

S-8 Basin

Description of the Basin

The S-8 drainage basin is 201.4 square miles in area and is located (Figure 15) in southwestern Palm Beach County (151.1 square miles) and in southeastern Hendry County (50.3 square miles). 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 16.

The Project canals and water control structures in the S-8 basin have five primary functions: (1) to remove excess water from the S-8 basin to storage in Water Conservation Area 3A (WCA 3A); to prevent over-drainage of the S-8 basin; (3) to supply water from Lake Okeechobee to the S-8 basin as needed for irrigation, (4) to provide conveyance for regulatory releases from Lake Okeechobee to storage in WCA 3A and for water supply releases to be passed from the lake to eastern Dade County and Everglades National Park, and (5) to receive discharges of excess water from the L-3 borrow canal when these discharges will not cause flooding in the S-8 basin. Pump station S-8 removes excess water from the S-8 basin and discharges it to WCA 3A. Regulatory releases from Lake Okeechobee can be made to the Miami Canal by way of S-354. On the rare occasions such releases are made, they are passed to WCA 3A by way of S-8. Water supply releases from Lake Okeechobee are made to the Miami Canal by way of S-354 and S-3. These releases are passed to WCA 3A, and subsequently to eastern Dade County and Everglades National Park, by way of S-8. G-88 controls discharge of water from the L-3 borrow canal to the L-4 borrow canal.

There are two Project canals in the S-8 basin: the Miami Canal and the L-4 borrow canal.

The Miami Canal connects Lake Okeechobee to WCA 3A. The connection to Lake Okeechobee is by way of S-3 at the north end of the canal at the town of Lake Harbor. The connection to WCA 3A is by way of S-8, 15 miles west of U.S. Highway 27 on the Broward-Palm Beach County line.

The L-4 borrow canal is aligned east-west along the south boundary of the basin west of the Miami Canal. It connects the L-3 borrow canal to the Miami Canal. The L-4 borrow canal is connected to the L-3 borrow canal by way of G-88 at the intersection of the Palm Beach, Broward, and Hendry county lines. The L-4 borrow canal makes an open channel connection with the Miami Canal at S-8, 15 miles west of U.S. Highway 27 on the Palm Beach-Broward County line.

There are four Project control structures affecting flow in the S-8 basin: S-3, S-8, S-354, and G-88. Design criteria for these Project control structures are given in Table 7.

S-3 is a pump station located at the connection of the Miami Canal to Lake Okeechobee just north of the town of Lake Harbor. Pumping is initiated when the S-8 pump station cannot maintain the stage in the Miami Canal below 13.5 ft NGVD or if flooding occurs in the basin. The stage in the canal is not to be drawn down below 10.0 ft NGVD. S-354 is closed when pumping is underway. S-3 is used to augment water supply releases from Lake Okeechobee when the lake stage is too low for an adequate discharge through S-354. Water supply releases through S-2 are by syphoning through the pumps.

S-8 is a pump station and gated spillway located at the point where the Miami Canal enters WCA 3A fifteen miles west of U.S. Highway 27 at the Palm Beach-Broward County line. Water is discharged from the Miami Canal to WCA 3A when the stage at any point in the canal exceeds 12.5 ft NGVD. Discharge is by gravity flow through the gated spillway if the stage in WCA 3A is low enough to permit a discharge adequate to maintain the optimum stage in the Miami canal; otherwise, discharge is by pumping. The headwater (i.e., the north side) stage is not to be drawn down below 9.5 ft NGVD. Pumping at S-8 may be initiated upon request by the Army Corp of Engineers to provide regulatory discharge from Lake Okeechobee by way of S-354 and the Miami Canal when the capacity of S-8 is not needed for removal of water from the basin.

S-354 is a gated spillway[3] located in L-D2 at the connection of the Miami Canal to Lake Okeechobee. The primary functions of the structure are to prevent a hurricane surge on the lake from entering the Miami Canal and to make water supply releases. The gates are often closed, but may be opened for any of four reasons: (1) to supply water for irrigation to the S-3 and the S-8 basins when dry season water levels in the Miami Canal fall below 11.0 ft NGVD; (2) to supply water from Lake Okeechobee to eastern Dade County and Everglades National Park; (3) to make regulatory releases from Lake Okeechobee to storage in WCA 3A; and (4) to discharge flood flows from the S-3 basin when Lake Okeechobee is below 11.0 ft NGVD. In general, cases 2 and 3 are implemented only when the water level in the Miami Canal is below 11.0 ft NGVD. Cases 3 and 4 are rare occurrences.

G-88 is a culvert in the alignment of the L-3 borrow canal at the intersection of L-3 and L-4 at the northwest corner of WCA 3A. Control of flow is by riser and stoplogs. The structure is operated as a weir to control water levels upstream in the L-3 borrow canal. Boards generally are set at 14.0 ft, but are adjusted as necessary during storm events to remove excess water from the L-3 borrow canal.

Comments on Design and Historic Operation

Project Design

Design of the canals and water control structures in the S-8 basin was based on two primary considerations: flood control and water supply. For flood control the design removal rate was determined to be three-quarters of an inch of runoff per day for the drainage area. For water supply, the canals and structures were designed to deliver water at a maximum rate of 4.3 cubic feet per second for each square mile of area served.

The design removal rate is less than the rate at which it is possible for individual growers to pump to the canals in the EAA, and the capacity of the Project canals and water control structures is less than the total of the possible grower discharges. Thehowever, because of three factors: (1) not all the land in the EAA is in production at design removal rate and the capacities of the canals and structures are adequate, one time, (2) much of the EAA is planted to watertolerant crops (e.g., sugarcane),

[3]At the time of publication S-354 is under construction; the scheduled completion date is July 1990. The structure will replace Hurricane Gate Structure 3, which is already out of service.

and (3) the canals in the EAA have some storage capacity.

Water supply to the basin was intended for irrigation and to maintain water levels in the basin as high as possible to minimize soil subsidence and oxidation. The COE recognized that the optimum water level in the Miami Canal would have to be lowered over time as subsidence in the basin occurred. The intake elevation for the pumps at S-8 was determined taking into consideration the anticipated lowering of the optimum water level.

Lake Okeechobee Regulatory Releases

Although lake regulation was not a factor in the original design, it was anticipated that, with no local inflows to the Miami Canal, lake regulatory releases would be made up to the capacity of the canal. There are six principal outlets for regulatory releases from Lake Okeechobee: the Caloosahatchee River (C-43), the St. Lucie Canal (C-44), and the four agricultural canals, the L-10/L-12 borrow, the Miami, the North New River, and the Hillsboro. The levees and discharge structures for Lake Okeechobee were designed assuming releases would be made by way of all six outlets during a major storm event. Regulatory releases from the lake to these canals are made in accordance with the Lake Okeechobee regulation schedule (Figure 6).

Although the St. Lucie Canal and the Caloosahatchee River can pass the largest discharges from the lake, they are not the preferred outlets from the lake since water released in this way is lost to the ocean and, in some cases, damages the estuaries of the St. Lucie and Caloosahatchee Rivers. To the extent possible, regulatory releases are made to the agricultural canals. Water released to these canals is stored in the WCAs and is kept in the system. This affords additional opportunity for using the water, and it limits the amount of freshwater that enters the estuaries of the Caloosahatchee and St. Lucie Rivers. However, this is not a common practice and little of the regulatory discharge from Lake Okeechobee is handled in this way.

