THE EFFECT OF THE FAKA UNION CANAL SYSTEM ON WATER LEVELS IN THE FAKAHATCHEE STRAND, COLLIER COUNTY, FLORIDA

U.S. GEOLOGICAL SURVEY

Water Resources Investigations 77-61

Prepared in cooperation with the
NATIONAL PARK SERVICE

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BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No.

4. Title and Subtitle
THE EFFECT OF THE FAKA UNION CANAL SYSTEM ON WATER LEVELS IN THE FAKAHATCHEE STRAND, COLLIER COUNTY, FLORIDA

5. Report Date
September 1977

6.

7. Author(s)
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8. Performing Organization Rept. No. USGS/WRI-77-61

9. Performing Organization Name and Address
U.S. Geological Survey, Water Resources Division
325 John Knox Road, F-240
Tallahassee, Florida 32303

10. Project/Task/Work Unit No.
FL-250

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U.S. Geological Survey, Water Resources Division
325 John Knox Road, F-240
Tallahassee, Florida 32303

13. Type of Report & Period Covered

14.

15. Supplementary Notes
Report prepared in cooperation with the National Park Service.

16. Abstracts
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17. Key Words and Document Analysis. 17a. Descriptors
Ecology, Drainage, Drainage Effects, Drainage Practices, Water Levels.

17b. Identifiers/Open-Ended Terms
Big Cypress Swamp, Fakahatchee Strand.

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
No restriction on distribution	UNCLASSIFIED	19
	20. Security Class (This Page) UNCLASSIFIED	22. Price

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UNITED STATES DEPARTMENT OF THE INTERIOR

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THE EFFECT OF THE FAKA UNION CANAL SYSTEM ON WATER LEVELS IN THE FAKAHATCHEE STRAND, COLLIER COUNTY, FLORIDA

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ABSTRACT

The Faka Union Canal system, constructed in the western Big Cypress Swamp in the early 1970's, lies about 3.5 miles west of the centerline of the Fakahatchee Strand, a forested water course which the State of Florida has designated as an Area of Critical State Concern in order to conserve natural resources. Between 1970 and 1975 the canal system annually discharged to the Gulf of Mexico from 143,200 to 275,600 acre-feet of freshwater. Discharge lowered ground-water levels as much as 4 feet near the eastern canal and created a water-level gradient that indicates water flowed from the Fakahatchee Strand west toward the canal during most of the year. In June 1975, water from early summer rains was impounded in the eastern canal upstream of the control structure at Janes Scenic Drive, and, as water levels rose in this reach, water flowed from the canal into the aquifer and around the control structure.

The annual low-water level in the center of the Fakahatchee Strand declined from nearly 3 feet above mean sea level in 1972 to 1 foot above mean sea level in 1974.

INTRODUCTION

The Fakahatchee Strand, a forested water course located in the western Big Cypress Swamp, has been designated by the State as an Area of Critical State Concern (fig. 1). An Area of Critical State Concern contains natural resources of regional and statewide importance.

The Faka Union Canal system, which was constructed in the western Big Cypress Swamp in the early 1970's, lies to the west of the Fakahatchee Strand (fig. 1a). This canal system has caused concern because of the effects it might have on the water level in the strand. Preservation of the unique ecosystem of the Fakahatchee Strand is dependent on a seasonal flow of freshwater and on seasonal inundation. If canal drainage has the effect of lowering water levels or changing the hydroperiod in the strand, alteration of the strand's ecosystem would occur.

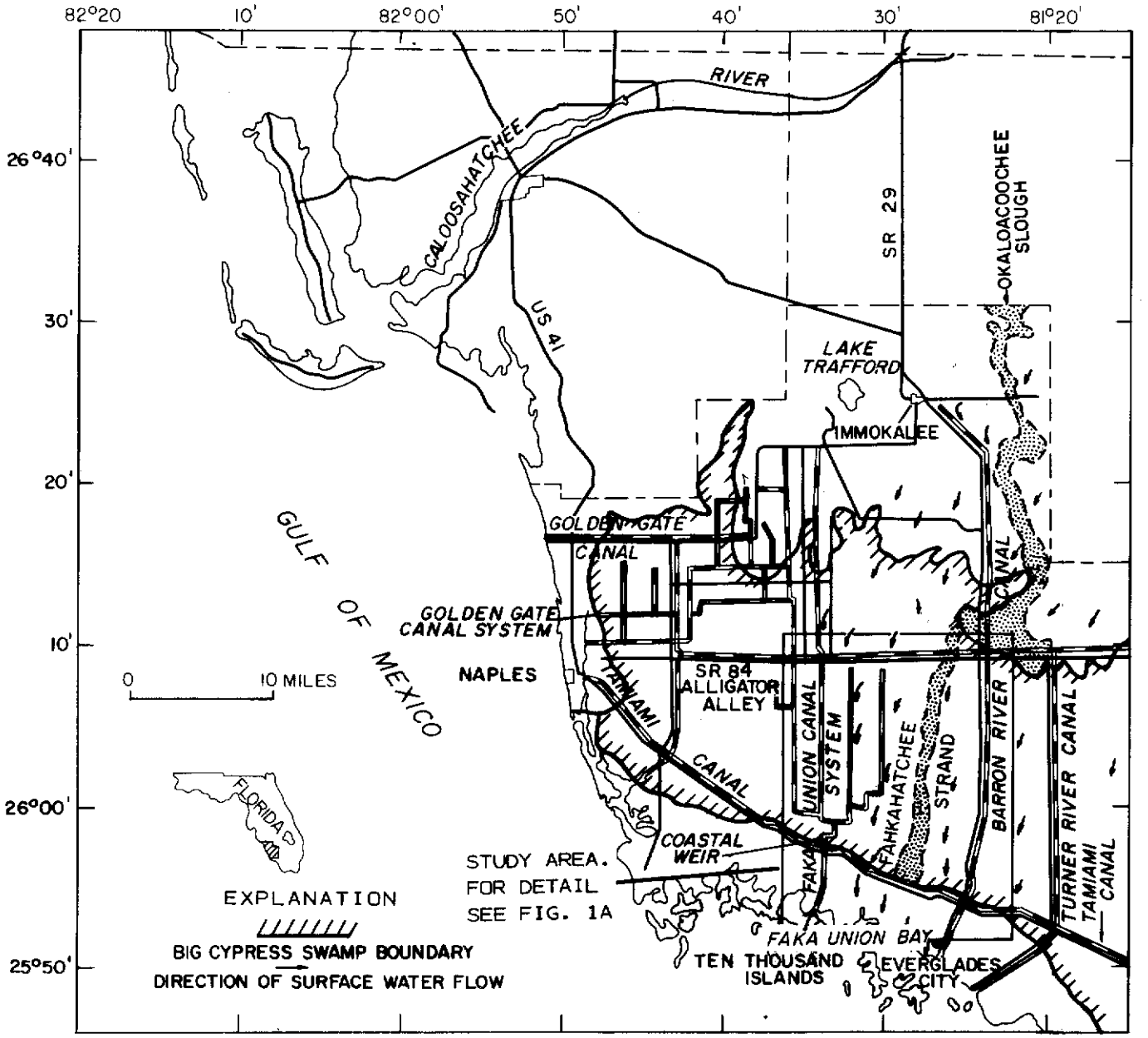

Figure 1. Location of the Fakahatchee Strand and major drainage canals.

