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May 1988

PRELIMINARY EVALUATION OF THE LAKE OKEECHOBEE REGULATION SCHEDULE

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by

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Water Resources Division
Resource Planning Department
South Florida Water Management District

EXECUTIVE SUMMARY

Lake Okeechobee is the second largest fresh water lake lying wholly within the boundaries of the United States. This body of water benefits south Florida by storing massive amounts of water during wet periods for subsequent withdrawals by agricultural and urban users during dry periods. However, south Florida's potential for heavy rains and severe tropical storms requires that water levels in the lake be carefully monitored to insure that they do not rise to levels that would threaten the structural integrity of the levee system surrounding the lake. Therefore, when water levels in the lake reach certain elevations designated by the regulation schedule, discharges are made through the major outlets to control excessive build up of water in the lake. The timing and magnitude of these releases is not only important for preserving the flood protection of the region, but also for protecting the natural habitats of Lake Okeechobee's littoral zone and the estuaries downstream of the St. Lucie canal and Caloosahatchee River. Extended high water levels in the lake are harmful to the lake's littoral zone habitat, while frequent large discharges to the estuaries may cause undesirable changes to the estuaries.

In summary, the competing objectives associated with managing the lake water levels are:

1. Provide adequate flood protection for the regions surrounding the lake.

2. Meet the water use requirements of the agricultural and urban areas dependent on Lake Okeechobee for water supply.

3. Preserve the biological integrity of the estuaries downstream of the lake.

4. Preserve and enhance the lake's littoral zone which provides a natural habitat for fish and wildlife.

The extreme rainfall patterns in Florida during the 1980's have brought to focus many issues that are affected by Lake Okeechobee's regulation schedule. In this analysis, four criteria were defined to evaluate the effectiveness of alternative schedules in meeting the competing objectives associated with managing Lake Okeechobee.

The results of thirty alternative schedules that were tested using the South Florida Regional Routing Model (Technical Publication 86-3) for the rainfall conditions that occurred during the historical period of 1952 to 1984 are summarized in this report. These results indicate that an alternative schedule may be more beneficial for meeting the competing goals of managing the lake water levels and discharges.

Key findings of this report based on the rainfall conditions that occurred between 1952 through 1984 are:

1. Reducing the fall and winter allowable buildup of storage in the lake would be beneficial for the estuaries, flood protection and the littoral zone. Normally this water is not required for water supply purposes.

2. Establishing a zone of low level discharges that have minimal environmental impact to the estuaries is desirable. This zone will help prevent the need for larger releases that are undesirable for the estuaries.

3. The minimum level of the schedule could be raised slightly without decreasing overall flood protection when compensating adjustments are made to the schedule. This would have helped water supply during the 1981-1982 drought.

4. The upper lake schedule could be raised to 18.5 feet (msl) during January and February without altering flood protection. This would be very useful in reducing Zone A releases to the estuaries during late winter and spring months.

5. A new zone of required discharges greater than the present Zone B discharges but less than present Zone A releases would be useful in reducing Zone A discharges, and would provide additional flood protection for the regions surrounding Lake Okeechobee.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF TABLES

ACKNOWLEDGMENTS

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Dee Azeredo and Karen Lythgoe should be commended for the excellent work they did in executing the South Florida Regional Routing Model. This computer model was used as an analytic tool to evaluate the different Regulation Schedules.

Special recognition also needs to be given to Dawn Reid, Barbara Brown, Rick Miessau, Annie Angueira, and Steve Bell for their help in organizing the report along with the quality of graphics and tables they produced on short notice and to Nettie Winograd for her efforts in typing this report in a timely fashion.

ABSTRACT

Findings of this report indicate that there may be an alternative regulation schedule that would better meet the competing objectives of the water management of Lake Okeechobee. These objectives are:

1. Flood protection for the regions surrounding the lake.

2. Water supply for the agricultural and urban areas dependent on the lake for water during dry periods.

3. Protection of the lake's littoral zone habitat from high water levels.

4. Protection of the estuaries from undesirable salinity changes that may be created by receiving large lake discharges.

These findings are based on computer model simulations incorporating hydrologic data from the period 1952 to 1984, and indicate that it is possible to reduce large (Zone A) discharges to the estuaries without reducing either the flood protection of the surrounding regions or the water supply. The buildup of storage in the lake to 17.5 feet (msl) during the fall and winter months is not normally necessary to meet water use requirements of the regions that are dependent on the lake. This buildup of storage is also undesirable for the lake's littoral zone and the Caloosahatchee and St. Lucie estuaries. The slope of the present regulation schedule can be modified during the dry season to produce a more gradual drawdown of the lake and therefore reduce the necessity for large freshwater discharges.

KEY WORDS: *estuarine ecology, flood protection, littoral zone habitat, multi-objective analysis, regulation schedule, water supply.*

I. INTRODUCTION

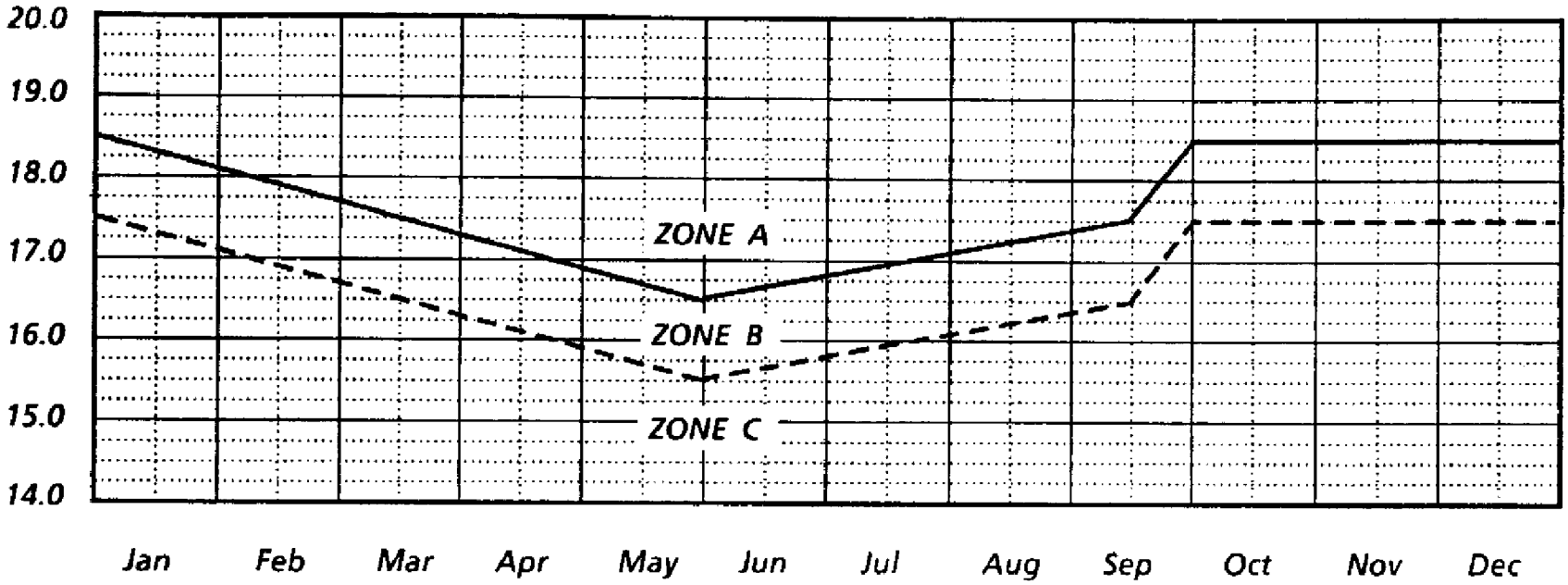
The regulation schedule for Lake Okeechobee was revised in May 1978 in an effort to store a greater amount of the water that was available during wet periods for use during subsequent extended dry periods. A schematic of this schedule appears in Figure 1. During the period between 1960 and 1978, the lake experienced several extended periods which rainfall amounts remained precariously low. The available water supply stored in the lake was stressed several times during this period, particularly in 1971 and 1974. In addition, with the projected increase in water use requirements of the service areas surrounding the lake and those of the lower east coast, it was estimated that the situation might get worse in the future. Based on model simulations for rainfall conditions that occurred for the period from 1965 to 1974, it did not appear that this schedule change would hurt the Lake Okeechobee ecosystem with extended periods of high water levels since the lake was not projected to reach schedule on a regular basis.

Once the new schedule was in operation, rainfall amounts were sufficient to cause the lake stage to reach regulation schedule by autumn of 1978. The lake remained at or near schedule until June 1980 requiring extended periods of discharges through the St. Lucie Canal and the Caloosahatchee River to sea. From June 1980 to February 1982 the interior sections of south Florida received one of its worse droughts on record. Lake Okeechobee reached its lowest level on record in August 1981; water use in south Florida was being carefully monitored. The higher regulation schedule undoubtedly helped store larger quantities of water for use during this drought and helped prevent more severe drought damage. However, the question arose the months following the drought as to whether it was necessary to lower the Lake Okeechobee stage to 15.5 feet mean sea level (msl) by June 1, or whether additional storage could have been saved in the Spring of 1980 for the following drought without significantly increasing the chances of a major flood disaster.

In the months of February through June 1982 rainfall amounts again became abundant in south Florida. The Lake Okeechobee stage rose from 10.54 feet on May 22 to near its regulation schedule at about 16.30 feet by the end of August due to above normal spring rainfall and the normal rainy summer conditions. The lake stage remained near regulation schedule for the next several months. Then in January and February 1983, south Florida got drenched with heavy winter rainfall. In January the region received about 250% of the normal rainfall, while in February it received near 400% of normal rainfall. This pushed the Lake Okeechobee stage into Zone A of its regulation schedule and thus maximum releases were required through all major lake outlets. Over 2 million acre-feet of water were released to the sea through the St. Lucie Canal and the Caloosahatchee River during the winter and spring of 1983. These releases through the St. Lucie Canal and the Caloosahatchee River undoubtedly caused some undesirable environmental changes to the St. Lucie and Caloosahatchee estuaries. Haunert and Startzman (Technical Publication 85-1) found significant changes in the St. Lucie Estuary in response to discharges as low as 2,500 cfs for a three week test period. The heavy rains of the winter and spring of 1983 brought forth additional questions concerning the Lake Okeechobee regulation schedule. A major concern was related to the allowable 2 feet of storage buildup during the autumn and early winter combined with the steep downward slope of the schedule in the late winter and spring months which may be conducive to the need for large discharges during the spring. Furthermore, when the lake stage reached regulation schedule again in the winter of 1984, concerns were raised as to whether the higher lake stages occurring since the adoption of the present lake schedule were adversely affecting the littoral zone of Lake Okeechobee.

The recent extremes in Florida's rainfall patterns ranging from severe drought to record rains have brought to focus many of the issues affected by the choice of Lake Okeechobee's regulation schedule. Many regulation schedules have been evaluated in recent years to determine if an alternative schedule to the current one may be more effective in addressing the concerns that recently have been voiced by a number of local environmental groups and governmental agencies while at the same time maintaining the level of flood protection and water supply capabilities of the present schedule.

This report is a preliminary document written to summarize the status of the work completed in evaluating Lake Okeechobee regulation schedules so that the results may be reviewed by all concerned agencies and that the final steps of the analyses may be cooperatively planned and completed. Also included in this report is a brief summary of the history of the previous regulation schedules that have been in operation for the lake.