There are three reasons that regulatory releases to the agricultural canals are rare.

1. Most significantly, regulatory releases to the agricultural canals cannot be made if to do so would compromise agricultural water control in any of the basins the canals pass through. In the case of the Miami Canal, the S-3 and S-8 basins are of concern. In general, it is required that weather conditions in the S-3 and S-8 basins be dry and that water levels in the Miami Canal be low enough not to restrict local inflows. As a rule of thumb, the canal water level must be below 11.0 ft NGVD. With no local inflows, however, the water level at the outlet structure, S-354, can be allowed to rise as high as 13.5 ft NGVD during regulatory discharge.
2. Although COE and District policy does not explicitly restrict regulatory releases to the WCAs when the WCAs are over schedule, such releases usually are not made if it is perceived the releases would be harmful to the environment in the receiving WCA, e.g., by drowning deer in WCA 3A or by compromising the WCA 2A drawdown.
3. Regulatory releases to the agricultural canals cost more to make than do releases to the St. Lucie Canal or the Caloosahatchee River since water discharged to the agricultural canals must be pumped to the receiving WCA.

The wet weather conditions that cause Lake Okeechobee to go over schedule also are likely to create wet conditions in the EAA basins, with water levels over 11.0 ft NGVD, and to cause the WCAs to go over schedule. These factors combine to make regulatory releases by way of the agricultural canals rare events.

S-354

The original structure, Hurricane Gate Structure 3, controlling discharges from the lake to the Miami Canal has been replaced by a gated spillway, S-354. The old hurricane gate, for the last few years of its long service, could not be operated as designed and could pass only limited discharges. The new structure allows regulatory and water supply discharges up to the capacity of the Miami Canal.

S-8 Basin Boundary

The S-8 basin is that portion of the EAA draining to the Miami Canal from which the pump station S-8 was designed to pump excess water at a maximum rate of three-quarters of an inch of runoff per day. Currently, however, normal (non-flood) drainage of the S-3 basin is to the S-8 basin by way of the Miami Canal. Because of environmental problems in Lake Okeechobee resulting from inflows of nutrient-rich water to the lake, the current District water management plan for the EAA discourages discharge of water to Lake Okeechobee from the EAA. As a result, S-3 (located at the north end of the Miami Canal) is operated only when necessary to prevent flooding in the S-3 basin. This water management plan is known as the Interim Action Plan (IAP) and was originally implemented under the Lake Okeechobee Temporary Operating Permit (LOTOP) from the Florida Department of Environmental Regulation (FDER). FDER has since granted the District permission to continue the plan on a permanent basis under the Lake Okeechobee Operating Permit (LOOP).

Holeyand Wetland Restoration

A wetlands restoration project is currently under way in the S-8 basin. The area being restored is known as the Holeyland. It is located in the southeastern quarter of the S-8 basin (see Figure 15) and includes a small area in the southwest corner of the S-7 basin. Levees are being constructed around the northern perimeter of the Holeyland to isolate the area hydrologically from the surrounding basins. When the levees and structures of the Holeyland restoration are completed, water from the Miami Canal will be pumped into the Holeyland at its northwestern corner and will be distributed along the north perimeter by a spreader canal. Water will move through the area by sheet flow to the south. This flow will be discharged to WCA 3A by way of three gaps cut in L-5.

Modified Hendry County Plan

Levees 1, 2, and 3 were constructed to protect the west side of the EAA. The levees intercept flows to the east, which have resulted in flooding west of the levees. The Modified Hendry County Plan was formulated to alleviate this flooding. As it affects the S-8 basin, the plan calls for construction of the L-3 East Canal, connecting the L-8 borrow canal with the Miami Canal. Control of water flow in the canal will be affected by water control structures at either end of the canal.