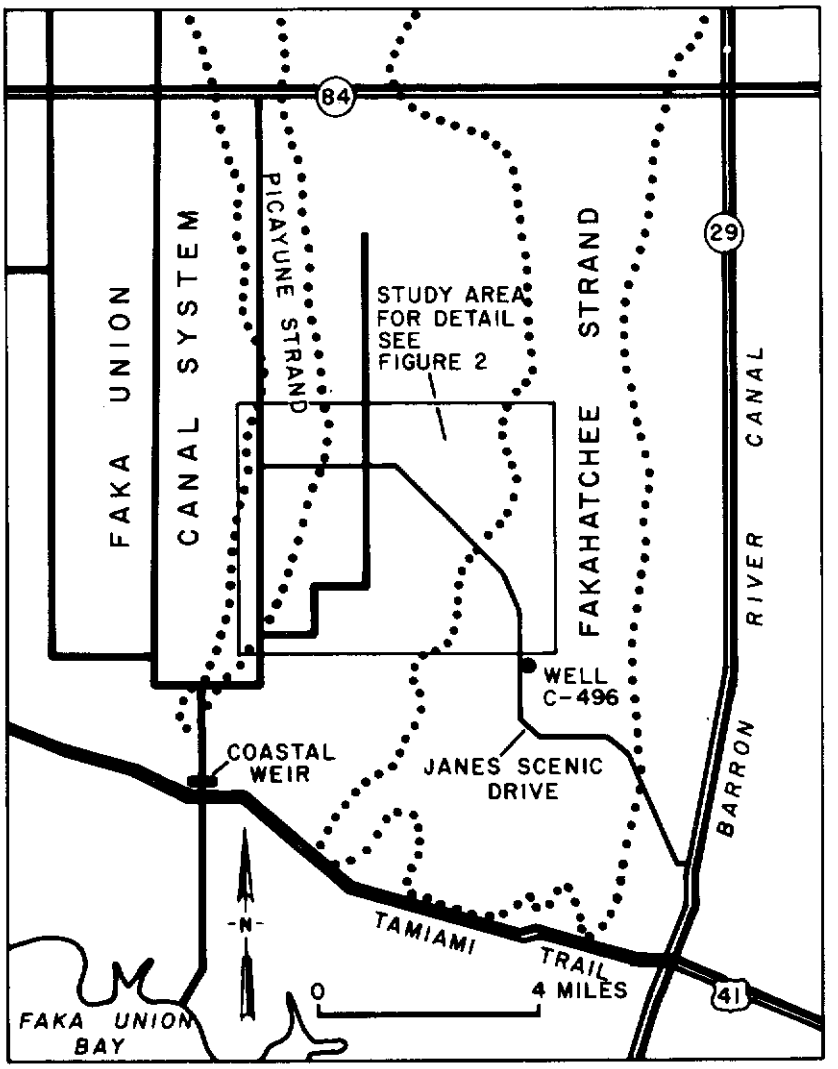

Figure 1a. Location of study area in Fakahatchee Strand and Faka Union Canal system.

Purpose and Scope

This investigation was started in response to the growing concern expressed by the State of Florida and the National Park Service regarding the preservation of the Big Cypress Swamp.

The purpose of the investigation was to make a preliminary evaluation of the effects of the Faka Union Canal system on water levels in the Fakahatchee Strand. The evaluation includes use of data collected specifically for the report as well as other data.

The scope of the investigation is of limited areal extent and does not cover the entire Fakahatchee Strand. To the east, for example, the possible effects of the Barron River Canal on the strand are not considered. Also, information on the areal extent and period of flooding and on discharge in the strand were not collected. The investigation, however, has indicated where data are needed to evaluate more completely the effects of canal drainage on the strand. This report also includes recommendations for a continued and expanded study to provide these data.

Methods

The question of whether or not the Faka Union Canal system is acting to drain the Fakahatchee Strand can be partly answered by determining water-level gradients. If the gradient is predominantly from the strand toward the canal then water movement is predominantly toward the canal. If the gradient is reversed, then water moves toward the strand.

To determine water-level gradients between the Fakahatchee Strand and the Faka Union Canal system, 11 observation wells were drilled along two lines (fig. 2) between the easternmost canal and the strand. The north line extends 1.6 mi towards the Fakahatchee Strand and has 4 wells. This line is 0.9 mi north of the secondary control structure in the canal at Janes Scenic Drive. The south line of 7 wells is 1.8 mi south of the secondary control structure and extends 2.3 mi, terminating in the Fakahatchee Strand (fig. 2). Selection of well sites was based mainly on accessibility. Water levels in the wells were measured 12 times between December 1974 and December 1975 to determine seasonal changes in hydraulic gradient.

For use of those readers who may prefer to use metric rather than English units, the conversion factors for the terms used in this report are listed below:

Multiply English Units	By	To obtain Metric Units
feet (ft)	0.305	meters (m)
miles (mi)	1.609	kilometers (km)
acre-feet (acre-ft)	1.233×10^{-3}	cubic hectometers (hm^3)
cubic feet per second (ft^3/s)	0.028	cubic meters per second (m^3/s)