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-308C
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

* Releases 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 1. CURRENT REGULATION SCHEDULE

II. EARLY REGULATION OF LAKE OKEECHOBEE

Before the period in which Lake Okeechobee was regulated, the average water level in the lake was near 19 feet (msl). It was not uncommon for water levels in the lake to rise above 20 feet (msl). Large inflows occurred from regions to the north that drained into the lake from the Kissimmee River, Fisheating Creek, Taylor Creek and Nubbin Slough. To the east of the lake the Orlando Ridge acted as a natural boundary for the lake. On the south side of the lake the boundary between the lake and the Everglades was often indistinguishable during the wet periods. Water movement was very slow to the south due to the flat terrain and thick vegetation. During drier periods, the Everglades occasionally dried out. The only significant overland outflow for the lake was through the marsh on the western bank of the lake and into the Caloosahatchee River. This water movement was again limited by the thick vegetation in this marsh. The major losses of water from the interior regions of Florida were through evapotranspiration.

In the middle of the 19th Century, the potential that the Everglades rich soils had for agricultural purposes began to be recognized. By the end of the 19th Century a canal was built connecting Lake Okeechobee to the Caloosahatchee River for the purpose of lowering water levels in the lake to aid in draining the northern portion of the Everglades for agricultural purposes. In the early 20th Century (1900's) the dredging of the Miami, North New River, Hillsboro, West Palm Beach, and St Lucie canals provided additional drainage for the Everglades agricultural area. An eight foot muck dike was built along the lake's south shore to protect residents and farmlands from periods of high waters in Lake Okeechobee. However, during the hurricanes of 1926 and 1928, massive amount of damage occurred and many lives were lost. The damage of the 1928 hurricane was especially severe with the wind tide rising to approximately 27 feet (msl). These storms brought forth the need for a well built levee system that could sustain storm surges generated by hurricanes that pass in the vicinity of the lake. The U.S. Army Corps of Engineers constructed control gates and major levees along Lake Okeechobee's shores that reached heights between 32 and 45 feet (msl).

During the early years, the Everglades Drainage District generally attempted to maintain water levels in Lake Okeechobee at 14 feet (Okeechobee datum) between June 1 and October 15, while during the dry season between November 1 and April 1 stages were permitted to rise up to 17 feet (Okeechobee datum). The Okeechobee datum was 1.44 feet below sea level so that these stages are equivalent to 12.56 feet (msl) and 15.56 feet (msl) respectively. The period from April 1 to June 1 and October 15 to November 1, were transitional periods. In 1940 a plan of operation was put in effect that was based on a rainfall and evapotranspiration formula developed by the U. S. Corps of Engineers from a study of the lake hydrological records. This plan appears in Figure 2 (U. S. Corps of Engineers, November 22, 1978). Discharges were determined from the difference between rainfall and evapotranspiration accumulated for the calendar year and the lake stage as illustrated. The official range of the lake schedule was still between 12.56 and 15.56 feet (msl). In April 1948, the lake regulation schedule was unofficially lowered to a range from 12.5 to 14.5 feet (msl) in response to the hurricane of 1947 that was preceded by a very wet summer. In 1951, an interim schedule was put into effect with three zones which are illustrated in Figure 3a. When lake water levels were in Zone C, the only releases made from the lake were for agricultural use. In Zone B, releases were made not only for agricultural use, but also if it became apparent that sufficient inflow was going to occur to raise the lake into Zone A. The Lake Okeechobee outlets were opened as required to offset the projected inflows entering the lake and prevent the lake from entering Zone A. During the wet season (June 1 to October 31), the Caloosahatchee River was used as the primary outlet with the St. Lucie Canal being used only if additional discharges were required. During the dry season (November 1 to May 31) releases were initially made through the agricultural area when the capacity was available even before they were made to the Caloosahatchee River so that the water could be kept in storage for future use. Maximum discharges were always to be made when the lake water level entered Zone A.

In response to the very wet years prior to 1954, particularly the fall of 1953, a new schedule was put in effect in May 1954 in an effort to offer a higher degree of flood protection. Figure 3b illustrates this schedule. It had maximum discharges through the Caloosahatchee River while water levels were in Zone B. Other features that increased the flood protection afforded by this schedule were the earlier spring decline of the lower schedule and the lower elevation of the upper schedule in the summer and fall months. It may be assumed that the absence of Zone B during the period between November 15 and February 1 was incorporated to increase the water supply for spring water use requirements.

In 1958 refinements were made to the schedule adopted in 1954 which are illustrated in Figure 3c. These refinements were made in an effort to reduce the overall flow to the St. Lucie Canal during the wet season and also attempted to prevent erosion within St. Lucie Canal by limiting the velocity of flow through the St. Lucie Canal when possible.

In 1965 the regulation schedule was modified to allow storage to accumulate during the wet season. This was in response to the dry conditions of the early sixties and particularly the dry spring months of the same year so that water could be stored for water use purposes. This schedule (Figure 3d) was only in operation for the summer and fall of 1965. This was one of the first schedules put into operation that did not have the lowest point of the schedule immediately prior to the peak of the hurricane season. The schedule put into operation in January 1966 was derived primarily in accordance with an interagency agreement to deliver water to the Everglades National Park. This schedule is illustrated in Figure 3e.

In 1972 Zone C was discontinued and the lower level of Zone B was raised up one-half of one foot in an attempt to increase water supply. This schedule along with its operational rules appear in Figure 3f.

Due to the extended dry period in the early seventies, and the increased water use requirements of the lake, the levee system surrounding the lake was improved so that the lake could safely be regulated between 15.5 feet (msl) and 17.5 feet (msl). While the work was nearing completion in 1974, an interim schedule was put into operation to raise the schedule one-half of one foot to a range between 14.5 to 16 feet (msl). The 15.5 to 17.5 foot schedule went into operation in the summer of 1978.

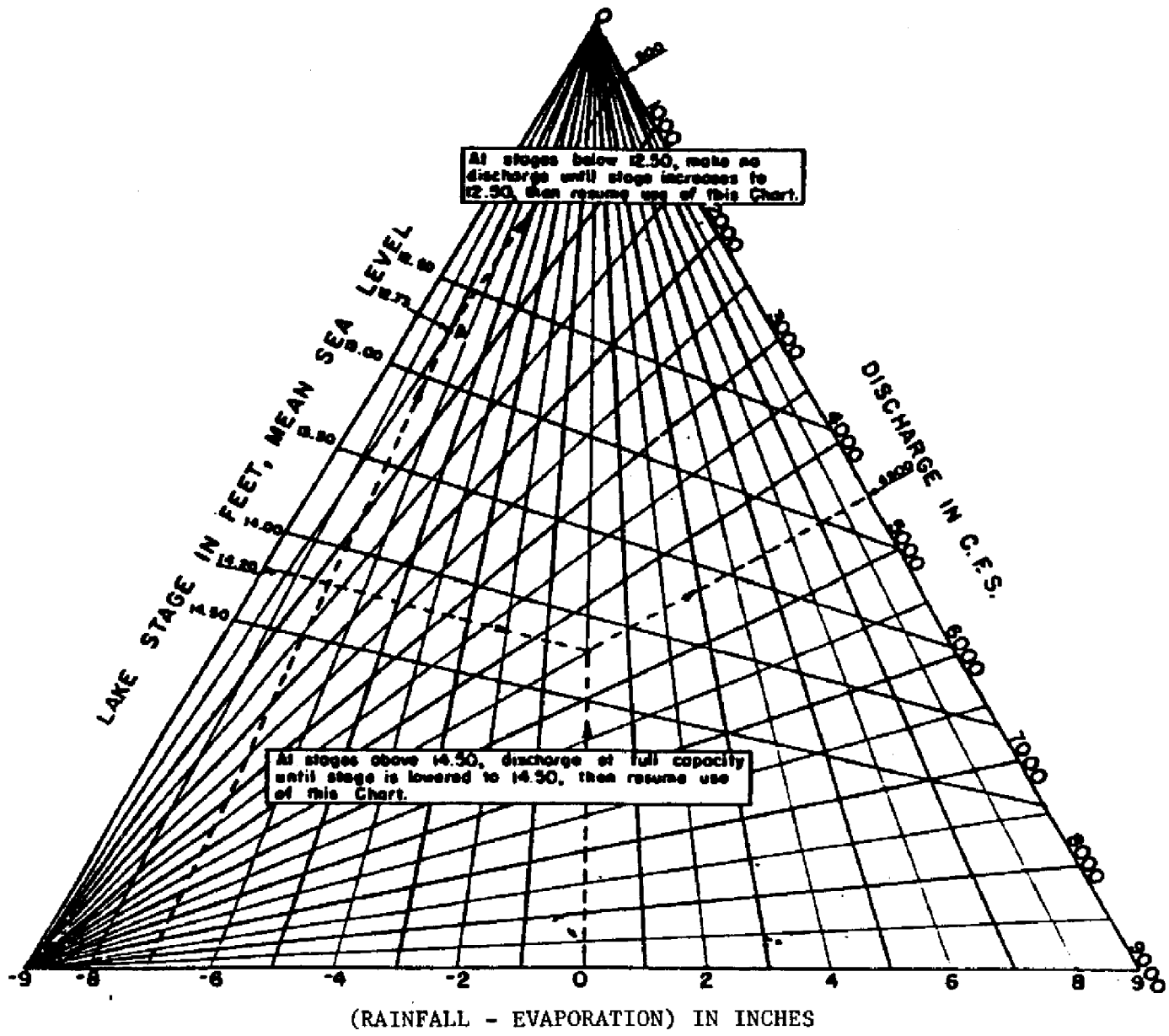
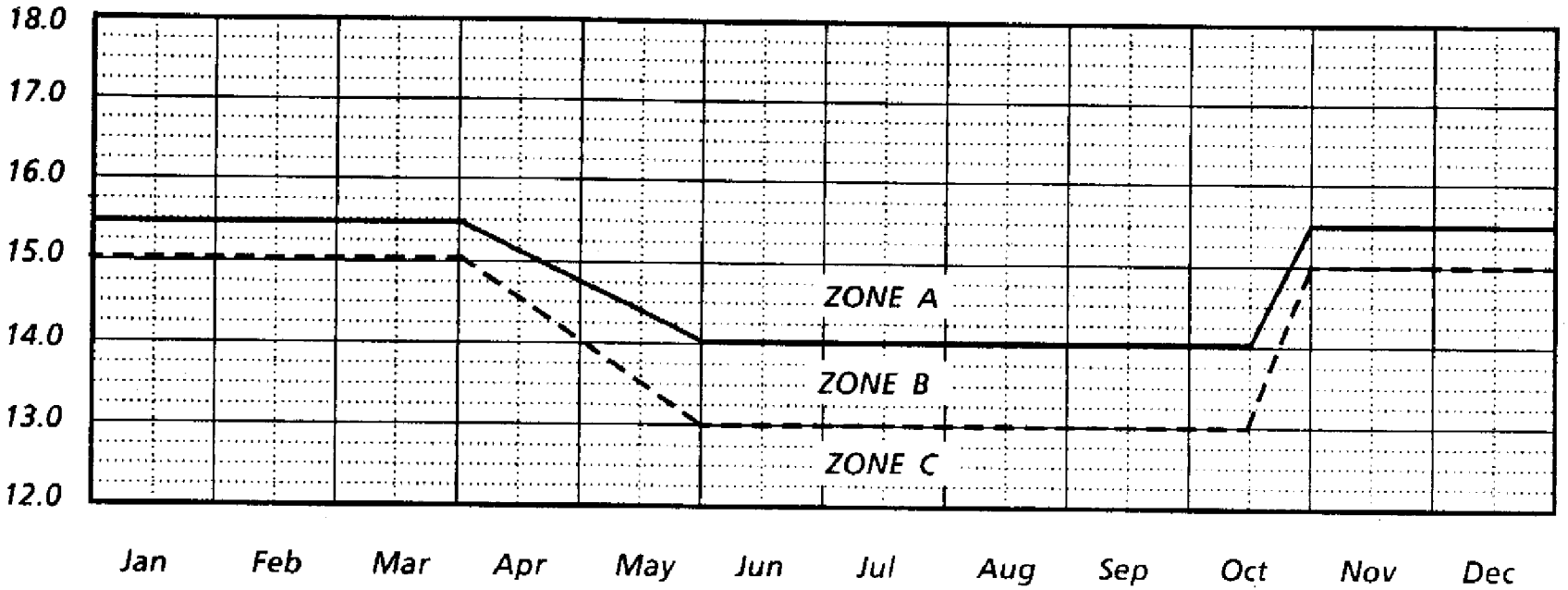