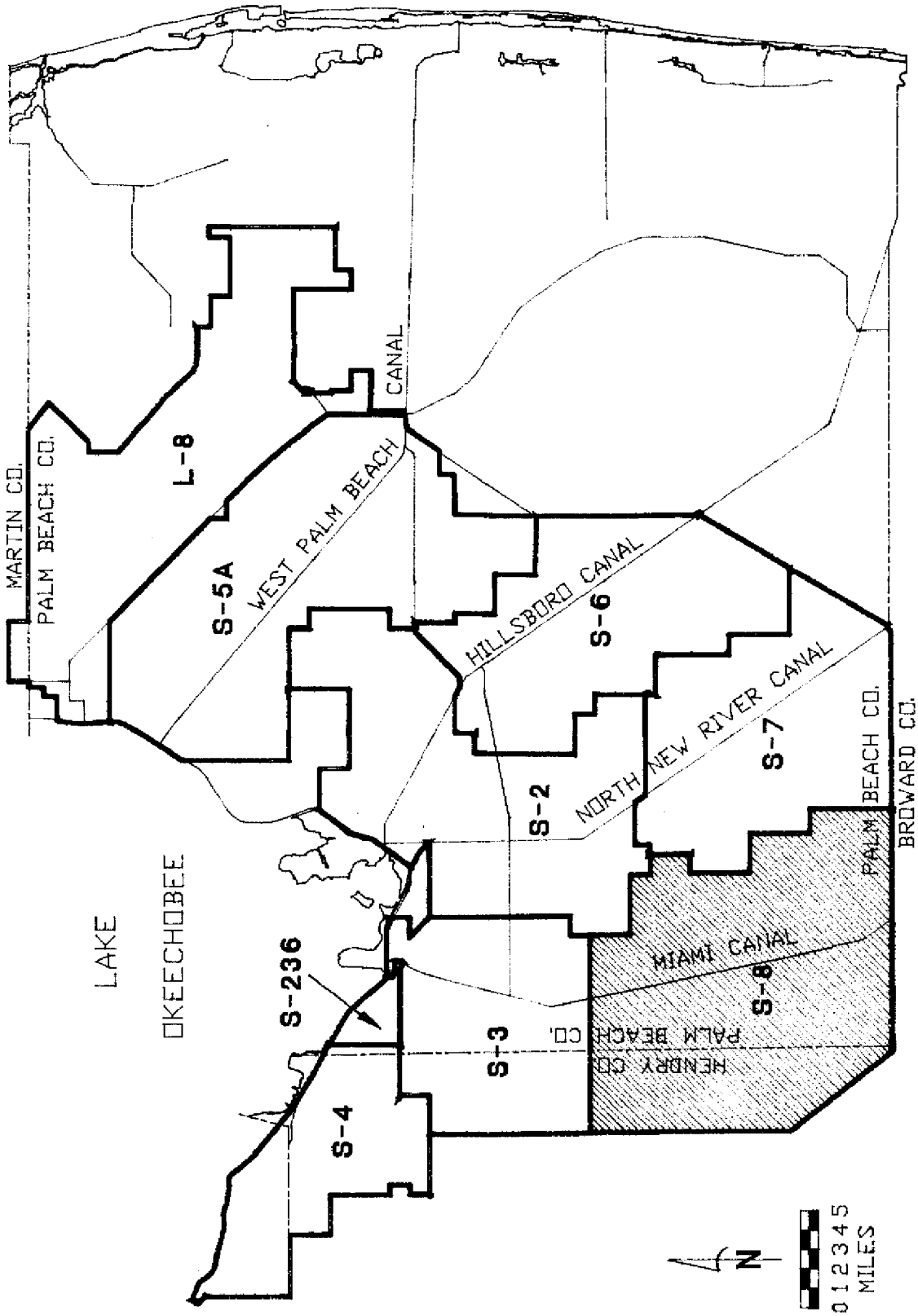


FIGURE 15. S-8 BASIN LOCATION MAP

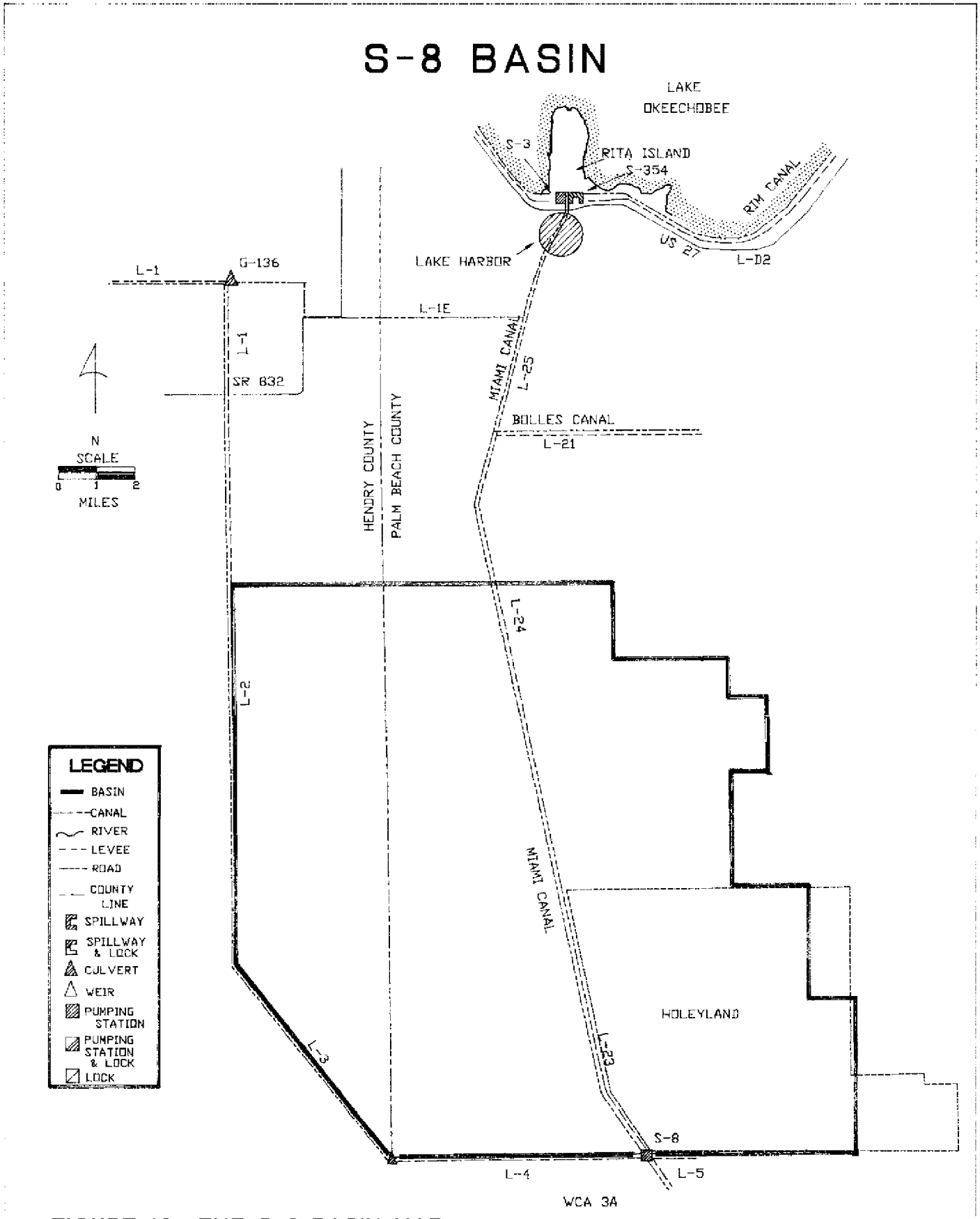


FIGURE 16. THE S-8 BASIN MAP

TABLE 7 S-8 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-3*	Pump Station 3 Units-890 cfs each	13.0 (canal side)	19.4 (lake side)	10.0-12.5 in Miami Canal	2580	Lake = 18.38 Canal = 14.92 Q(north) = 2280 Q(south) = 2790	3/9/83 10/2/65 3/24/66 3/26/70
S-8	Pump Station 4 Units-1040 cfs each Gated Box Culverts 1-16.5ftx14.4ftx78.5ft Reinforced Concrete Boc Invert elev = 1.0ft NGVD	12.0 (Pumped Discharge) 12.0 (Gravity Discharge) (EAA side)	16.5 (Pumped Discharge) 11.9 (Gravity Discharge) (WCA 3A side)	10.0-12.5 in Miami Canal	4170 (Pumped Discharge) 500 (Gravity Discharge)	HW = 13.05 TW = 14.69 Q = 4240 (pump) Q = 1252 (SPW)	2/15/66 7/11/66 10/22/69 1/18/77
S-354**	Gated Spillway 2-Gates 8.3t highx23.0ft wide Net crest lgth = 46.0 ft Crest elev = 3.2 ft	Water Supply 10.5 Regulatory Releases 24.8 (lake side)	Water Supply 10.0 Regulatory Releases 13.2 (canal side)	Not used to control stage	Water Supply 1450 Regulatory Releases 2000	Lake = 18.38 Canal = 14.92 Q(north) = 2280 Q(south) = 2790	3/9/83 10/2/65 3/24/66 3/26/70
G-88	Gated Culvert with riser and stop logs 4-72in x 91ft CMP Invert elev = 6.0ft NGVD			HW ≤ 15.0			

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

*The peak discharges given for S-3 and S-354 are the combined discharges for the structures.

**S-354 will replace Hurricane Gate Structure 3 (HGS-3) by the end of 1990. HGS-3 was at the same location and served a similar function as S-354.

S-236 Basin

Description of the Basin

The S-236 drainage basin is 10.3 square miles in area and is located (Figure 17) on the south shore of Lake Okeechobee in western Palm Beach County. The basin boundary relative to local roads and landmarks is shown on Map A. A schematic map showing the basin boundary, canal, and control structure for the S-236 basin is shown in Figure 18.

The Project water control structures in the S-236 basin have two functions: (1) to provide flood protection and drainage for the basin and (2) to remove water entering the basin as seepage through L-D2. Excess water in the basin is discharged to Lake Okeechobee by way of S-236.