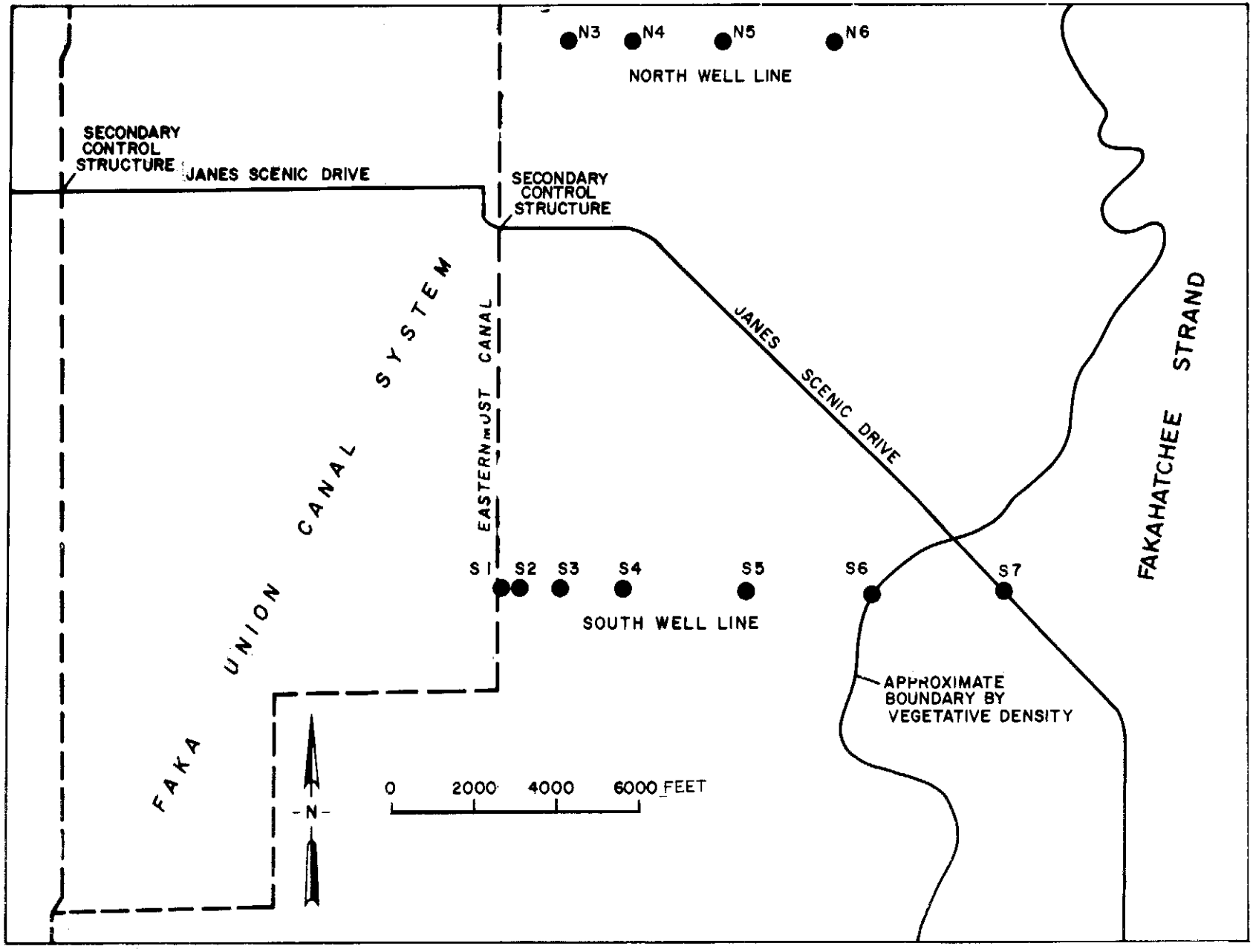

Figure 2. Location of north and south lines of observation wells.

DESCRIPTION OF THE FAKAHATCHEE STRAND

A strand is a forested water course. In the Big Cypress (fig. 1) a number of strands convey water from north to the south and southwest toward the Gulf of Mexico. The largest of these is the Fakahatchee Strand which extends some 20 mi from north of Alligator Alley (State Road 84) to the estuaries near Everglades City (fig. 1). The Fakahatchee is composed of several water courses, numerous ponds, and slightly higher land containing hammock forest.

Historically, water entered the Fakahatchee Strand from rainfall on and near the strand itself, and from rainfall to the north which was conveyed southward by the Okaloacoochee Slough (fig. 1). The original (natural) water-level conditions in the Fakahatchee Strand probably ended about 1900 with channelization of the Caloosahatchee River (Tabb and others, 1976). Before channelization, ground-water gradients trended toward the south and caused water to move into the upper Okaloacoochee Slough. Channelization tended to reverse these gradients. Today, most of the remaining southward flow from the Okaloacoochee Slough has been diverted by canals, and the ecological integrity of the strand is largely dependent on local rainfall. The Barron River Canal, for example, diverts water from the Okaloacoochee Slough that formerly went to the Fakahatchee. Intermittent records indicate that the Barron River Canal may divert about 150 ft^3/s during high-water periods (Klein and others, 1970).

The Fakahatchee was logged in the late 1940's and early 1950's and most of the large cypress trees were removed. Railroad track beds of elevated earth were constructed in the strand to support small logging trains which were used to remove the cypress logs. After logging was completed the rails were removed, but the track beds of elevated earth remained and are now densely forested.

The Fakahatchee is still a diverse and interesting botanical area. Large oaks, maples, cabbage palms and a variety of tropical trees form a dense canopy. Royal palms tower above the canopy, and a large variety of epiphytes, ferns, vines, and shurbs form a dense understory. Pop ash, pond apple, and cypress dominate the deep-water areas. The strand has long been known for its abundant and diverse air plants; over 45 species of orchids have been found, of which many are now rare. (Luer, 1964; Finn 1966).

The Fakahatchee Strand is one of the larger remaining wilderness habitats in the State. Because of its size and relative inaccessibility it supports a variety of wildlife. It is one of the few remaining retreats of the Florida black bear and the panther. Raccoon, otter, and deer are often seen. Wading birds are seasonally abundant.

The plants and animals of the Fakahatchee Strand depend on abundant water and seasonal flooding. The distribution of plants is controlled in part by the depth and duration of flooding. The animal communities are, in turn, closely related to the plant communities and the water regime. The animals of the strand are water-dependent or water-tolerant.

The biological production of the Fakahatchee Strand is closely related to a seasonal abundance of freshwater. Carter and others (1973) determined that production in Fakahatchee Strand was twice that of a nearby, recently drained strand. Stress caused by dewatering resulted in a thinning of the forest canopy in the drained strand. Thinning of the canopy not only decreased biological productivity, but also increased sunlight penetration to the forest floor. Increased sunlight accelerated drying of leaf litter and made the drained strand vulnerable to fire damage (Carter and others, 1973).

In the recent past, the Fakahatchee Strand has been stressed by reduced water flow from the north, logging, and severe fires. Today, drainage developments to the west are a threat to what remains of a diverse and unique plant and animal community, if the drainage system further diverts water from the strand and lowers water levels in the strand.

DESCRIPTION OF THE FAKA UNION CANAL SYSTEM

In 1968 a land-development corporation began construction on the Faka Union Canal system in the western Big Cypress Swamp. The purpose of the canal system was to drain swamp land for residential development. The main canal that extends from Faka Union Bay to about 2 mi north of U.S. Highway 41, and the western feeder canal of the system, were completed by 1970. The two eastern feeder canals were dug in 1970-71. The easternmost feeder canal, which is closest to the Fakahatchee Strand, was dug north to within 2 mi of Alligator Alley by December 1973 (table 1).