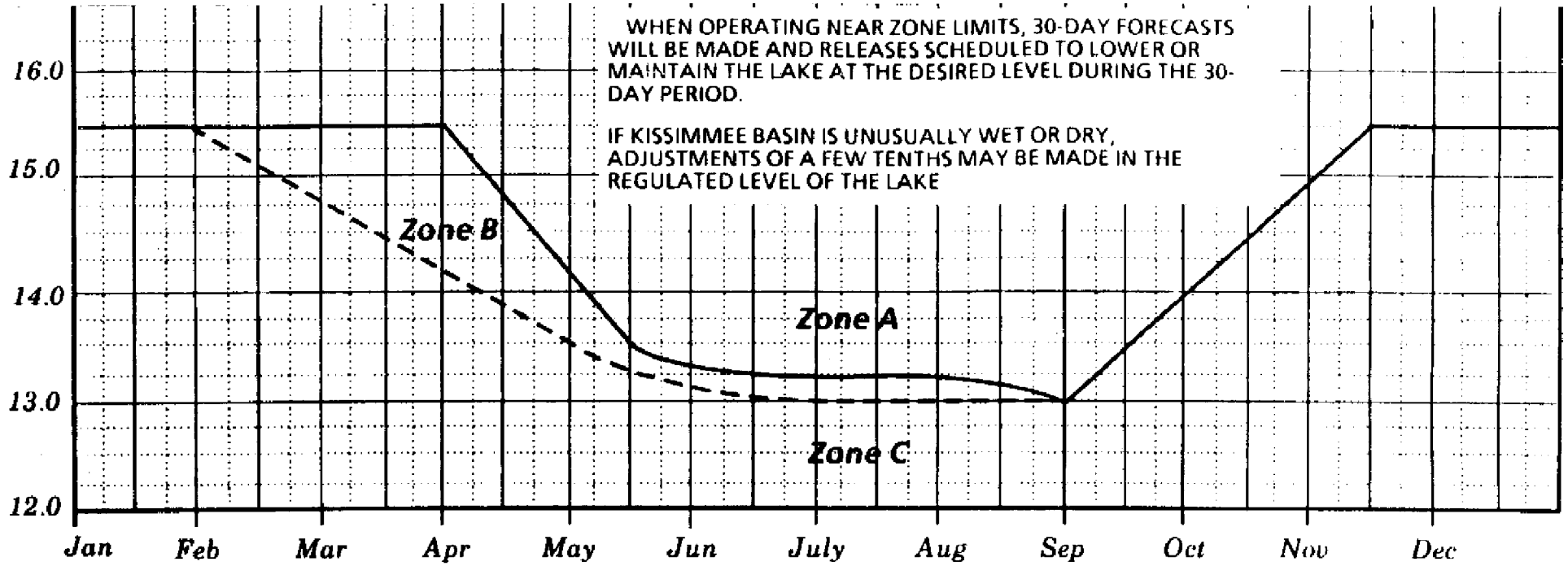
FIGURE 2. LAKE OKEECHOBEE DISCHARGE CHART (Corps of Engineers, Master Regulation Manual. 1978)

1951 REGULATION SCHEDULE



ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Maximum Practicable	Maximum	Maximum
B	Releases Made to Offset Projected Inflows	Releases Made to Offset Projected Inflows	Releases Made to Offset Projected Inflows
C	No Regulatory Discharge	No Regulatory Discharge	No Regulatory Discharge

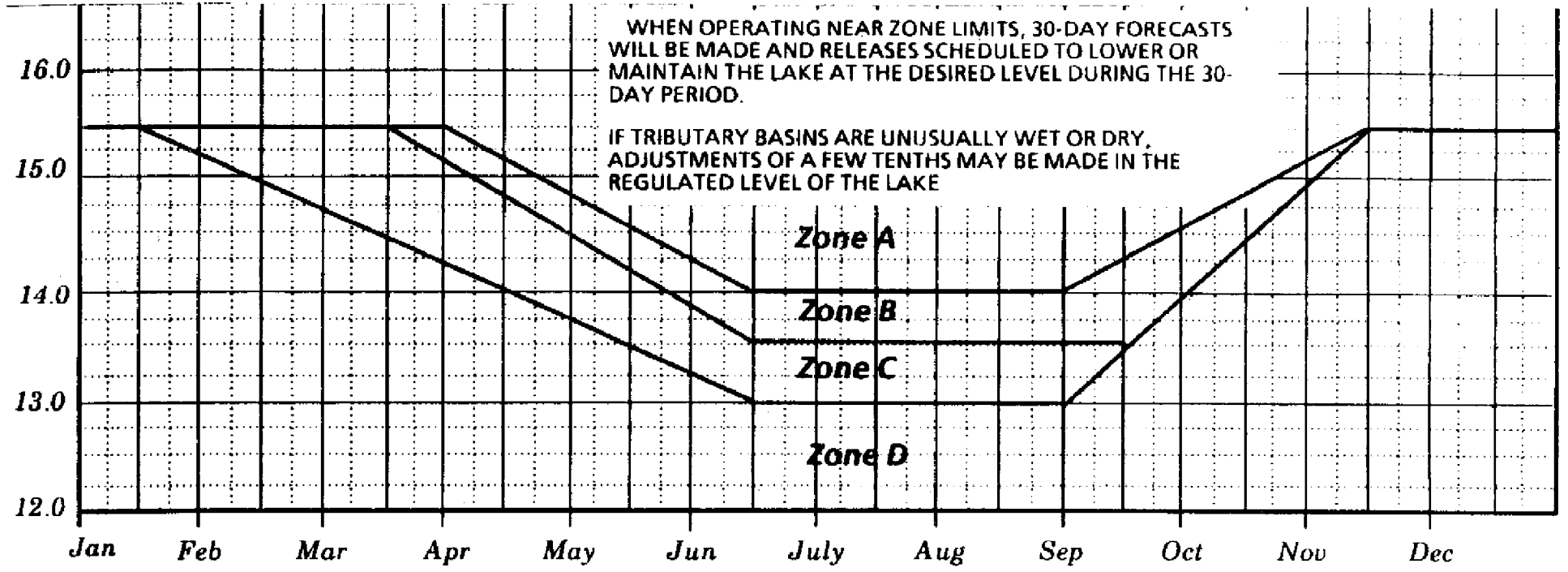
FIGURE 3a. INTERIM REGULATION SCHEDULE EFFECTIVE 1951 (Corps of Engineers, Master Regulation Manual, 1978)



RELEASE THROUGH OUTLETS AS INDICATED			
Zone	**Agricultural Canals**	**Caloosahatchee River**	**St. Lucie Canal**
A	MAXIMUM CAPACITY	MAXIMUM CAPACITY	MAXIMUM CAPACITY
B	MAXIMUM CAPACITY	MAXIMUM CAPACITY	NO REGULATORY DISCHARGE
C	AG DEMAND ONLY	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

Central and Southern Florida
INTERIM REGULATION SCHEDULE--LAKE OKEECHOBEE
Department of the Army, Jacksonville District
Corps of Engineers, Jacksonville, Florida
OCTOBER, 1954

FIGURE 3b. REGULATION SCHEDULE EFFECTIVE IN 1954



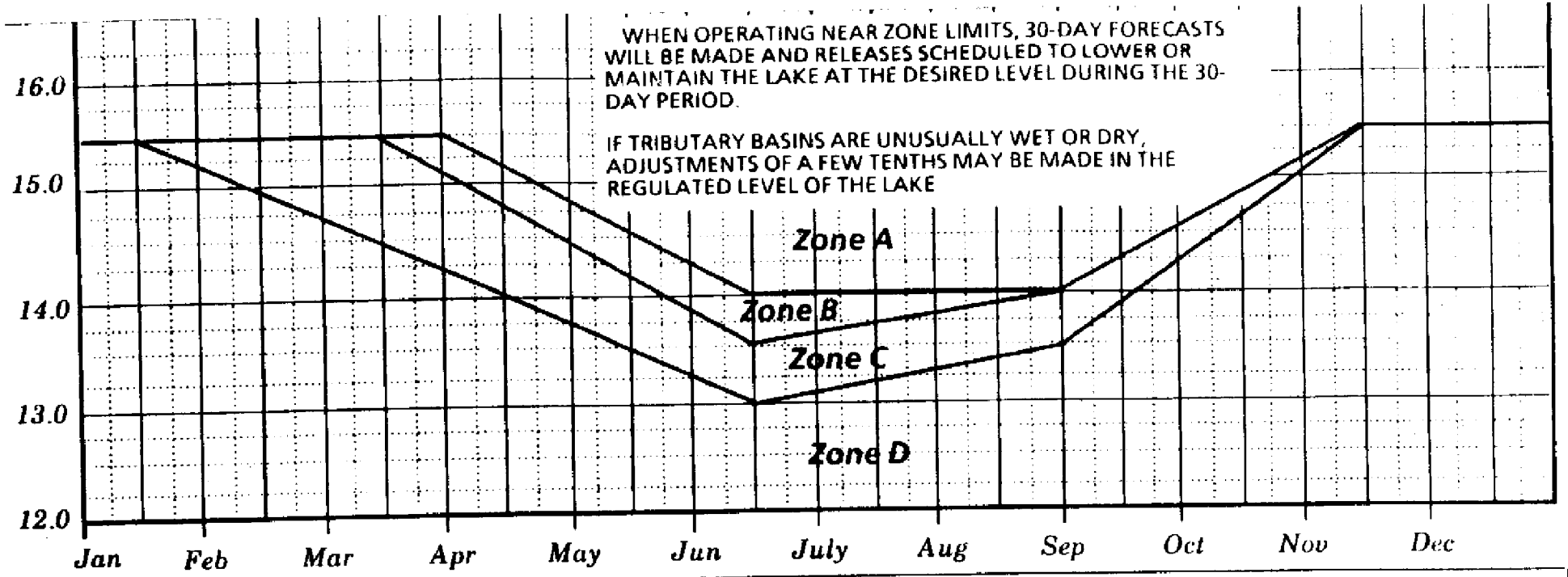
RELEASE THROUGH OUTLETS AS INDICATED			
Zone	**Agricultural Canals**	**Caloosahatchee River**	**St. Lucie Canal**
A	MAXIMUM DISCHARGE AFTER REMOVAL OF LOCAL INFLOW	MAXIMUM DISCHARGE WITHOUT LOCAL FLOODING	MAXIMUM DISCHARGE
B	MAXIMUM GRAVITY RELEASES AFTER REMOVAL OF LOCAL INFLOW		MAXIMUM DISCHARGE WITH AVERAGE VELOCITY LIMITED TO 2.5 FT/SEC
C	MAXIMUM GRAVITY RELEASES AFTER REMOVAL OF LOCAL INFLOW	MAXIMUM CAPACITY	0 TO 3500 CFS
D	FOR AG DEMAND ONLY	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

PRIORITY FOR USE OF OUTLETS

1. GRAVITYRELEASES THROUGH THE AGRICULTURAL CANALS
2. ST LUCIE CANAL AND/OR CALOOSAHATCHEE RIVER DEPENDING ON LOCAL CONDITIONS. WHEN THERE IS AN UNUSUAL RED-TIDE HAZARD, RELEASES THROUGH THE CALOOSAHATCHEE MAY BE CURTAILED
3. PUMPED RELEASES THROUGH THE AGRICULTURAL CANALS