There are two Project water control structures in the S-236 basin: S-236 and Culvert #3. S-236 is a pump station on the south shore of Lake Okeechobee in the alignment of L-D2 about two miles southeast of the town of Clewiston. Discharge is to Lake Okeechobee. Pumping is initiated when the headwater stage (i.e., canal side) rises to 9.7 ft NGVD and is terminated when the headwater stage drops to 7.5 ft NGVD. If a heavy rainfall is predicted to raise the headwater stage above 9.7 ft NGVD, all pumps are put into operation, and the stage is drawn down to and held at 7.5 ft NGVD until the storm has passed. Design criteria for S-236 are given in Table 8. The pump is operated and maintained by the South Florida Conservancy District.

Culvert #3 is a culvert through L-D2 and is located just to the southeast of S-236. The culverts provide gravity drainage from the S-236 basin to Lake Okeechobee when the water level in the basin exceeds that of the lake. Flap gates on the lake side prevent water from the lake from entering the basin. The gates may be opened, however, as necessary to supply water to the basin for irrigation.

Comments on Design and Historic Operation

Project Design

The S-236 pump station was designed to pump water from the basin to the lake at a maximum rate of 255 cfs. Of the total capacity, 205 cfs is for flood protection to the basin and is equivalent to a removal rate of three-quarters of an inch of runoff per day. The remaining 50 cfs is for removal of seepage water from the basin. The seepage is from the lake through L-D2.

Prior to 1979, the area now drained by S-236 was drained by the Bare Beach Pump Station (owned and operated by the South Florida Conservancy District). When the maximum water level for Lake Okeechobee was raised to 17.5 ft NGVD, it was necessary to provide alternate drainage for the basin as the Bare Beach Pump station could not pump to 17.5 ft NGVD. Two plans were proposed: (1) to excavate a canal (C-21A) parallel to U. S. Highway 27 to traverse the basin and connect to the Miami Canal to the east, and (2) to construct a new pump station that could pump to 17.5 ft NGVD. The pump station alternate (S-236) was selected as being the more cost effective. The need to construct several bridges over the proposed canal significantly increased the estimated cost of construction.