The Faka Union Canal system extends north from the estuaries of the Ten Thousand Islands nearly to Lake Trafford, about 30 miles (fig. 1). To the northwest of the Fakahatchee Strand the Faka Union Canal system joins the Golden Gate Canal system. Several weirs or control structures limit drainage from the shallow aquifer, and a coastal weir in the main canal just north of U.S. Highway 41 retards saltwater intrusion. The canal system, however, has more than doubled the pre-canal surface-water runoff (Lehman, 1976).

Annual flow from the Faka Union Canal system for the period 1970-75 (table 1) at the coastal weir ranged from 143,200 acre-ft (1972) to 275,600 acre-ft (1970). The largest mean monthly discharge was 2,037 ft^3/s, in September 1971.

Table 1.--Flow from the Faka Canal system during and after major construction of the system, and average annual and average dry-season (Dec - May) rainfall at Immokalee and Everglades City, Florida [1].

Year	Annual flow (acre-ft)	Annual rainfall (inches)	Dry season flow (acre-ft)	Dry season rainfall (inches)	Remarks
1968	--	69	--	17	Construction began
1969	--	64	--	13	Construction on western feeder canals
1970	275,600	47	95,050	18	Construction begun on eastern feeder canals
1971	275,120	43	16,676	6	Construction on eastern feeder canals continued
1972	143,200	56	16,584	15	Eastern feeder canals extended to or near State Road 84
1973	185,200	52	16,883	12	do.
1974	236,400	50	2,658	10	do.
1975	192,648	47	3,552	12	do.

1 1968-70 rainfall is based only on Everglades City gage.

The Faka Union Canal system is cut into a shallow aquifer of high permeability composed of limestone and sand. Ground water drains rapidly to the canals, when canal stages are lower than the water table (Klein, 1972).

Carter and others (1973) reported that the Faka Union Canals lowered ground-water levels as much as 4 ft below natural levels. Klein and others (1970) reported a similar lowering of water levels after the Golden Gate Canal system was constructed. Water levels in the Golden Gate area declined 2 to 4 ft over a 54-mi^2 area of the Big Cypress.

WATER-LEVEL GRADIENTS

The water-level gradient along the south well line sloped westward from the Fakahatchee Strand to the easternmost Faka Union Canal throughout the wet and dry seasons, 1974-75 (figs. 3 and 4). Gradients were largest in December 1974 and December 1975, about 4 ft over a distance of 12,000 ft. At the end of the dry season, May 1975, the gradient was 1.4 ft in 12,000 ft.

The persistent east to west gradient in water level in the south well line indicates that the reach of the easternmost Feeder Canal downstream from the control structure on Janes Scenic Drive is continuously draining water from the Fakahatchee Strand.

The water-level gradient in the north well line fluctuated both seasonally and in response to operations of the control structure at Janes Scenic Drive. The gradient declined 2 ft from east to west over a distance of 8,000 ft during December 1974 (fig. 5). In May 1975 there was essentially no gradient. In June 1975 the water-level gradient reversed and declined 2 ft from west to east (fig. 6). The change in gradient was caused by runoff from early summer rains that raised water levels in the canal north of the control structure. The rise in the water level in the canal--above the level of the water table--allowed water to seep from the canal into the aquifer. The control structure was open from August 6, 1975 to November 19, 1975 and the profile for September 15 shows that by then the westward water level gradient was restored (fig. 6).

During the time the control structure was open, about 14,000 acre-ft of water flowed through the structure. If this water had not been drained, a longer hydroperiod upstream of the control structure could have been attained.

Figures 7 and 8 depict a generalization of ground-water flow in the area between the Fakahatchee Strand and the easternmost feeder canal. Figure 7 shows the direction of ground-water flow during the dry season when the shallow aquifer drains to the canal along the entire reach of the canal. Figure 8 shows the direction of ground-water flow at the beginning of the rainy season when the shallow aquifer is recharged along the reach of the canal upstream of the closed control structure at Janes Scenic Drive. Downstream of the closed control structure, however, the shallow aquifer continues to discharge to the canal.