Central and Southern Florida
INTERIM REGULATION SCHEDULE--LAKE OKEECHOBEE
Department of the Army, Jacksonville District
Corps of Engineers, Jacksonville, Florida
DEC 1958

FIGURE 3c. REGULATION SCHEDULE EFFECTIVE IN 1958



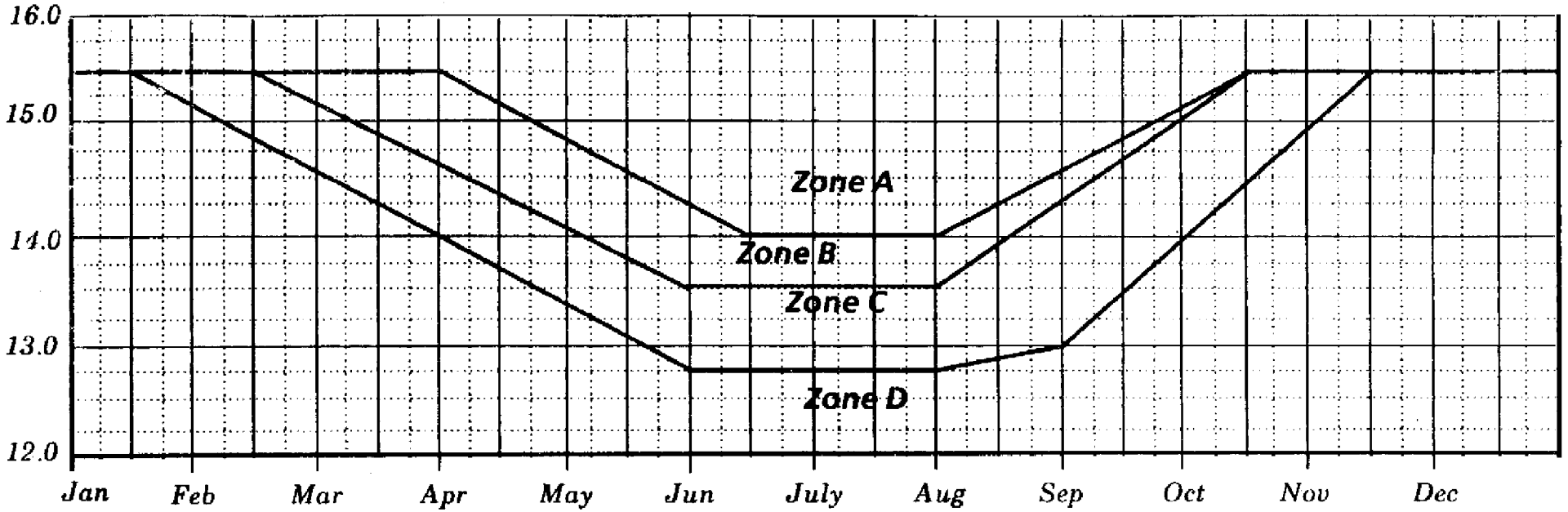
RELEASE THROUGH OUTLETS AS INDICATED			
Zone	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	MAXIMUM DISCHARGE AFTER REMOVAL OF LOCAL INFLOW	MAXIMUM DISCHARGE WITHOUT LOCAL FLOODING	MAXIMUM DISCHARGE
B	MAXIMUM GRAVITY RELEASES AFTER REMOVAL OF LOCAL INFLOW		MAXIMUM DISCHARGE WITH AVERAGE VELOCITY LIMITED TO 2.5 FT/SEC
C	MAXIMUM GRAVITY RELEASES AFTER REMOVAL OF LOCAL INFLOW	MAXIMUM CAPACITY	0 TO 3500 CFS
D	FOR AG DEMAND ONLY	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

PRIORITY FOR USE OF OUTLETS

1. GRAVITYRELEASES THROUGH THE AGRICULTURAL CANALS
2. ST LUCIE CANAL AND/OR CALOOSAHATCHEE RIVER DEPENDING ON LOCAL CONDITIONS. WHEN THERE IS AN UNUSUAL RED-TIDE HAZARD, RELEASES THROUGH THE CALOOSAHATCHEE MAY BE CURTAILED
3. PUMPED RELEASES THROUGH THE AGRICULTURAL CANALS

Central and Southern Florida
ALTERNATE REGULATION SCHEDULE--LAKE OKEECHOBEE
Department of the Army, Jacksonville District
Corps of Engineers, Jacksonville, Florida
Summer and Fall, 1965

FIGURE 3d. INTERIM REGULATION SCHEDULE IN OPERATION IN SUMMER AND FALL OF 1965



RELEASE THROUGH OUTLETS AS INDICATED				S-12 Regulation Discharge to Park
Zone	Agricultural Canals	Caloosahatchee River	St. Lucie Canal	
A	PUMP MAXIMUM FOR REGULATION WITH 1000 CFS FOR PARK AFTER REMOVAL OF LOCAL RUNOFF	MAXIMUM DISCHARGE WITHOUT LOCAL FLOODING	MAXIMUM DISCHARGE	1000 CFS*
B		UP TO MAXIMUM DISCHARGE WITHOUT LOCAL FLOODING	MAXIMUM DISCHARGE WITH AVERAGE VELOCITY LIMITED TO 2.5 FT/SEC	1000 CFS*
C	PUMP 500 CFS FOR PARK RELEASE FOR AG AND URBAN	NO REGULATORY DISCHARGE	0 TO 3500 CFS	500 CFS
D	PUMP 140 CFS FOR PARK RELEASE FOR AG AND URBAN	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	140 CFS
E	FOR AG AND URBAN USE ONLY	NO REGULATORY DISCHARGE		FCD INTERIM SCHEDULE SUBERSEDES

FIRST PRIORITY SECOND PRIORITY THIRD PRIORITY

Central and Southern Florida
INTERIM REGULATION SCHEDULE--LAKE OKEECHOBEE
Department of the Army, Jacksonville District
Corps of Engineers, Jacksonville, Florida
MARCH, 1966

* UNTIL EMERGENCY CONSTRUCTION TO INCREASE CONVEYANCE CAPACITY OF LOW-FLOW CANALS BETWEEN PS-7, PS-8 AND S-12 IS COMPLETED, DISCHARGE IN EXCESS OF 500 CFS IS DEPENDENT UPON WATER LEVELS IN CONSERVATION AREAS 2A AND 3A BELOW S-11

Notes

1 RELEASES FROM LAKE FOR PARK BY PUMPING OR GRAVITY AT FCD OPTION.

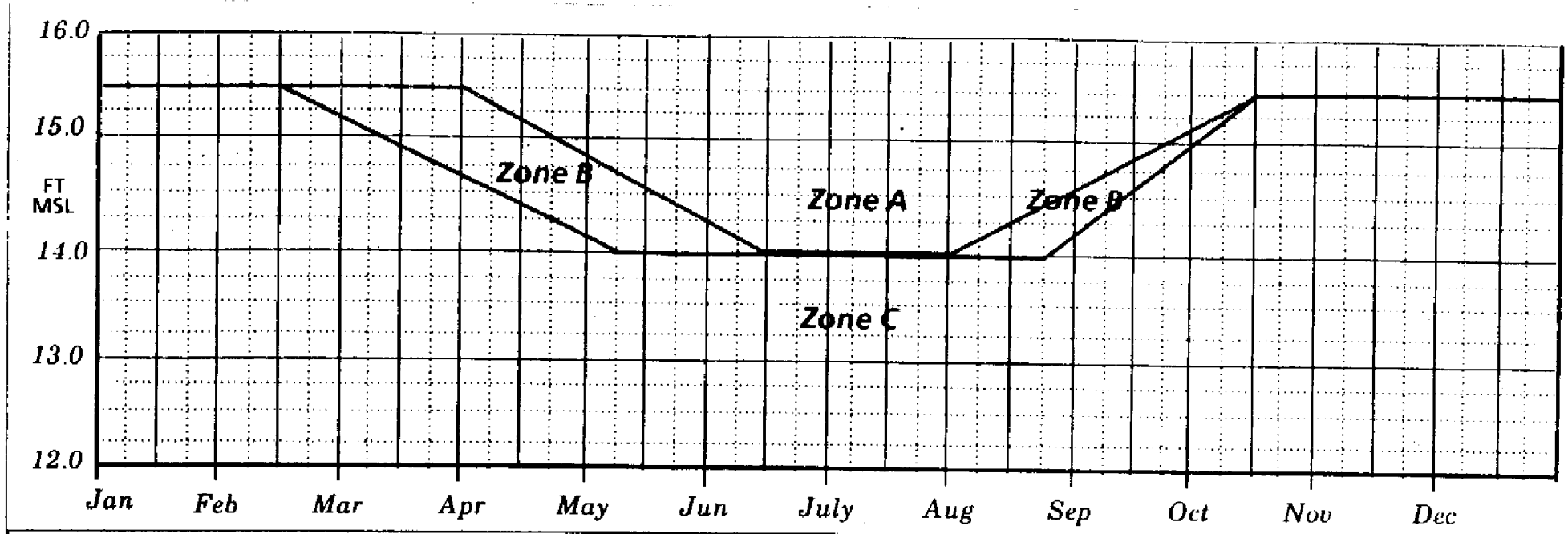
2 NO PUMPING FROM LAKE IS REQUIRED WHEN CONSERVATION AREAS 1,2A AND 3A ARE FULL. RELEASES THROUGHS-12 WILL BE REQUIRED TO MAINTAIN REGULATION OF AREA 3A

3 MAXIMUM ANNUAL VOLUME TO BE RELEASED FROM LAKE TO PARK IS 500,000 AC FT

4 WHEN OPERATING NEAR ZONE LIMITS, 30-DAY FORECASTS WILL BE MADE AND RELEASES SCHEDULED TO LOWER OR MAINTAIN THE LAKE AT THE DESIRED LEVEL DURING THE 30-DAY PERIOD

5 IF TRIBUTARY BASINS ARE UNUSUALLY WET OR DRY, ADJUSTMENTS OF A FEW TENTHS MAY BE MADE IN THE REGULATED LEVEL OF THE LAKE

FIGURE 3e. REGULATION SCHEDULE EFFECTIVE IN 1966



RELEASE THROUGH OUTLETS AS INDICATED			
Zone	**Agricultural Canals**	**Caloosahatchee River**	**St. Lucie Canal**
A	PUMPMAXIMUM FOR REGULATION AFTER REMOVAL OF LOCAL RUNOFF	UP TO MAXIMUM DISCHARGE WITHOUT LOCAL FLOODING	UP TO MAXIMUM DISCHARGE
B			UP TO MAXIMUM DISCHARGE WITH AVERAGE VELOCITY LIMITED TO 2.5 FT/SEC
C	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE
	FIRST PRIORITY	**SECOND PRIORITY**	**THIRD PRIORITY**

Notes

1. NO PUMPING FROM LAKE IS REQUIRED WHEN CONSERVATION AREAS 1, 2A AND 3A ARE FULL. RELEASES THROUGH S-12 WILL BE REQUIRED TO MAINTAIN REGULATION OF AREA 3A.
2. WHEN OPERATING NEAR ZONE LIMITS, 30-DAY FORECASTS WILL BE MADE AND RELEASES SCHEDULED TO LOWER OR MAINTAIN THE LAKE AT THE DESIRED LEVEL DURING THE 30-DAY PERIOD.
3. IF TRIBUTARY BASINS ARE UNUSUALLY WET OR DRY, ADJUSTMENTS OF A FEW TENTHS MAY BE MADE IN THE REGULATED LEVEL OF THE LAKE.