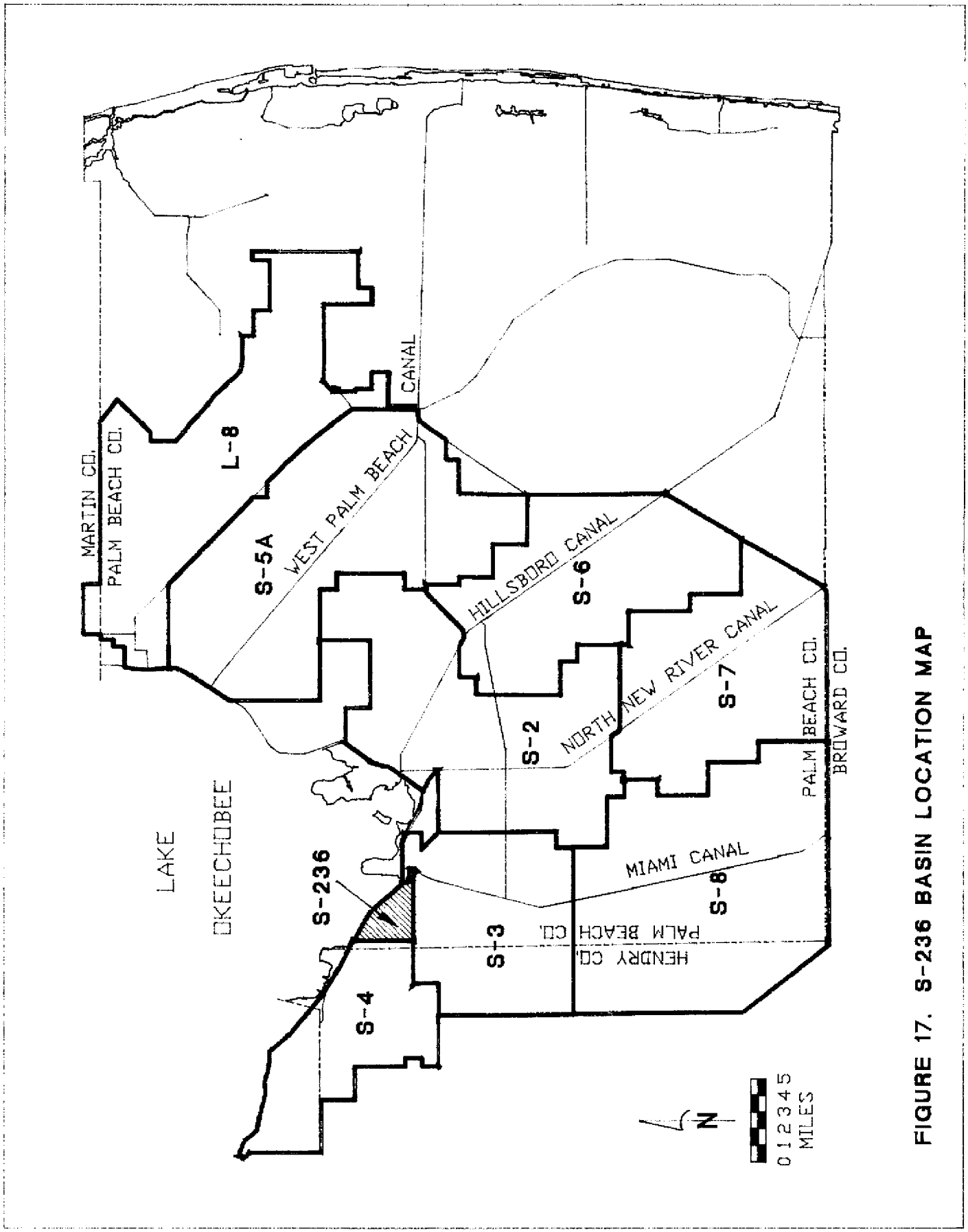


FIGURE 17. S-236 BASIN LOCATION MAP

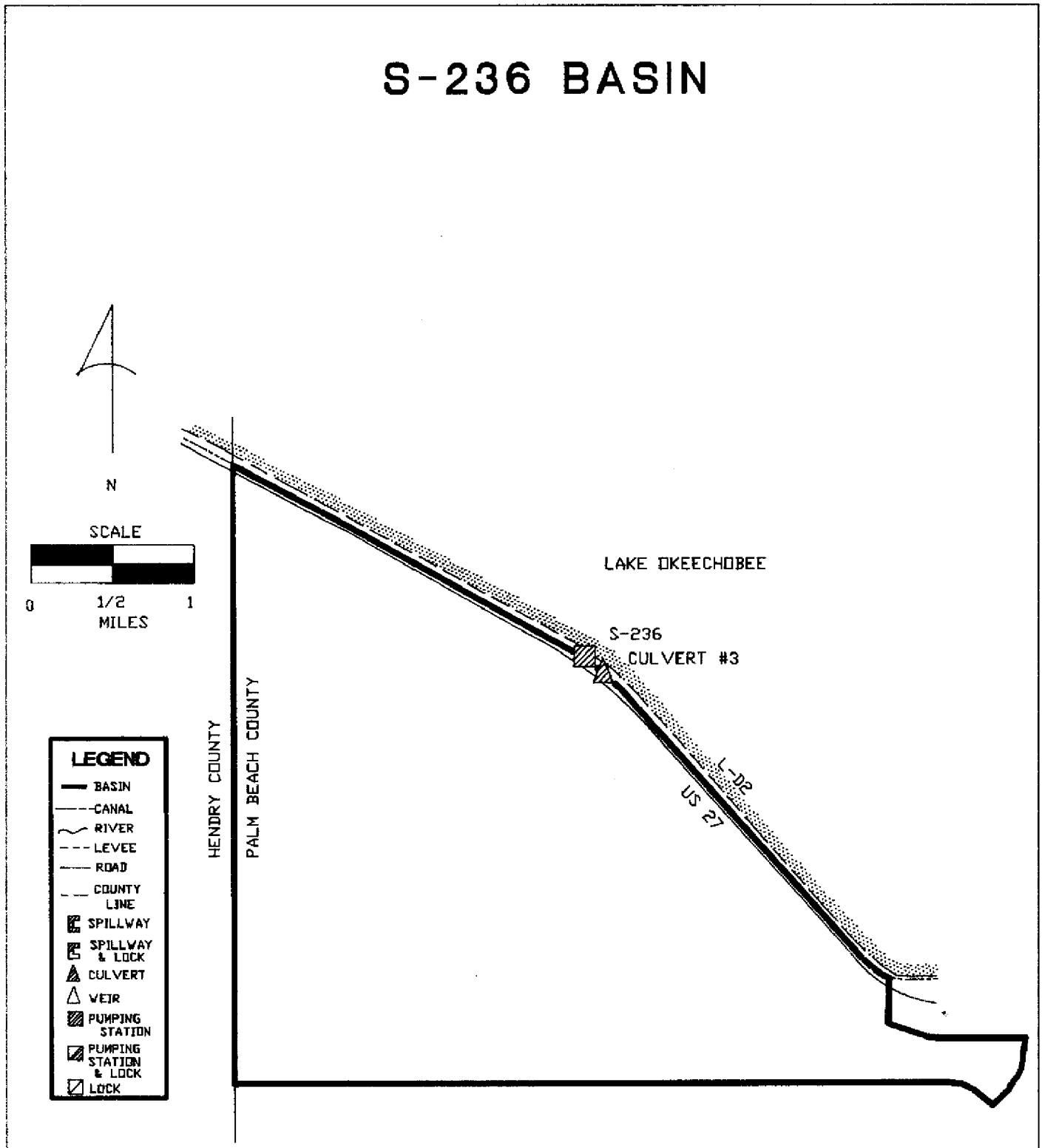


FIGURE 18. THE S-236 BASIN

TABLE 8 S-236 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-236	Pump Station 3 units-85 cfs each	7.5 (canal side)	18.5 (lake side	HW = 7.5-9.7	255	HW = 10.80 TW = 18.22	12/1/80 3/3/83
Culvert #3	Gated Culvert 2-120" CMP Invert Elev. = 5.5 ft NGVD						

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

S-4 Basin

Description of the Basin

The S-4 drainage basin is 73.4 square miles in area and is located (Figure 19) in northeastern Hendry County (47.3 square miles) and southeastern Glades County (26.1 square miles). 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 20.

The Project canals and control structures in the S-4 basin serve three primary functions: (1) to remove excess water from agricultural and urban lands in the basin, (2) to prevent over drainage of the S-4 basin; (3) to supply water from Lake Okeechobee to the basin as needed for irrigation. Excess water in the basin comes from rainfall, from Lake Okeechobee by seepage through L-D1 and L-D2, and from pumping water from agricultural and urban lands to Project canals. Excess water is removed from the basin to Lake Okeechobee by way of S-4, S-310, and the L-D1 culverts, and to the Caloosahatchee River by way of S-235. Water supply to the basin is made from Lake Okeechobee by way of S-310 and Culvert #2 and from the Caloosahatchee River by way of S-235.

There are three Project canals in the S-4 basin: C-21, C-20 and the L-D1 borrow canal. The Industrial Canal, a non-Project Canal, is an important part of the primary system in the basin and is effected by operation of Project structures. C-21, C-20, and the L-D1 borrow canal form a continuous canal along the northern part of the basin. C-21 extends east to west bordering Clewiston on the north. At its east end C-21 connects to the north end of the Industrial Canal by way of S-169. C-20 extends approximately north to south connecting the west end of C-21 to the east end of the L-D1 borrow canal. The L-D1 borrow canal extends east to west along the land side of L-D1 from the borrow canal's connection with C-21 to its connection with C-43 (the Caloosahatchee River) by way of S-235 at Moore Haven. The Industrial Canal extends north to south along the east side of Clewiston. At its north end, the Industrial Canal connects to C-21 by way of S-169 and to Lake Okeechobee by way of S-310.

There are seven Project water control structures affecting water flow in the basin: S-4, S-169, S-235, S-310, and the L-D1 culverts, Culverts #1, #1A, and #2. Design criteria for these Project control structures are given in Table 10.

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There are two operational strategies for the water control structures in the S-4 basin: one for operation under a hurricane alert and one for operation under normal conditions (i.e., any condition other than a hurricane alert). During a hurricane alert, S-235, S-310, and the L-D1 culverts are closed to prevent water from flood flows or storm surges on Lake Okeechobee from entering the basin, S-169 is opened to connect the Industrial Canal by an open channel to the rest of the basin, and S-4 is put into operation. The headwater (i.e., on the canal side) stage at S-4 is pumped down to and held at 10.0 ft NGVD for the duration of the alert. Operation during a hurricane alert supercedes any normal operation. A summary of the normal operations of these structures is given in the following paragraphs and in Table 9.

Table 9. Gate operation for Structures in the S-4 Basin.

Lake Stage (ft, NGVD)	Gate Status				Headwater Stage at S-4 (ft, NGVD)
	S-310	Culvert #2	S-235	S-169	
Over 15.5	closed	closed	open	auto	11.0-14.0
13.0-15.5	open	closed	open	closed	11.0-14.0
below 13.0	open	open	closed	open	below 13.0

When the Lake Okeechobee stage is above 15.5 ft NGVD, excess water is discharged from the entire basin by gravity flow to C-43 by way of S-235 and by pumping to the lake by way of S-4. A stage of about 15.0 ft NGVD is maintained in the Industrial Canal by S-169, with excess flow in the Industrial Canal passing through S-169 to C-21. The headwater (i.e., on the canal side) stage at S-4 is held at between 11.0 and 14.0 ft NGVD.

When the Lake Okeechobee stage is between 13.0 and 15.5 ft NGVD, S-169 is closed and discharge from that part of the basin draining to the Industrial Canal is to the lake by gravity flow through S-310. The rest of the basin drains by gravity flow to C-43 by way of S-235 and by pumping to Lake Okeechobee by way of S-4. The stage in the Industrial Canal under these conditions is approximately equal to the lake stage. The stages in the C-21, C-20, canal the L-D1 borrow canal are held between 11.0 and 14.0 ft NGVD by S-4.