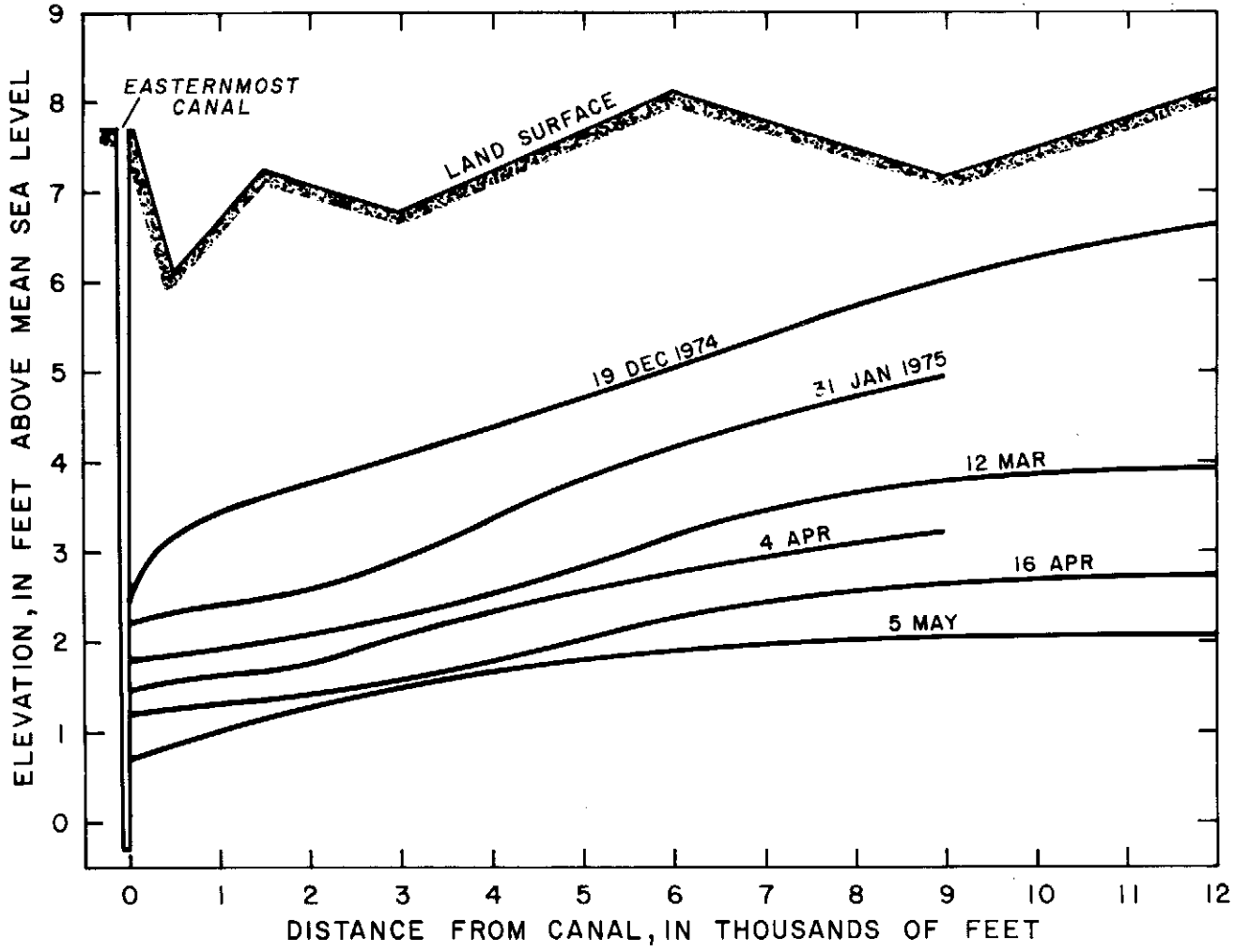

Figure 3. Ground-water gradients along the south well line from December 1974 to May 1975.

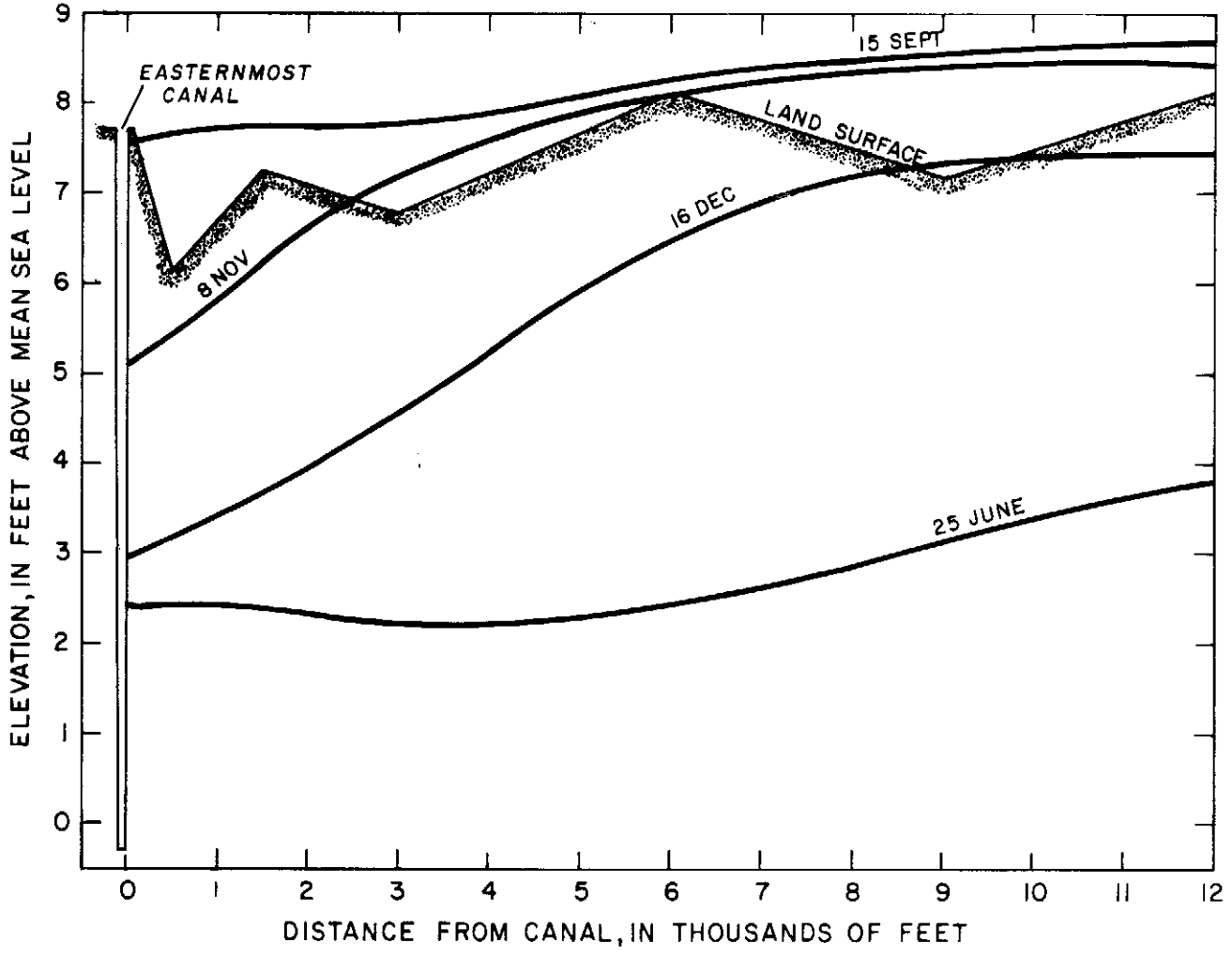

Figure 4. Ground-water gradients along the south well line from June 1975 to December 1975.