Central and Southern Florida
INTERIM REGULATION SCHEDULE--LAKE OKEECHOBEE
Department of the Army, Jacksonville District
Corps of Engineers, Jacksonville, Florida
MAY, 1970. FOR USE IN 1972

FIGURE 3f. REGULATION SCHEDULE EFFECTIVE IN 1972

III. MULTI-OBJECTIVE PURPOSE OF THE REGULATION SCHEDULE

A. Flood Protection

The regions adjacent to the lake have a potential for severe damage and loss of life if the lake's levee system were overtopped by wind driven surges. This situation is very unlikely under the present regulation schedule and it is of utmost importance that any newly proposed schedule maintain the same level of flood protection that exists under the present schedule.

With the St. Lucie Canal and the Caloosahatchee River having such large discharge capacities, water levels would rarely reach 19 feet (msl) under the present operational schedule. The levee system surrounding Lake Okeechobee ranges between 32 to 45 feet (msl); therefore, the likelihood of overtopping the levees from having excess storage is almost nonexistent. However, large surges of water caused by sustained hurricane force winds could overtop the levees under specific conditions. A relationship was derived in *The Rules Curves and Key Operating Criteria Master Regulation Manual* (U.S. Corps of Engineers, November, 22, 1978) for the predicted height of wind surges above the still water surface when given the wind velocity in miles per hour, the length of the wind sweep (fetch), and the depth of the water. This relationship is as follows:

$$h = c * V_a^2 L / d^{\frac{1}{2}}$$

where

- h - is the height of wind surge in feet
- c - is a constant to be determined
- V_a - is the velocity in miles per hour
- L - is the length of the wind fetch in miles, and
- d - is the depth of the water in feet

The results computed with the relationship compared well with the actual wind tides of the 1926 and 1928 hurricanes as documented in the *Rules Curves and Key Operating Regulation Manual.* Table 1 shows the estimated wind tide caused by a 100 mph wind at different stages in Lake Okeechobee.

To maintain the same level of flood protection for the region surrounding Lake Okeechobee, it is important that lake stages during the peak of the hurricane season (August, September, October) not exceed what they would be with the present lake schedule in effect. Hurricanes occur less frequently during the early summer months of June and July and normally do not have the atmospheric conditions to develop into severe hurricanes. Figure 4 illustrates the daily incidence of tropical storms and hurricanes over the North Atlantic for the years 1886 to 1977.

Table 1. Estimated Wind Tide with a 100 miles per HourWind and a Fetch of 35.6 Miles[1]

Lake Stage (Feet)	Depth (Feet)	Wind Tide (Feet)	Lake Stage at Downwind Shore (Feet)
12.0	6.5	14.6	26.6
14.0	8.5	13.7	27.7
16.0	10.5	12.9	28.9
16.8[2]	11.3	12.8	29.6
17.0	11.5	12.7	29.7
18.0	12.5	12.5	30.5
19.0	13.5	12.2	31.2
20.0	14.5	12.0	32.0
25.6	20.1	10.4	36.0

[1](Rules Curves and Key Operating Regulation Manual, November 22, 1987, Appendix D)
[2]1928 Hurricane

During the dry season the only limitation on the lake level related to flood protection is that it should not be allowed to rise so high that it could not be brought down to safe levels by the time the hurricane season occurs. It may, therefore, be possible to delay Zone A discharges in the spring months if it can be shown that water levels would still be able to be brought to safe levels by the beginning of the hurricane season. Preliminary results of this analysis appear in Section V.

B. Water Supply

Generally, the 15.5 - 17.5 ft (msl) schedule allows for an ample supply of water to be stored in Lake Okeechobee during wet periods for use during dry periods. The fact that this schedule was in effect during the 1980-1982 drought helped greatly in avoiding greater drought losses during this period. However, two water supply concerns have been raised related to this schedule. One concern is the minimum level of the regulation on May 31. Perhaps additional water could be saved to further reduce drought losses by raising the May 31 regulation stage. During the 1980-1982 drought, discharges to the ocean had to be made during the spring months prior to the drought in order to bring the lake stage down to 15.5 feet (msl). In addition, model simulations indicate that similar discharges would have been needed in the Spring of 1970 prior to the 1971 drought in order to reach the minimum of the schedule on May 31. Since the period

of late May through early June is not a period in which storm surges are to be expected, possibly more water could be stored in the lake during this period. A second concern pertains to the buildup of water volume in the lake during the fall and early winter months. Earlier discharges during this period may prevent the need for Zone A releases in the spring. It needs to be decided if this water is needed.

Figure 5 shows the change of storage for different periods during the dry season. Figure 6a shows a histogram of the historical dry season change in storage for the period of November 1 through June 1, likewise, Figures 6b and 6c show the same information for the period of December 1 through June 1, and January 1 through June 1 respectively. These changes in storage include the effects of ET, rainfall, inflows from major drainage basins, and water use by regions dependent on the lake for water supply but eliminate the effects of regulatory releases.

Figures 7a and 7b show the maximum and minimum change in storage for different periods during the dry season. Figure 5 shows that the average dry season change in storage (November-May) is -141569 acre feet. However, this change in storage is misleading as the distribution of the events are skewed towards the positive values. More meaninful statistics are presented in Figure 6. These figures indicate that 50% of the time there are losses greater than 500,000 acre feet during the dry season. The maximum loss is 1,631,000 acre feet. In addition to the dry season losses, several times during the study period of 1952-1984, below normal rainfall began the previous wet season and continued through the dry season. This suggests the need for carry-over storage in anticipation of dry conditions during the wet season.

Figure 8a shows the average wet season gains at different periods during the wet season. Likewise Figures 8b and 8c illustrate the maximum and minimum gains for the same periods during the wet season. Figures 9a and 9b show the histogram of the historical wet season gains for the periods of June 1 through November 1, and June 1 through October 1 respectively. These figures indicate that the average expected wet season gains from June 1 to October 31 are 1,336,561 acre feet, while the historical maximum and minimum gains for the same period were 4,166,103 and -470,720 acre feet respectively. These numbers help to quantify the amount of water needed in storage in the lake in order to meet possible losses at different times during the year.

C. St. Lucie and Caloosahatchee Estuaries

Prior to regulating water levels in Lake Okeechobee, very little water flowed from Lake Okeechobee directly to the St. Lucie Estuary, and flows to the Caloosahatchee Estuary were substantially less than those presently released from the lake. The ideal schedule for the estuaries would be one which minimizes Zone A discharges to the estuaries from the lake and also reduces the harmful extended periods of Zone B discharges to the lake as defined by the present regulation schedule. Another feature that would be desirable for the estuaries would be low flow discharges from the lake to maintain desired salinity levels in the estuaries during dry periods. Emphasis in selecting alternative schedules has been placed on incorporating features that will reduce the incidence of Zone A discharges to the estuaries.

The Martin Conservation Alliance provided valuable suggestions with the objective of protecting the St. Lucie Estuary. Their suggestions were incorporated, evaluated, and refined, and gave impetus to a major effort that culminated with the production of this report.

D. Lake Littoral Zone Habitat

Prior to Lake Okeechobee being enclosed by a levee system, the water spread horizontally across higher grounds as lake water levels rose. This situation always kept a region at the outer edge of the lake for the existence of a healthy littoral zone habitat. However, with the levee system in place, the water within the boundaries of the lake simply gets deeper, as water levels rise. The levee system prevents the water from spreading over the lands that surround the lake. This makes it difficult for the plants and animals of the littoral zone habitat to survive when water levels remain high for extended periods. Water levels need to be periodically lowered by lack of rainfall or by making discharges from the lake to protect this habitat. Specific criteria need to be developed for the water levels desired to ensure the protection of the littoral zone habitat. Table 2 shows the historical stage frequency data for the period of 1952 to 1977 when the present regulation schedule was implemented.

Table 2. StageFrequency Data for Lake Okeechobee for the period from 1952 to 1977

Stage	10	11	12	13	14	15	16	17	18
% Time equalled or exceeded	100	97	92	75	43	16	3	1	0

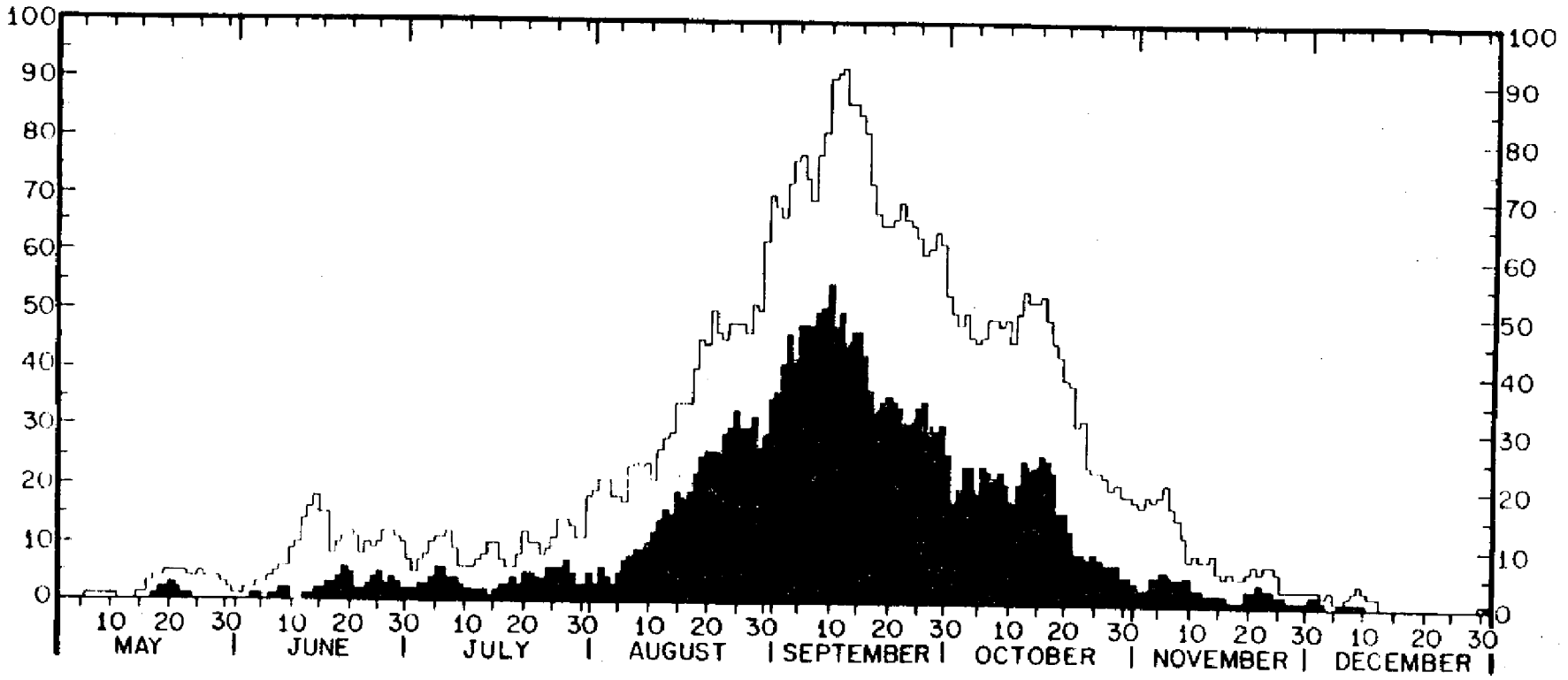


FIGURE 4. NUMBER OF TROPICAL STORMS AND HURRICANES (OPEN BAR) AND HURRICANES (SOLID BAR) OBSERVED ON EACH DAY, MAY 1 - DECEMBER 30, 1886 THROUGH 1977. (NATIONAL CLIMATE CENTER, 1978)