When the Lake Okeechobee stage is below 13.0 ft NGVD, all gated structures except S-235 are open. All areas in the basin are interconnected to each other and to Lake Okeechobee by open channels. Under these conditions, the stages in all the canals are approximately equal to the stage in the lake. S-235 is closed to prevent discharge to C-43.

During normal operation, S-235, S-310, and Culvert #2 may be opened, as needed to supply water to the basin for irrigation.

S-4 is a pump station in the alignment of L-D1 at the intersection of L-D1 and C-20 about three miles northwest of Clewiston. During normal operation, pumping is initiated when the headwater (i.e., on the canal side) stage is greater than 14.0 ft NGVD, and it is terminated when the headwater stage drops below 11.0 ft NGVD. During a hurricane alert, the headwater stage is drawn down to and held at 10.0 ft NGVD.

S-169 is a gated culvert located at the west end of C-21 just north of Clewiston. During normal operation, at lake stages greater than 15.5 ft NGVD the gates on S-169 are operated automatically to maintain a stage in the Industrial Canal of

between 14.7 and 15.2 ft NGVD, at lake stages between 13.0 ft NGVD and 15.5 ft NGVD the gates are closed, and at lake stages below 13.0 ft NGVD the gates are opened full. During a hurricane alert, the gates of this structure are open.

S-235 is a gated culvert in the L-D1 borrow canal at the outlet of the borrow canal to C-43. During normal operation, this structure is generally open, being closed only when the stage in Lake Okeechobee drops below 13.0 ft NGVD. During a hurricane alert, S-235 is closed.

S-310 is a lock structure and is located in L-D2 just north of Clewiston. During normal operation, S-310 is opened full when the lake stage is below 15.5 ft NGVD. When the lake stage is greater than 15.5 ft NGVD, the lock is operated daily between 5:30 AM and 8:00 PM and is closed between 8:00 PM and 5:30 AM. During a hurricane alert, S-310 is closed by the U. S. Army Corps of Engineers; otherwise, it is operated and maintained by the District.

The L-D1 culverts are all located in the alignment of LD-1 and connect the L-D1 borrow canal to Lake Okeechobee. Culvert #1 is located approximately one and one-half miles east of Moore Haven. It has a flap gate on the lake side and discharges water from the basin to the lake when the stage in the L-D1 borrow canal is greater than the stage in the lake. Culvert #1A is located about five miles east of Moore Haven. It has vertical screw gates on the lake side. The structure is rarely, if ever, operated. Culvert #2 is located just to the west of S-310. It has five flap gates and a slide gate on the lake side and discharges water from the basin to the lake when the stage in the L-D1 borrow canal is greater than the stage in the lake. The slide gate is opened as necessary to supply water to the basin for irrigation. During a hurricane alert, these structures are closed. The culverts are operated and maintained by the U. S. Army Corps of Engineers.

Comments on Design and Historic Operation

Excess water can be removed from the S-4 basin at the rate of three-quarters of an inch of runoff per day from agricultural lands (112 square miles) and at the rate of four inches of runoff per day from the City of Clewiston (4.5 square miles).