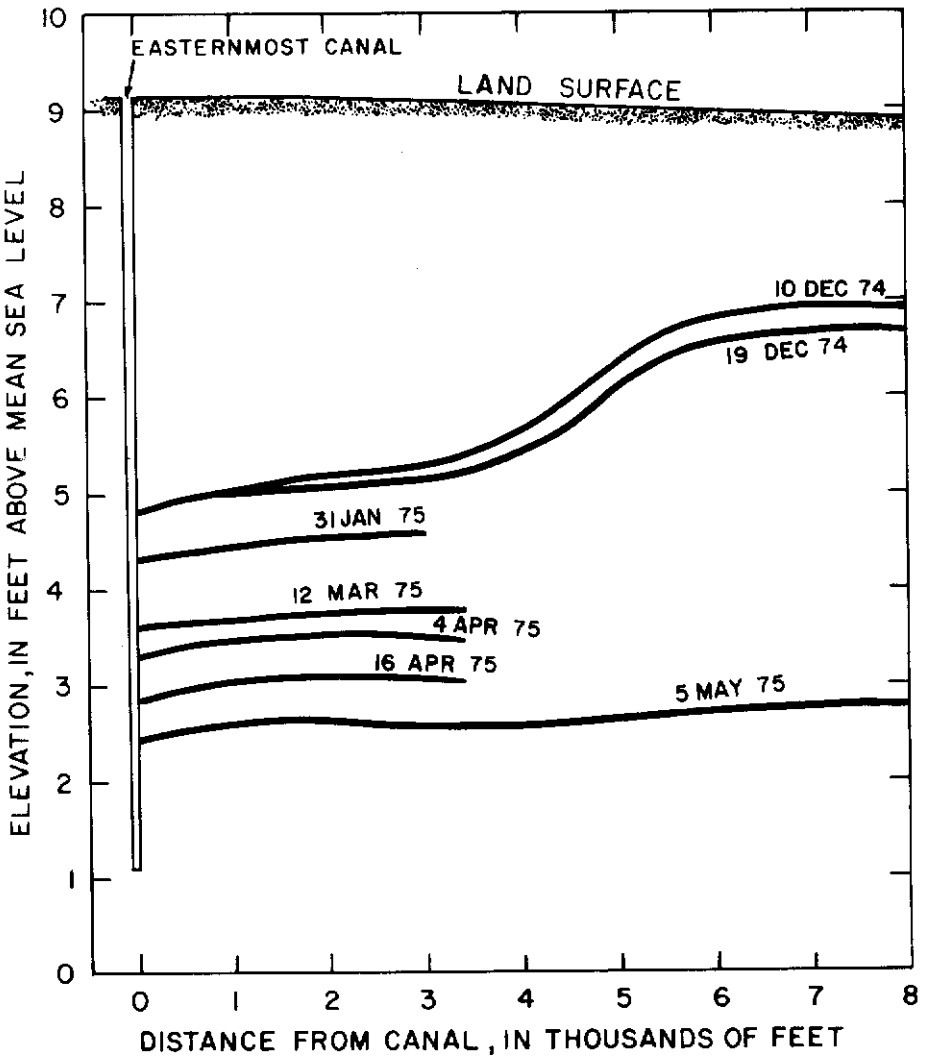

Figure 5. Ground-water gradients along the north well line from December 1974 to May 1975.

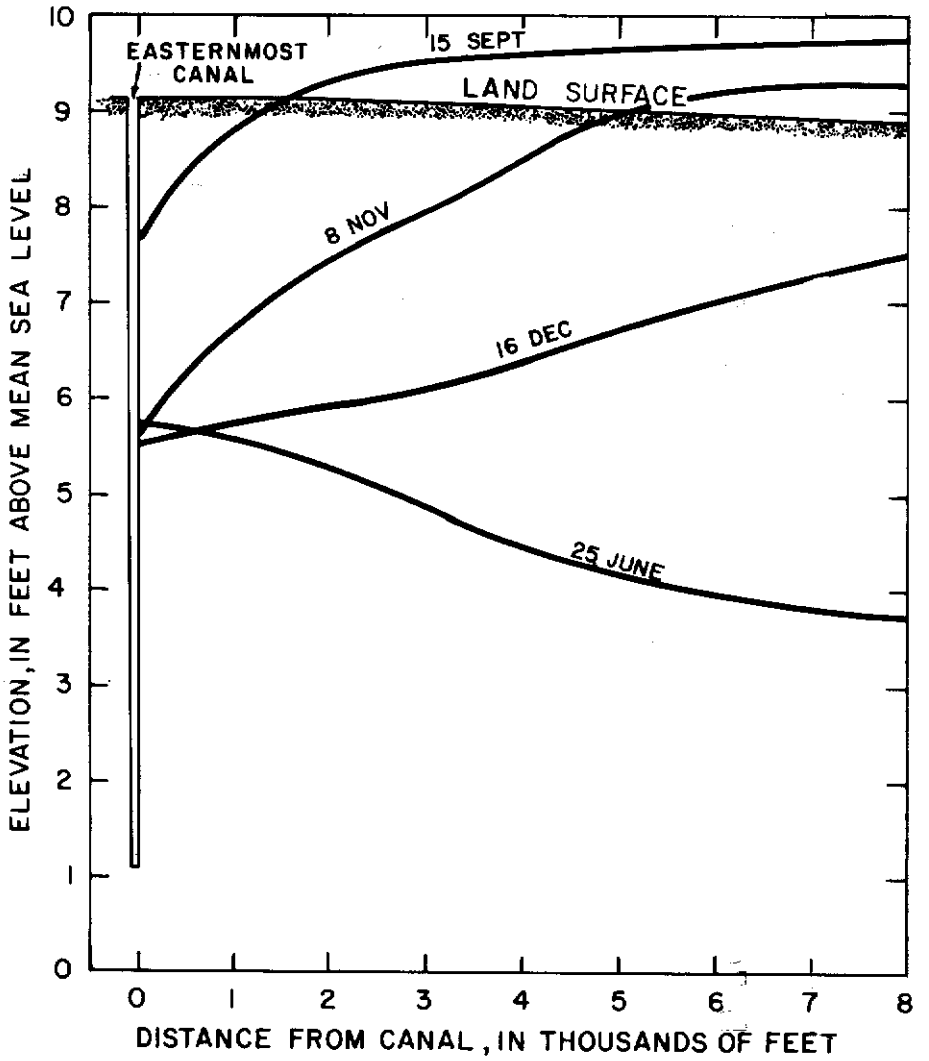

Figure 6. Ground-water gradients along the north well line from June 1975 to December 1975.