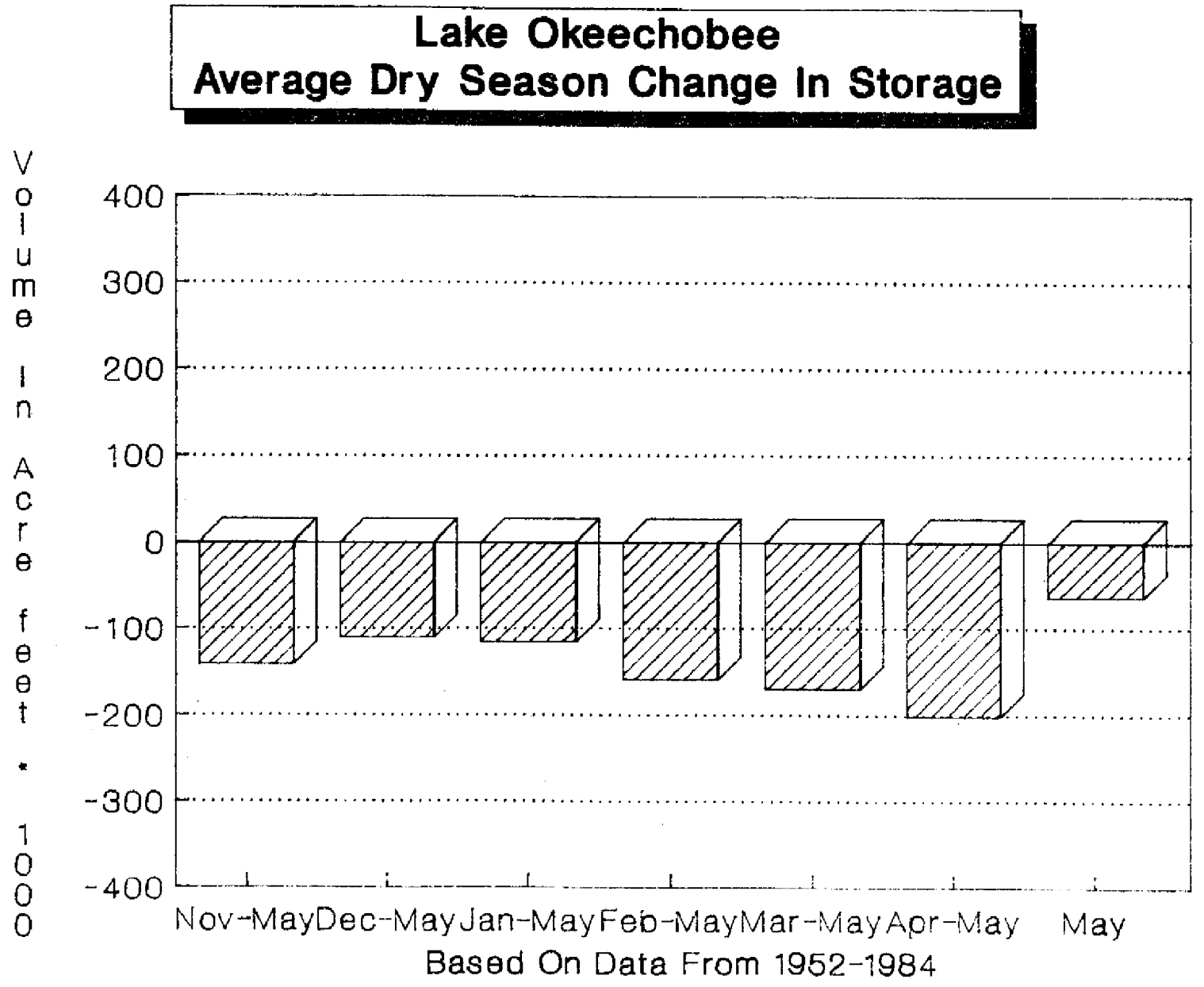


FIGURE 5. AVERAGE DRY SEASON CHANGE IN STORAGE

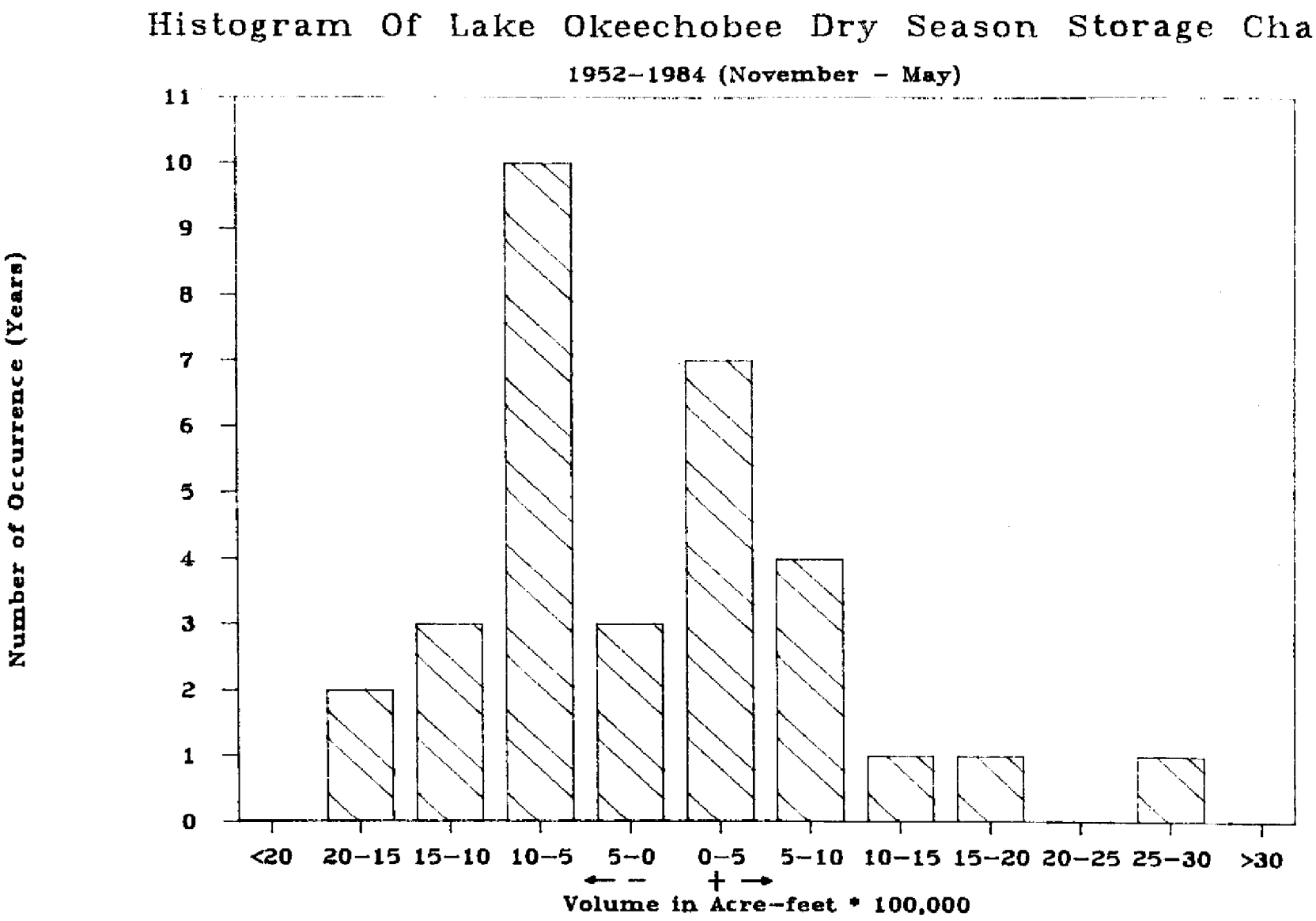


FIGURE 6a, HISTOGRAM OF DRY SEASON CHANGE IN STORAGE (NOVEMBER - MAY)

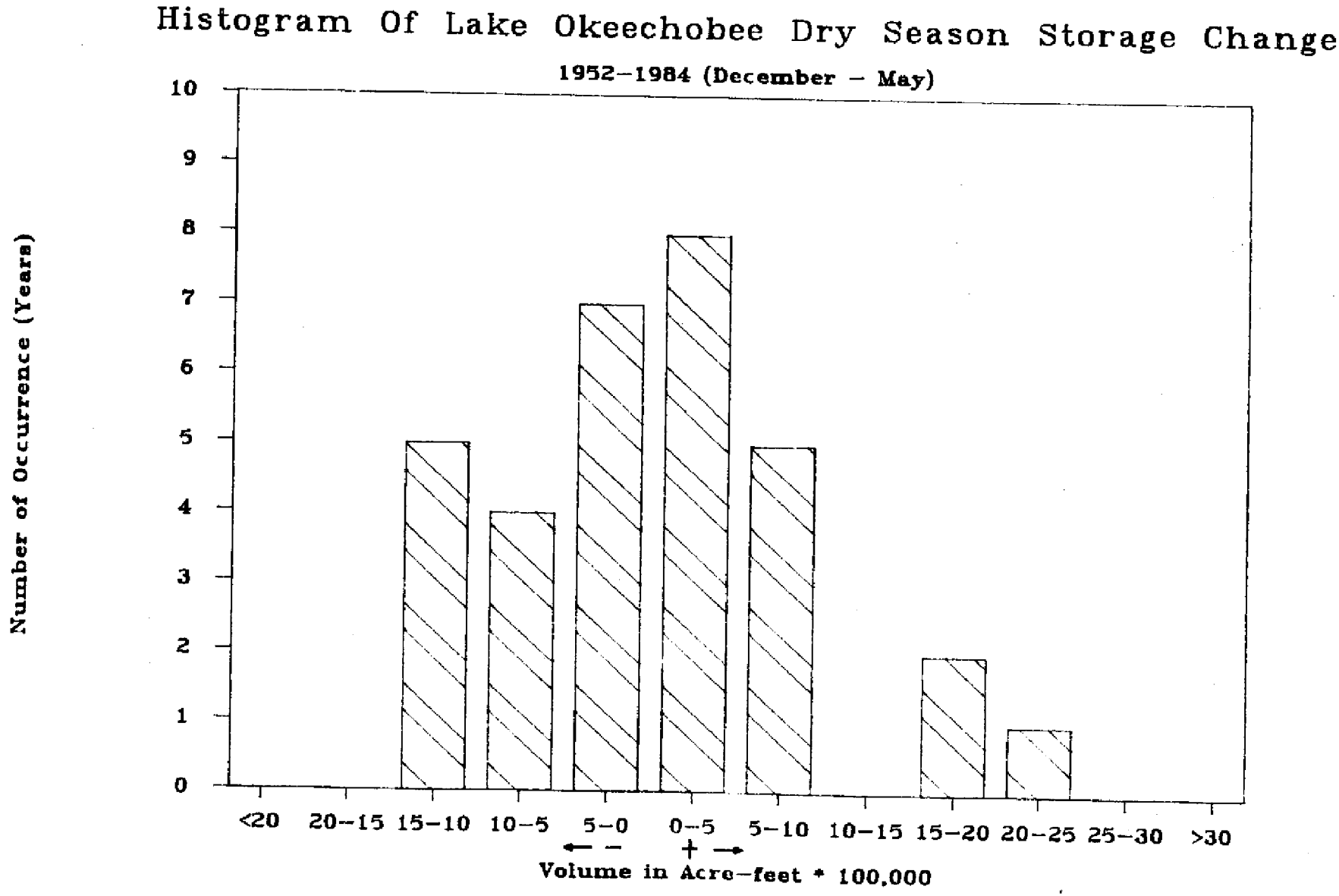


FIGURE 6b. HISTOGRAM OF DRY SEASON CHANGE IN STORAGE (DECEMBER - MAY)