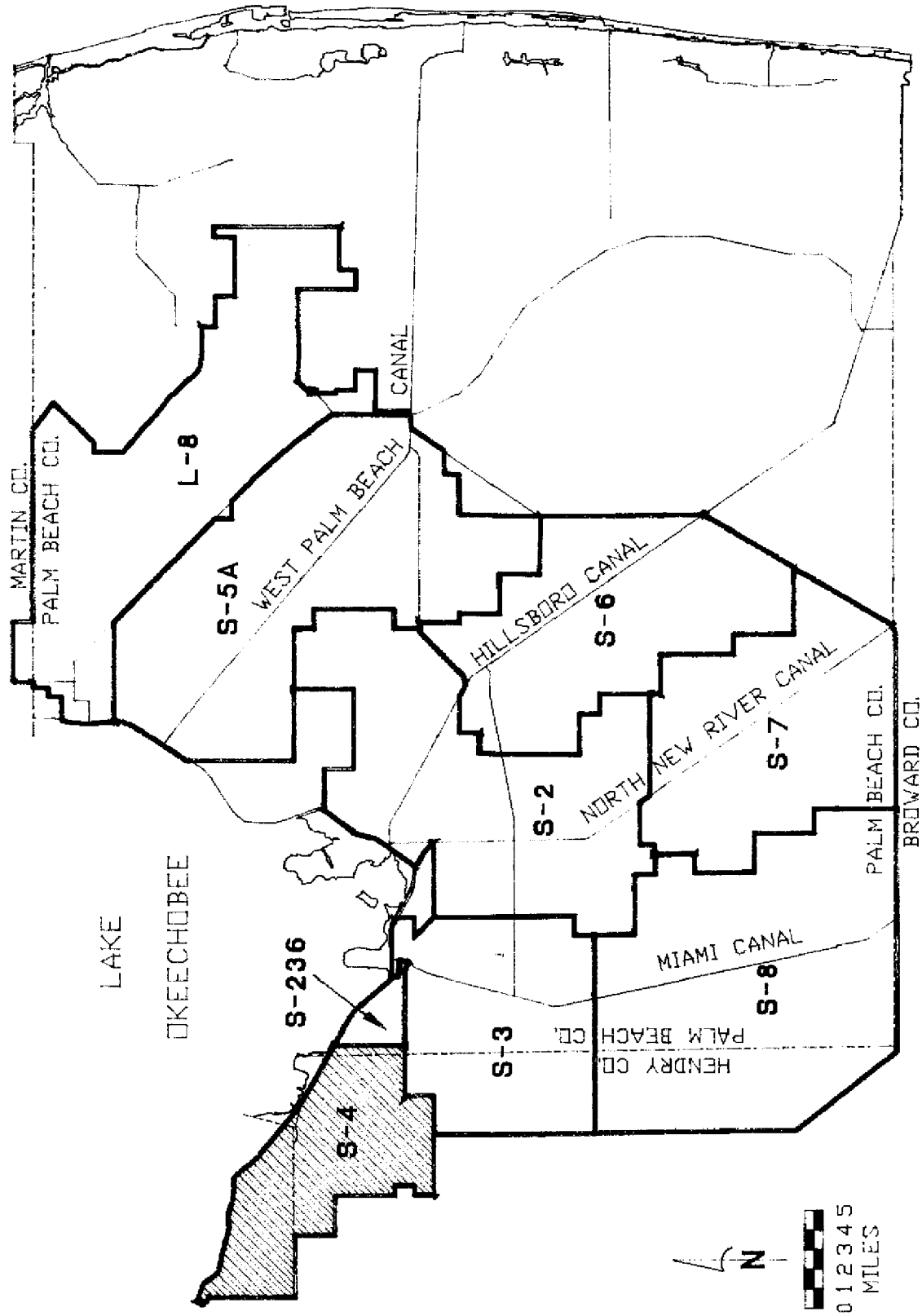

FIGURE 19. S-4 BASIN LOCATION MAP

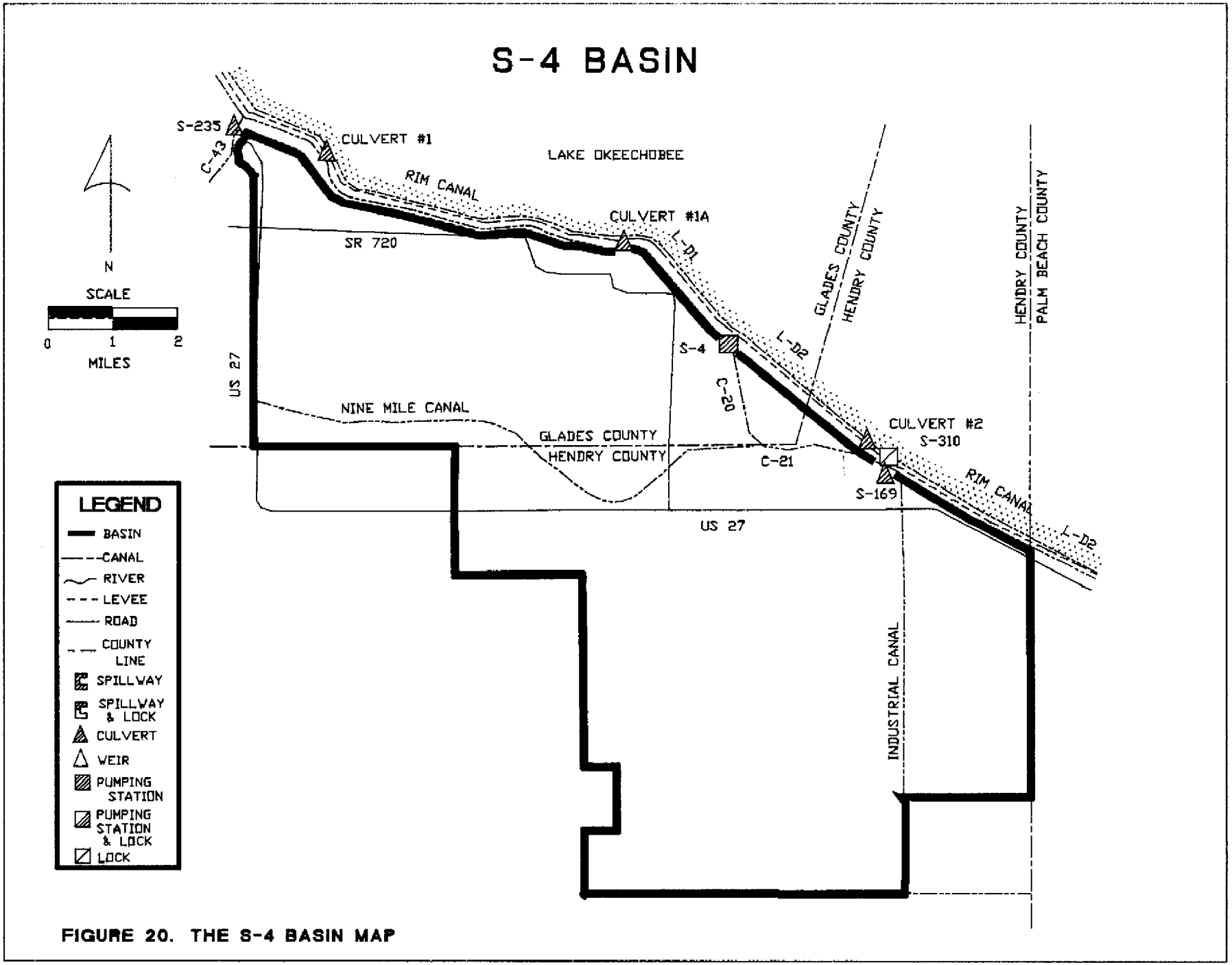

FIGURE 20. THE S-4 BASIN MAP

TABLE 10 S-4 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-4	Pump Station 3 units-935 cfs each	13.0 (canal side)	19.2 (lake side)	HW = 11.0-14.0	2805	Lake = 18.22 Canal = 14.3 Q = 1764	3/3/63 6/28/79 8/28/88
S-169	Gated Culvert 3-84inx60ft CMP Invert elev = 6.0ft	15.0 (Industrial Canal)	14.1 (C-21 side)	HW = 15.0	625	HW = 16.10 TW = 14.25	10/7/88 7/12/88
S-235	Gated Culvert 2-72inx70in RCP Invert elev = 4.1ft NGVD	13.0 (S-4 Basin)	12.5 (Caloosahatchee River)	Not used to control stage		HW = 14.7 TW = 12.8 Q = 584	5/21/80 9/23/78 12/8/85
S-310	Navigation Lock 60ft longx50ft wide			Not used to control stage		510	8/4/87
Culvert #1	Gated Culvert 2-120" CMP Invert Elev. = 5.5 Ft						
Culvert #1A	Gated Culvert 3-84" CMP Invert Elev. = 5.5 Ft						
Culvert #2	Gated Culvert 2-120" CMP Invert Elev. = 5.5 Ft						

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, much of the surface area in an urban area (e.g., roofs, roads, and parking lots) is impervious to water. Almost all the rain impacting impervious 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 may be subject to high stream flows (flooding) during rain events.

A vegetated area can intercept and retain a large part of the rainfall, and subsequent surface runoff from a rain event. This intercepted water has an 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 as that land which drains 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, with 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 and the tailwater stages 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 water surface elevation and, in general, flow increases as the difference in water surface elevation increases. In some basins, pumps are used to move water from lower to higher water surface elevations. Note that because of the flat topography in much of south Florida, water surface elevations may be independent of ground surface elevations. In these cases, it is possible for water to flow uphill relative to the ground surface.

The headwater side of a gravity flow structure is the side on which the stage is usually higher. The caveat is necessary since it is possible at some structures for the tailwater to occasionally be higher than the headwater stage. The headwater stage at a pumping station is usually defined as the side from which water is pumped and usually refers to the side with the lower stage. This convention allows the direction of water flow to be defined as from the headwater to the tailwater side in both cases.

Water surface elevations elsewhere 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) of 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.

Water Control Structures - Water control structures are devices (e.g., weirs, spillways, and culverts) placed in or between canals to regulate water levels (stage divide), amount of flow (water supply structure), or direction of flow (divide structure) in the canals. A structure may have more than one function. A divide structure is usually located at or near a basin boundary. When it is closed, 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). A divide structure also often serves as a water supply structure.

Hydraulic Analysis - A set of water surface elevations taken along the length of a canal is known as the hydraulic profile of the canal. In general, water surface elevations increase upstream. 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 water control structures in the basin will accommodate that storm's runoff without an unacceptable level of flooding occurring in the basin. Sometimes a basin is described as having "flood protection" up to a certain design storm. The level of protection is the flood level at which flood damages not eliminated by the Project are considered relatively minor and are economically acceptable.