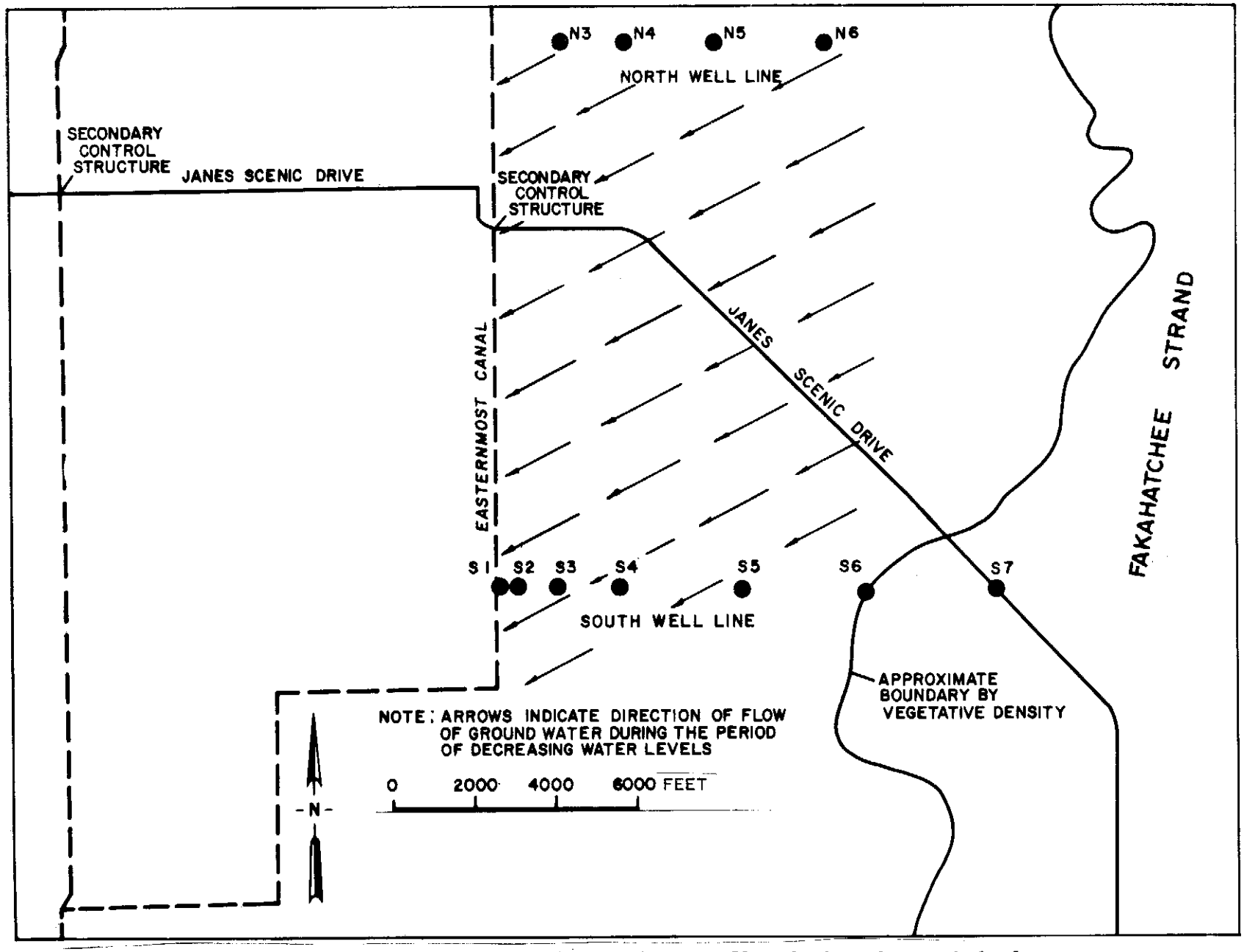

Figure 7. Generalized pattern of ground-water flow during the period of declining water levels (dry season).

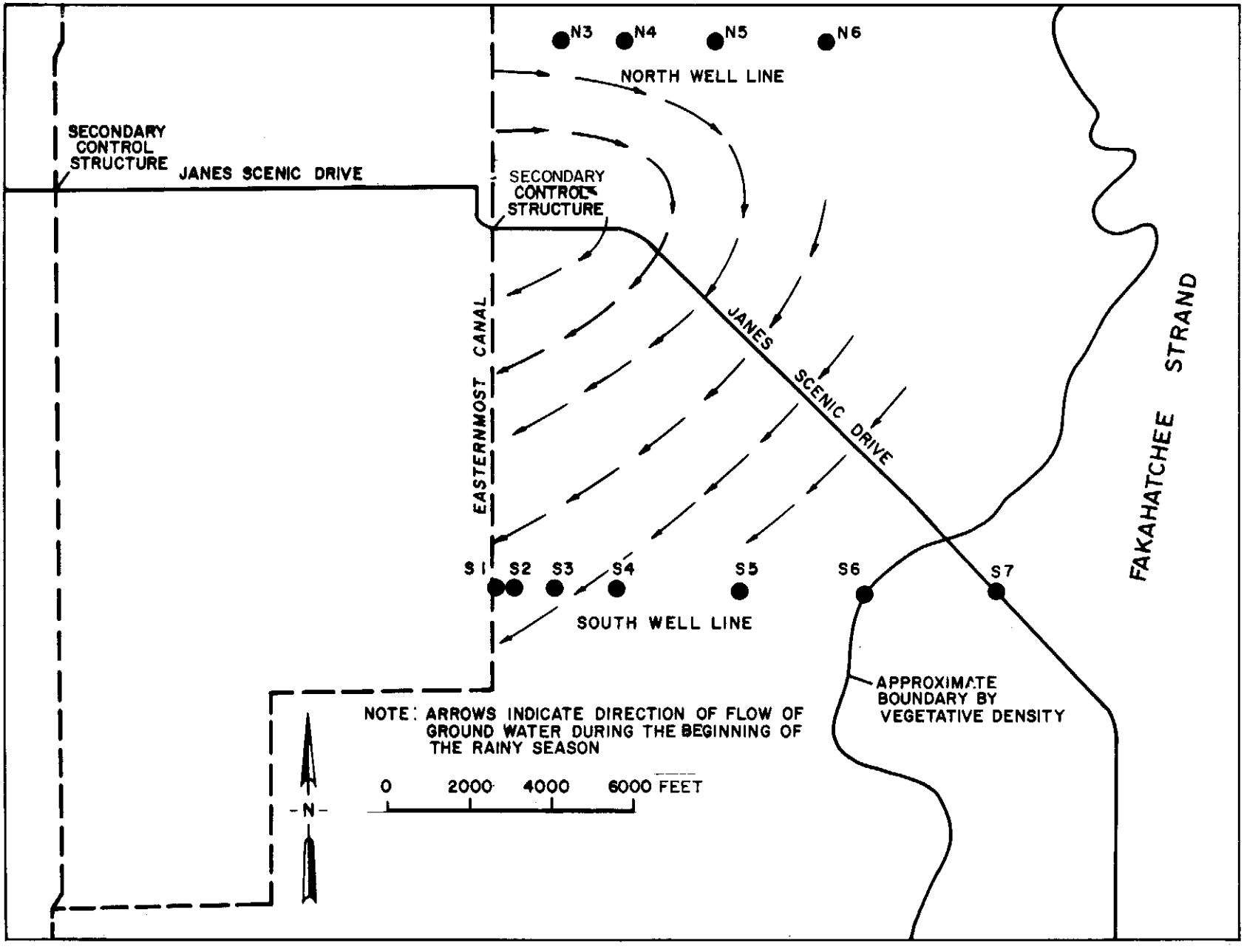

Figure 8. Generalized pattern of ground water flow at the beginning of the rainy season.

SEASONAL WATER-LEVEL FLUCTUATIONS

The water level at well C-496 (fig. 1a), in the center of the Fakahatchee Strand, fluctuates about 5 to 7 ft seasonally (fig. 9). The annual low-water level declined about 1 ft from 1971 into 1975. Annual low-water level was highest in 1972 at nearly 3 ft above mean sea level, but declined each year afterwards to a low in 1975 at about 1 ft above mean sea level. A decline in the annual low-water level is caused by a decrease in rainfall, an increase in drainage, or a combination of the two.

The average of annual and dry-season rainfall at the two long-term stations near the Fakahatchee Strand, Everglades City and Immokalee, are given in table 1. Average of annual rainfall was 43 in in 1971, and decreased from 56 in in 1972 to 47 in in 1975. Average dry-season rainfall varied from 18 in in 1970 to 10 in in 1974. These averages, however, may not be representative because rainfall can be extremely variable over short distances. Carter and others (1973) reported that rainfall in the Fakahatchee Strand in 1972 varied from 47 in to 76 in within a distance of about 3 mi. Because of the large areal variability in rainfall and the limited number of rainfall stations, it is virtually impossible to draw conclusions on the precise relation of precipitation to water-level changes in the strand.