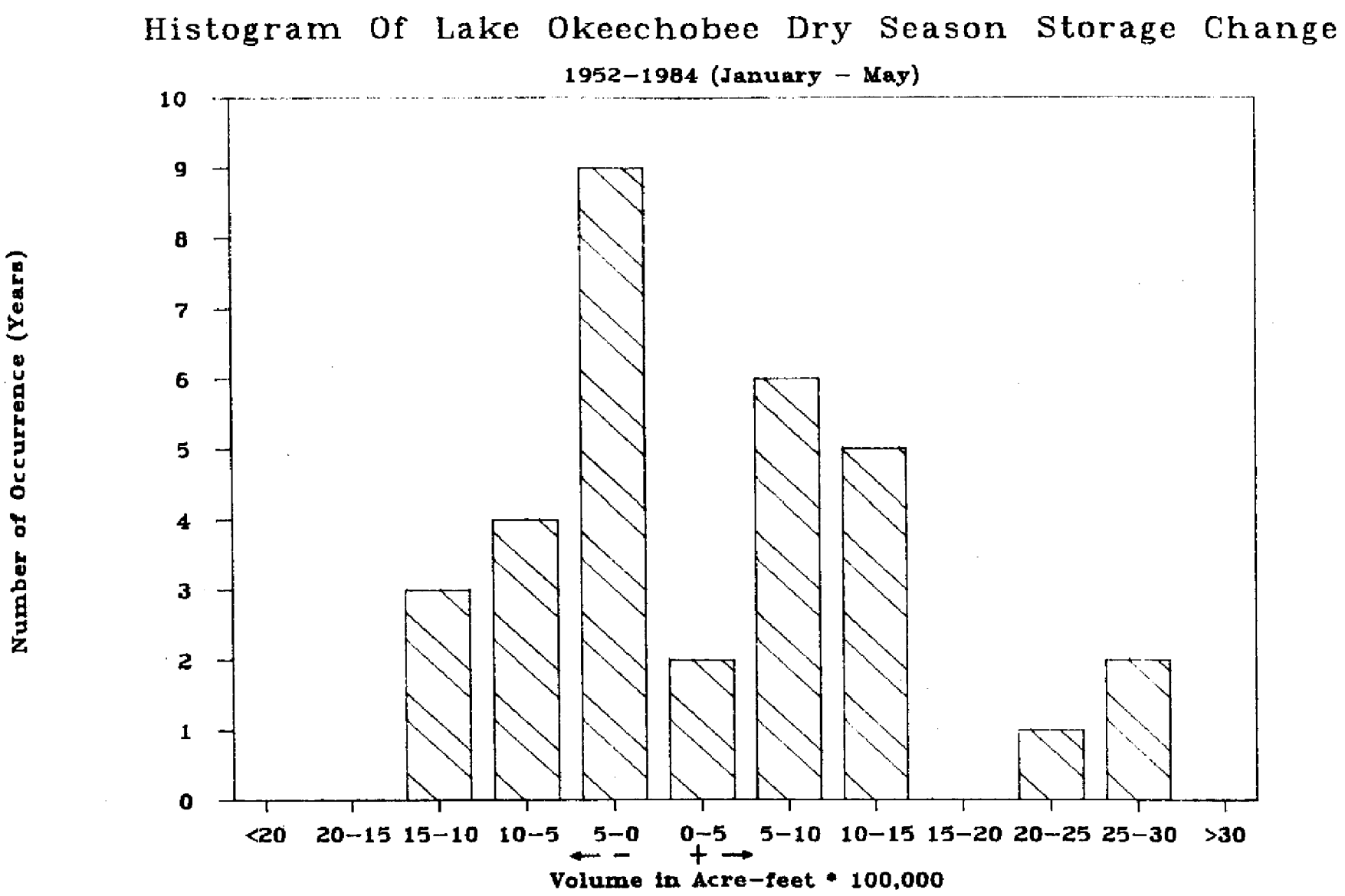


FIGURE 6c. HISTOGRAM OF DRY SEASON CHANGE IN STORAGE (JANUARY - MAY)