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 25 years (i.e., the storm has a four percent chance of being equalled or exceeded in any given year). This is written as 1-25 years and is read as one in 25 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 U. S. 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 SPS is intended to be reasonably characteristic of large storms that have or could occur in the Project area. 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 frequency (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 affect the relative amounts of surface runoff to be expected from the basins (see **Runoff and Drainage**). Urban areas will often have 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 Memorandums for the Project. The runoff calculated to occur for a given set of storm frequency, antecedent conditions, and land use is the design discharge.

APPENDIX 2 - GLOSSARY

Designations Given to Project Works

C-XXX

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

Culvert #XXX

The word culvert followed by a number designates a Central and Southern Florida Project culvert through one of the levees on the perimeter of Lake Okeechobee. Each culvert connects the lake to an adjacent basin. All are under the operation and maintenance of the COE.

G-XXX

The letter G followed by a number, designates a South Florida Water Management District control structure (see **Water Control Structures**, under **Basic Concepts**). For example, G-72 reads as "water control structure 72". G structures were built by the District.

HGS-X

The letters HGS followed by a number refer to a Hurricane Gate Structure. These structures were in the levee around Lake Okeechobee and connected the lake to various canals and basins. All of the structures have been replaced by gated spillways.

L-XXX

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

L-DX

The letter L followed by the letter D and a number refers to a Central and Southern Florida Project levee on the perimeter of Lake Okeechobee. For example, L-D9 refers to Levee 9 on the perimeter of the lake.

S-XXX

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

Terms

1-XXX year

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

Borrow Canal

In most cases the material for construction of a levee is obtained by excavation immediately adjacent to the levee. The excavation is termed a "borrow". When the borrow paralleling the levee is continuous and allows for conveyance of water, it is referred to as a "borrow canal". For example, the canal adjacent to L-8 and is called the L-8 borrow canal. Many borrow canals, such as the L-8 borrow canal, are important features of the Project.

Crest Elevation

The crest elevation of a structure is the level below which water cannot pass the structure. Where the crest elevation of a structure is used to control water flow, the crest elevation is set to maintain the desired upstream water level.

Culvert

A culvert is a closed conduit for the conveyance of water. Within the District, culverts may be made of corrugated metal pipe or reinforced concrete. The concrete culvert may be either circular or rectangular in cross section. When it is rectangular, the culvert is usually referred to as a box culvert. The cross-sectional area and length of the culvert determine, and in some cases limit, the amount of flow possible through the culvert for given headwater and tailwater conditions. Further control of flow through the culvert may be affected by placing a gate or a riser and stoplogs at the headwater end.

District

District is an abbreviation for the South Florida Water Management District (formerly the Central and Southern Florida Flood Control District), the agency which operates and maintains the Project.

Drainage

Drainage is the removal of groundwater from a basin to maintain optimum groundwater levels. Overdrainage is the lowering of groundwater levels below desired levels. See water control.

Excess water

Excess water in a basin is water that must be removed from the basin for flood protection or to maintain optimum water levels for agriculture. The excess water may derive from rainfall, seepage through levees, or from surface water inflows from adjacent basins.

Flood Control

Flood control is the removal of surface water from a basin to prevent or minimize flood damages. (see **Design Storm**, under **Basic Concepts**)

Gated Spillway or Culvert

A spillway or culvert is "gated" when water flow through the structure is controlled by a gate. Within the Project almost all gates open upward to allow flow beneath the gate.

General Design Memorandum

A General Design Memorandum is a document written by the U.S. Army Corps of Engineers that reports all work done prior to preparation of the final design of a project. In the General Design Memorandums for the Central and Southern Florida Project four important aspects of the Project are developed: (1) each of the surface water management basins is delineated, (2) a set of design storms is determined for each basin and the resulting basin discharges are estimated (3) the flood protection to be afforded each basin is specified, (4) the size, number and general location of canals and structures needed to achieve the desired level of flood protection are determined. The final designs of the canals and structures are given in the Detailed Design Memorandums.

Project

Project is an abbreviation for the Central and Southern Florida Project for Flood Control and Other Purposes. The Project was responsible for the construction of most of the major canals and structures in south Florida.

Regulation Schedule

A regulation schedule specifies the outlet operational strategy for a reservoir (e.g., Lake Okeechobee) as a function of the water level in the reservoir and the time of year. In general, a regulation schedule optimizes the reservoirs ability to receive excess water in the wet season and to provide water supply in the dry season.

Regulatory Release

A regulatory release is water discharged from a reservoir (e.g., Lake Okeechobee) in accordance with its regulation schedule.

Riser and Stoplogs

Riser and stoplogs refers to a means of regulating the water level upstream of a culvert or weir. Stoplogs are individual beams, of fixed dimension, set one upon the other to form a bulkhead supported by channels or grooves (i.e., the riser) at either end of the span. The stoplogs slide in or out of the riser, the number of stoplogs determining the crest elevation of the bulkhead. The structure may be effectively closed by addition of enough stoplogs. The riser is located at the headwater end of the culvert or on top of the weir.

Saltwater Intrusion

In coastal areas of South Florida, fresh and salt groundwaters meet. The fresh groundwater is less dense than the salt groundwater. It floats on, but does not mix with the salt water. As a general rule, the boundary between fresh and salt water occurs about 40 feet below sea level for each foot the fresh groundwater table is above sea level. It is necessary to maintain the water table in coastal areas high enough to prevent salt water from entering the local groundwater and contaminating any nearby well fields.

Spillway

A spillway is a means of passing water from one location to another (e.g., from a lake to a canal or from one part of a canal to another). The purpose of the spillway is to control the flow of water. Control may be affected by gates or by the crest elevation of the spillway or both. Control by gate operation allows variable control of water flow and may control either the amount of flow or the upstream water level. Control by the crest elevation is usually not variable and controls only the upstream water level. When water control is strictly by the crest elevation of the spillway, the spillway is usually referred to as a weir.

Water Control

Water control is the regulation of groundwater levels (i.e., by the regulation of canal water levels) at all seasons and the conservation of water during the dry season. During wet periods, water must be removed from basins to maintain desired groundwater levels. This is sometimes referred to as drainage and is differentiated from flood control which generally refers to removal of surface water from a basin. During dry periods, outflows from the basin are restricted to retain water in the basins to prevent "overdrainage" (i.e., lowering of groundwater levels). In agricultural areas, overdrainage can lead to crop yield reduction or failure, and in coastal areas, to saltwater intrusion to groundwater. In some cases, water must be supplied to the basin to maintain groundwater levels.

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. WCAs 1, 2A, and 3A border 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 water control structures. The WCAs are reservoirs managed to store excess water in the wet season, to provide water supply in the dry season, and to provide viable wetlands habitat. Water is stored in each WCA according to its regulation schedule. Outflows from a WCA are determined by the water level in the WCA relative to its regulation schedule and by the water requirements of basins downstream.

Weir

See Spillway.

ABBREVIATIONS

cfs:	Cubic feet per second
ft:	Feet
EAA:	Everglades Agricultural Area
ENP:	Everglades National Park
FDER:	Florida Department of Environmental Regulation
GDM:	General Design Memorandum
IAP:	Interim Action Plan
LOOP:	Lake Okeechobee Operating Permit
LOTOP:	Lake Okeechobee Temporary Operating Permit
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