NEEDS FOR ADDITIONAL STUDY

Additional study to include data on water inundation and flow throughout the Fakahatchee Strand would allow for an evaluation of the effects of canal drainage on the entire strand. Specific needs for an expanded study include:

(1) extending surveyed lines of observation wells from the Faka Union Canal system across the Fakahatchee Strand to the Barron River Canal to determine water-level gradients, and direction of flow, because water levels in the strand probably are affected by both the Faka Union Canal system and the Barron River Canal.

(2) relating the period and depth of flooding to different plant communities in the strand. This would allow areas of inundation to be mapped using the plants as indicators, because the survival of specific plant communities depends upon specific water depths and periods of flooding.

(3) measuring water flow within the strand and in nearby canals to determine discharge from the strand for comparison with discharge from the canal systems.

(4) surveying the land altitude to determine the location of the divide or ridge that separates the Fakahatchee Strand from the Picayune Strand to the west (fig. 1a), as this divide is the natural hydrologic western boundary of the Fakahatchee Strand.

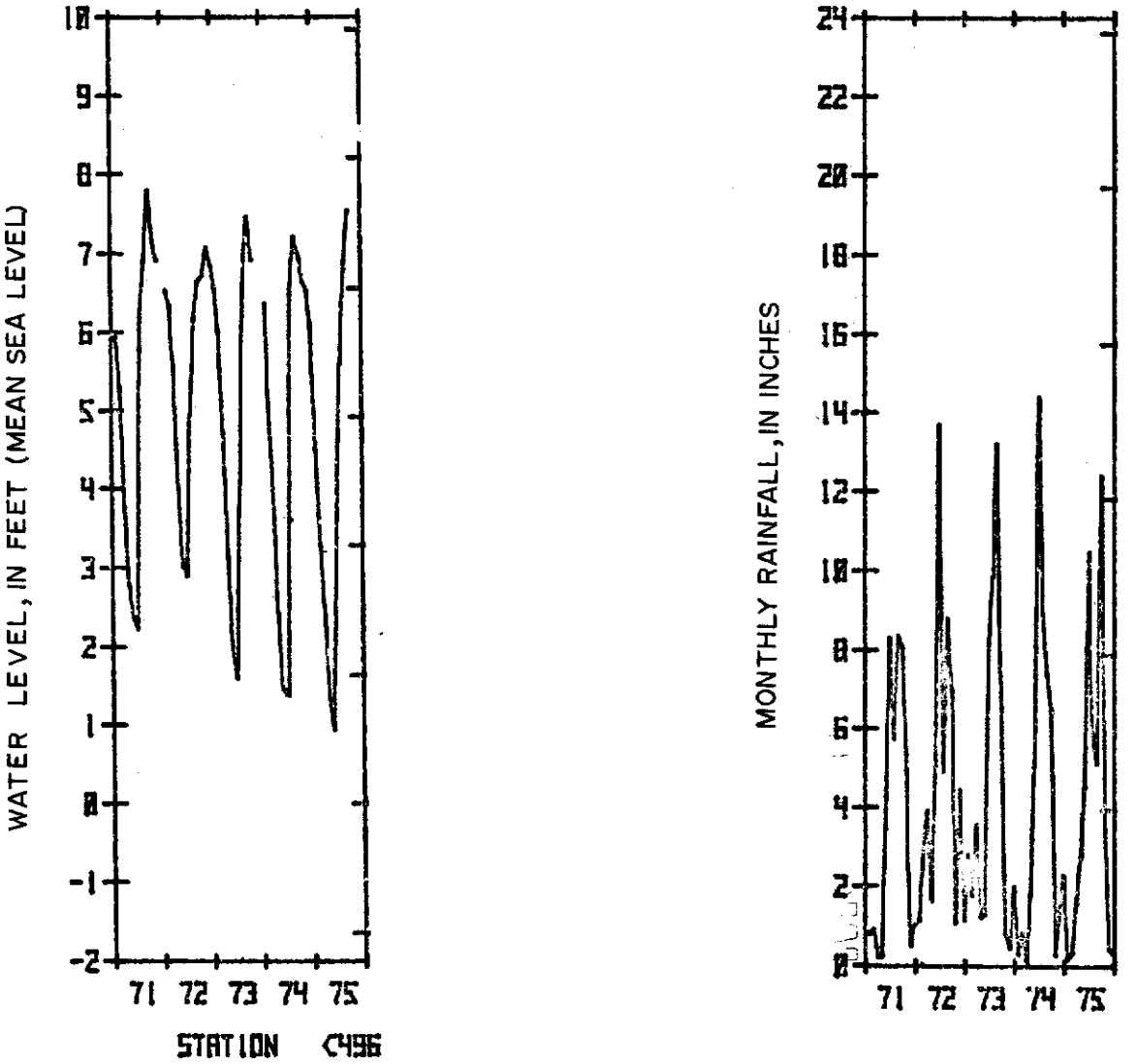

Figure 9. Hydrograph of well C-496 near the center of the Fakahatchee Strand and average of monthly rainfall at Immokalee and Everglades City, Florida.

CONCLUSIONS

The Faka Union Canal system, constructed in the western Big Cypress Swamp in the early 1970's, lies 3.5 mi west of the center of the Fakahatchee Strand, a forested water course designated by the State of Florida as an Area of Critical State Concern. The canal system discharged annually to the Gulf of Mexico from 143,200 to 275,600 acre-ft of freshwater between 1970 and 1974.

Drainage by the Faka Union Canal system has caused a downward slope in water level westward from the Fakahatchee Strand to the easternmost canal. The downward slope indicates ground water flowed from the strand toward the canal. The largest slope in ground-water level was at the end of the high-water period, December 1974, when the water-level gradient was about 4 ft in 12,000 ft.

The control structure in the canal at Janes Scenic Drive affected water-level gradients. South of the control structure, the water level sloped from the strand to the canal throughout the year. North of the control structure, water level sloped toward the canal in December 1974. However, throughout the winter and spring when the structure was closed the gradient was flat and ground-water flow toward the canal upstream of the structure was minimal. At the beginning of the rainy season, in June, water levels rose in the canal north of the structure, and water flowed from the canal into the aquifer and around the control structure.

The annual low-water level in the center of the strand declined about 1 ft from 1971 to 1975. Annual low-water level was highest in 1972 at nearly 3 ft above mean sea level, and declined each year afterwards to a low in 1975 of about 1 ft above mean sea level.

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*U.S. GOVERNMENT PRINTING OFFICE: 1977-743-970/716. Region 4.