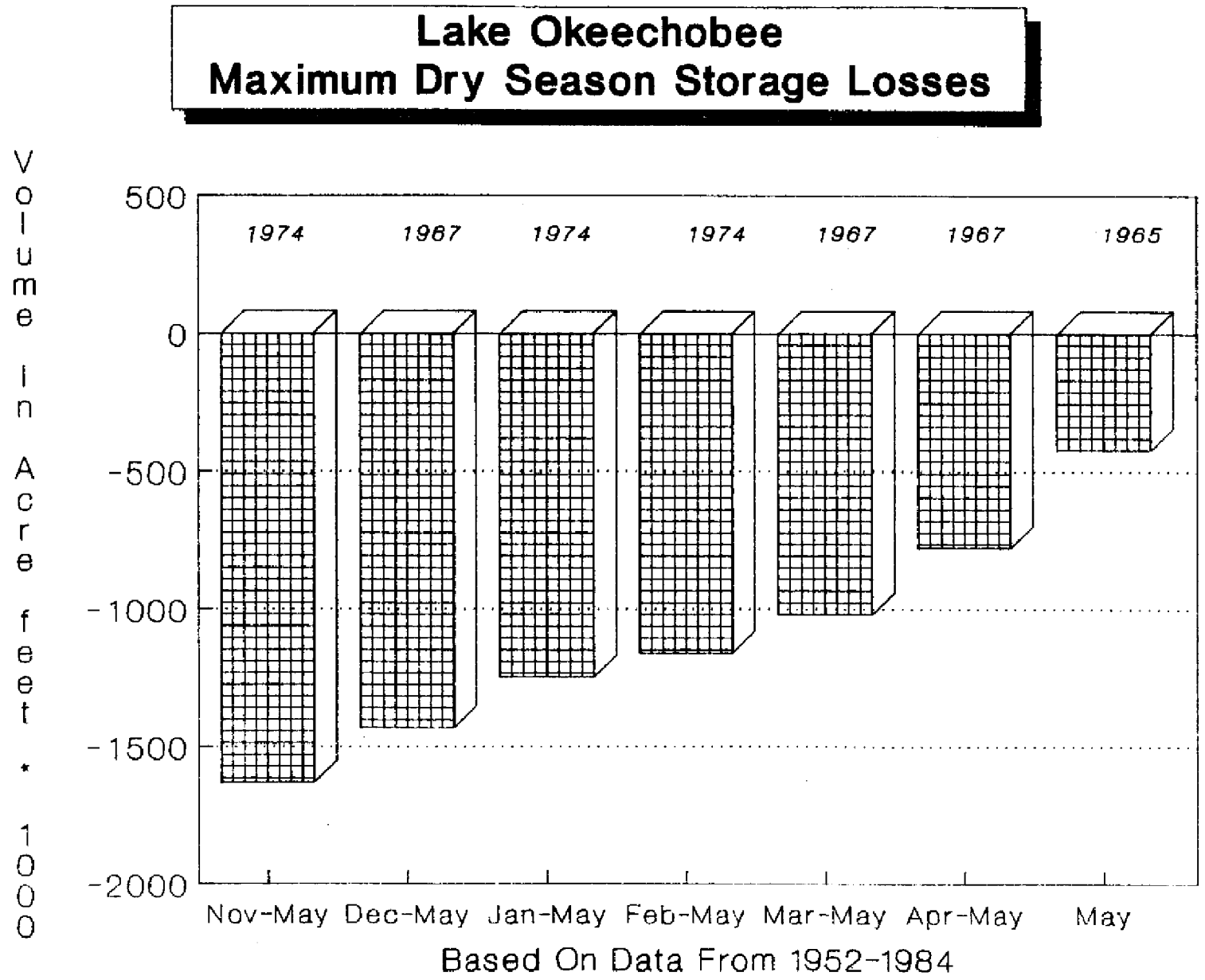


FIGURE 7a. MAXIMUM DRY SEASON STORAGE LOSSES

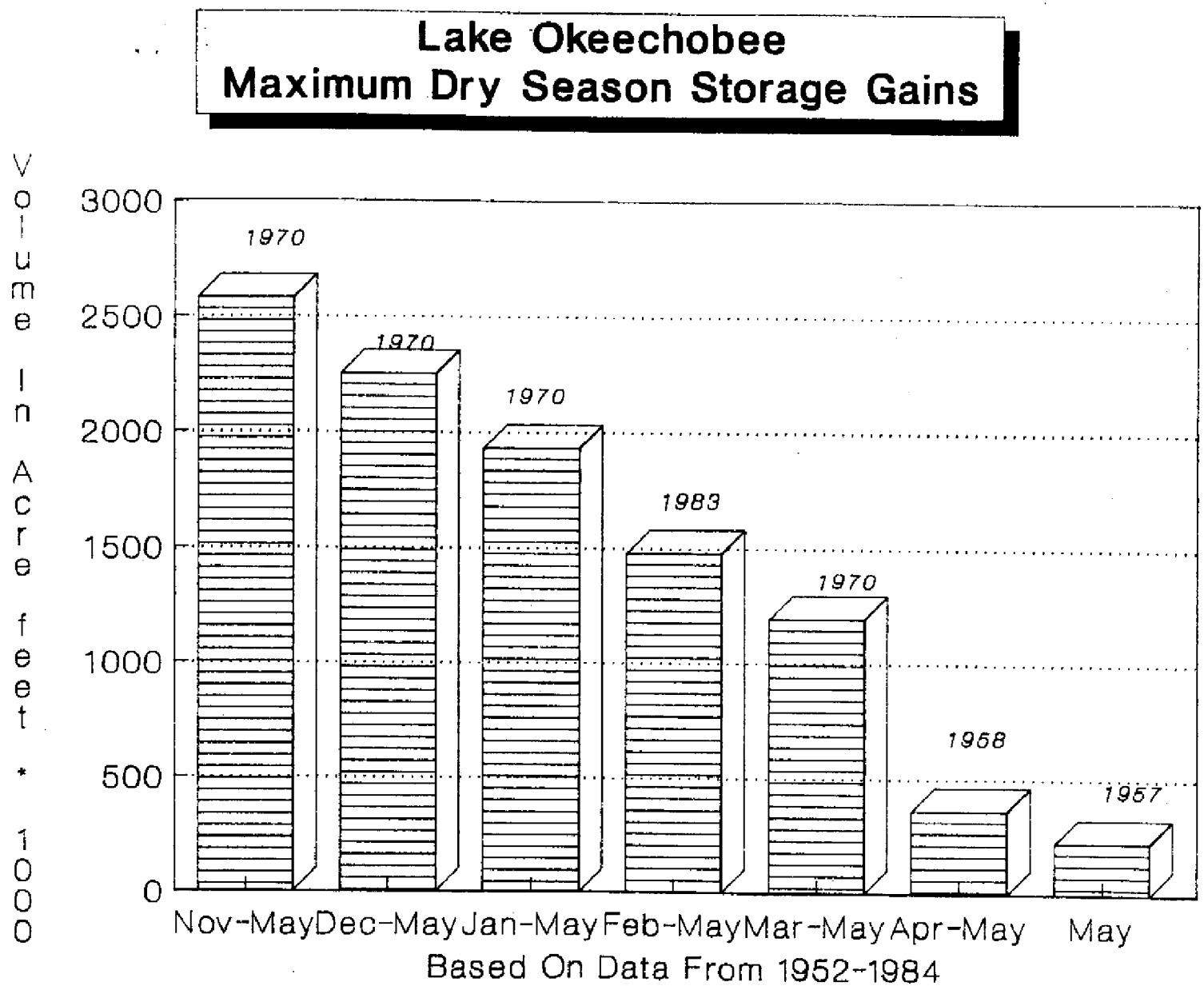


FIGURE 7b. MAXIMUM DRY SEASON STORAGE GAINS

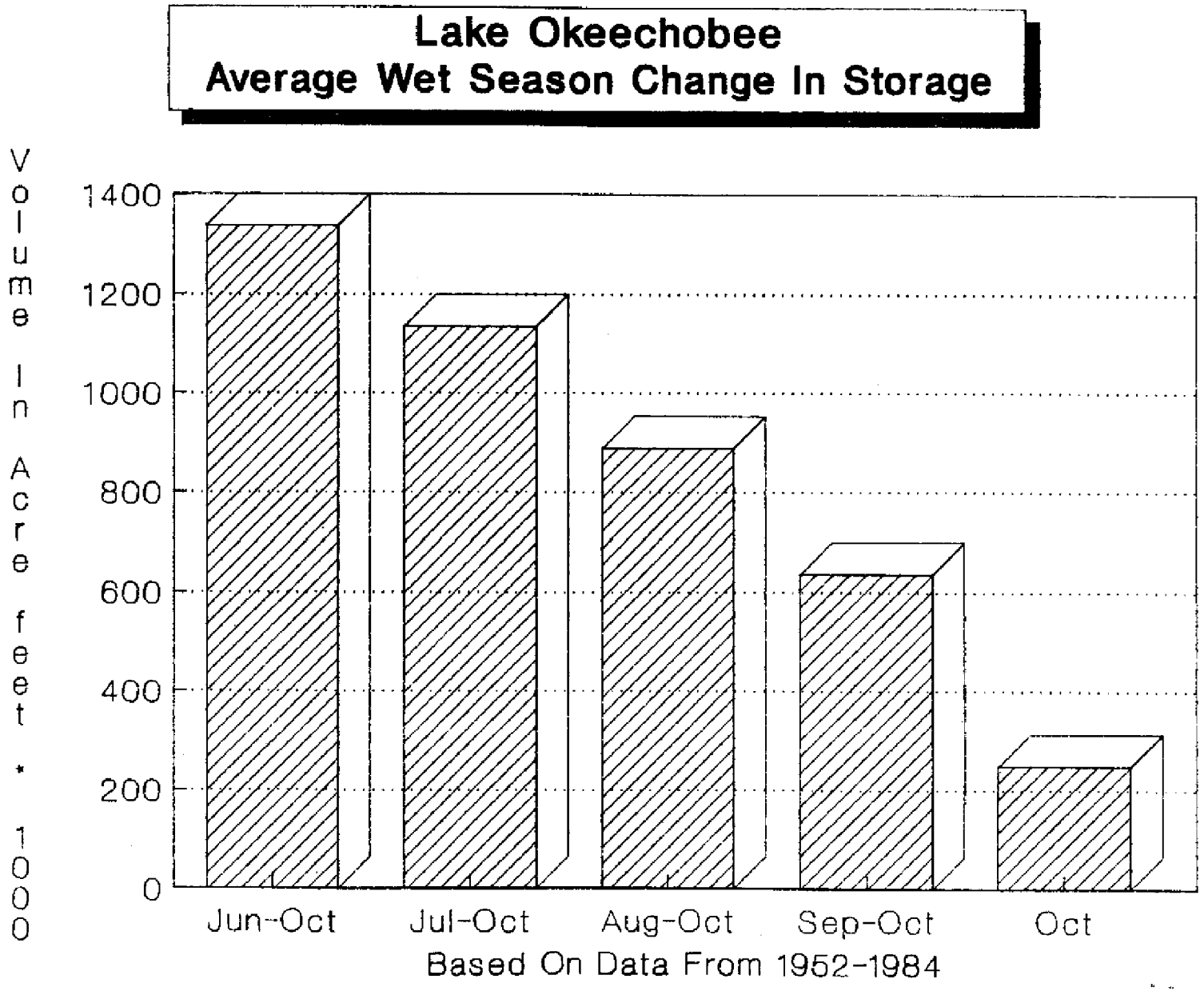


FIGURE 8a. AVERAGE WET SEASON CHANGE IN STORAGE

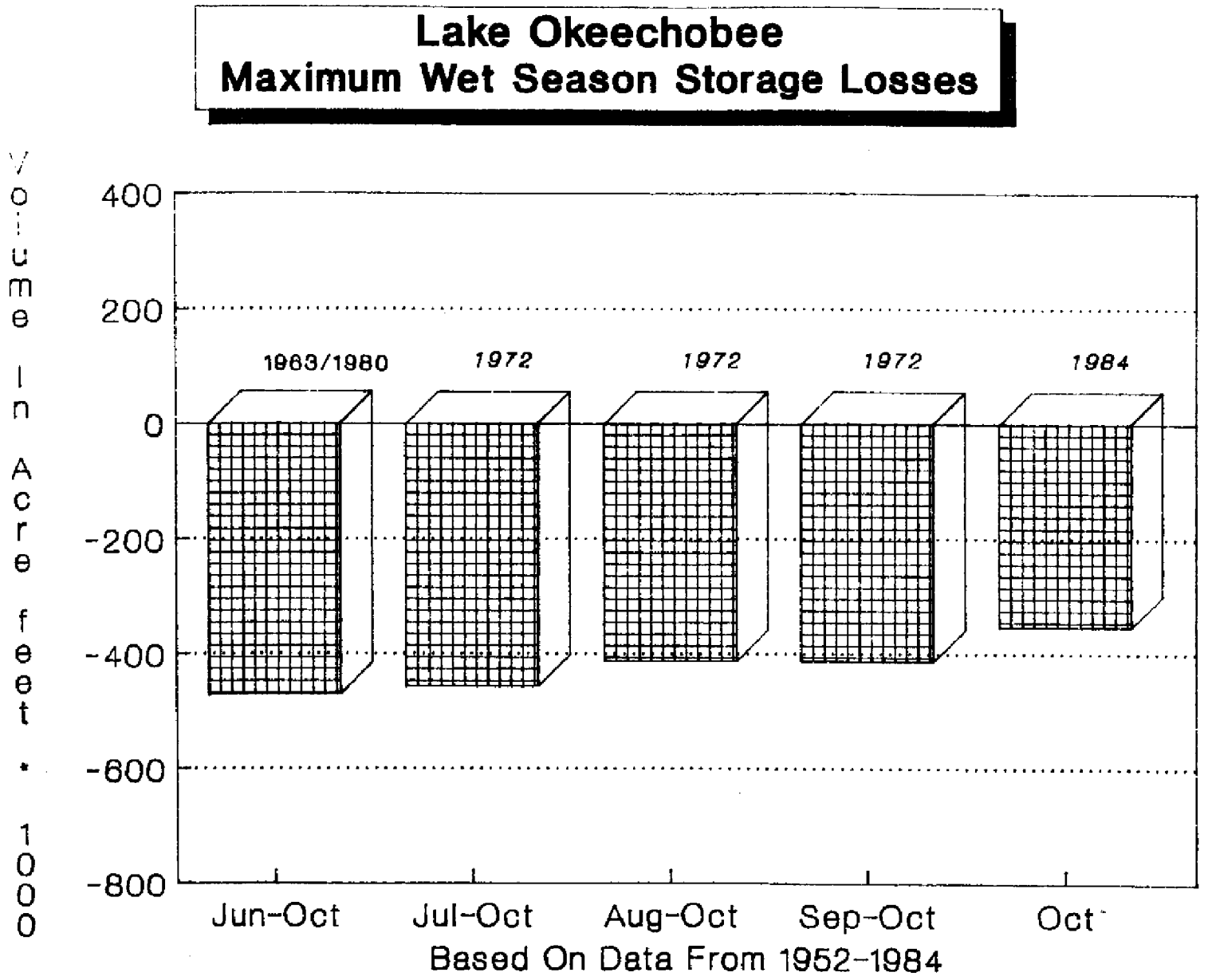


FIGURE 8b. MAXIMUM WET SEASON STORAGE LOSSES

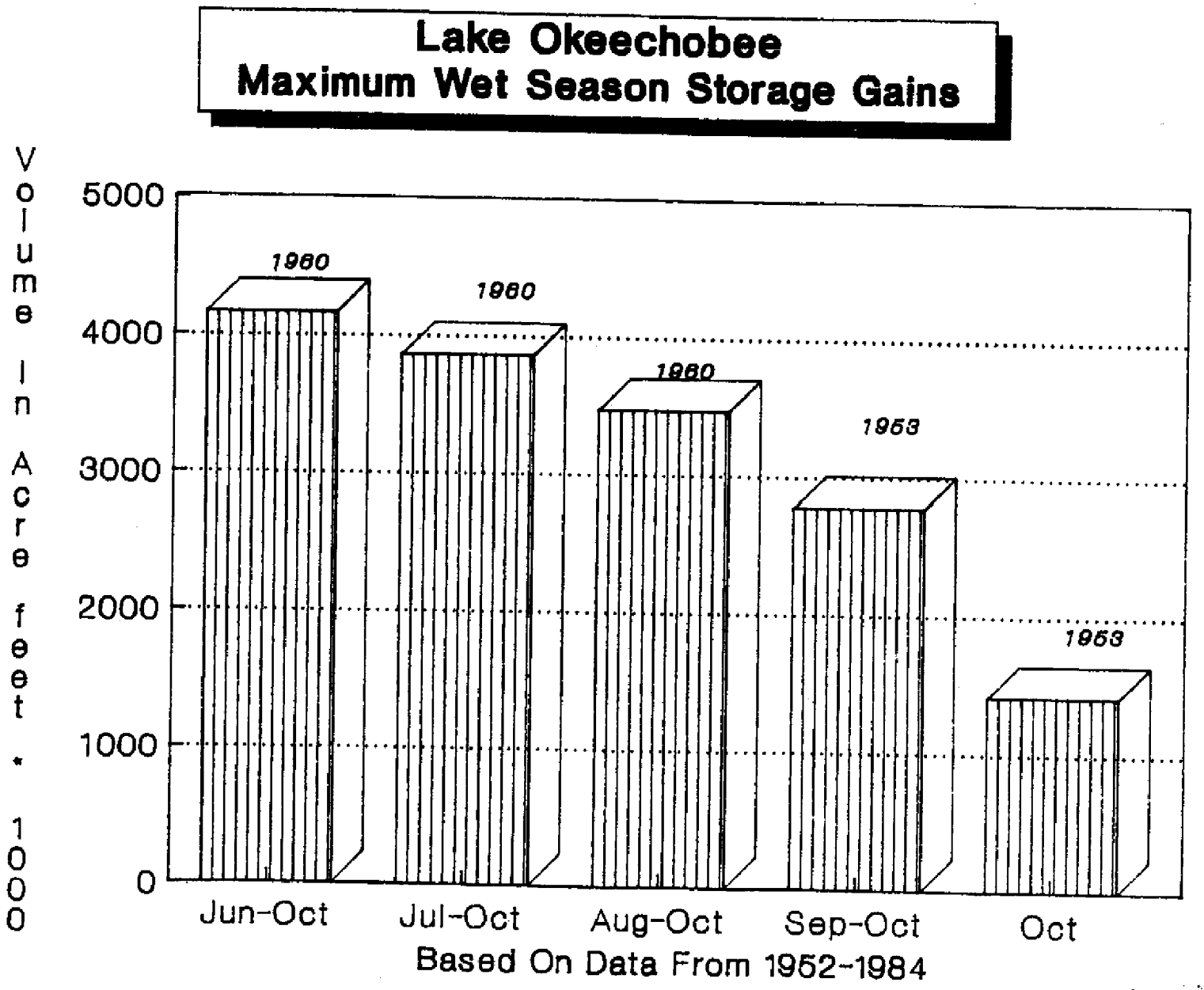


FIGURE 8c. MAXIMUM WET SEASON STORAGE GAINS

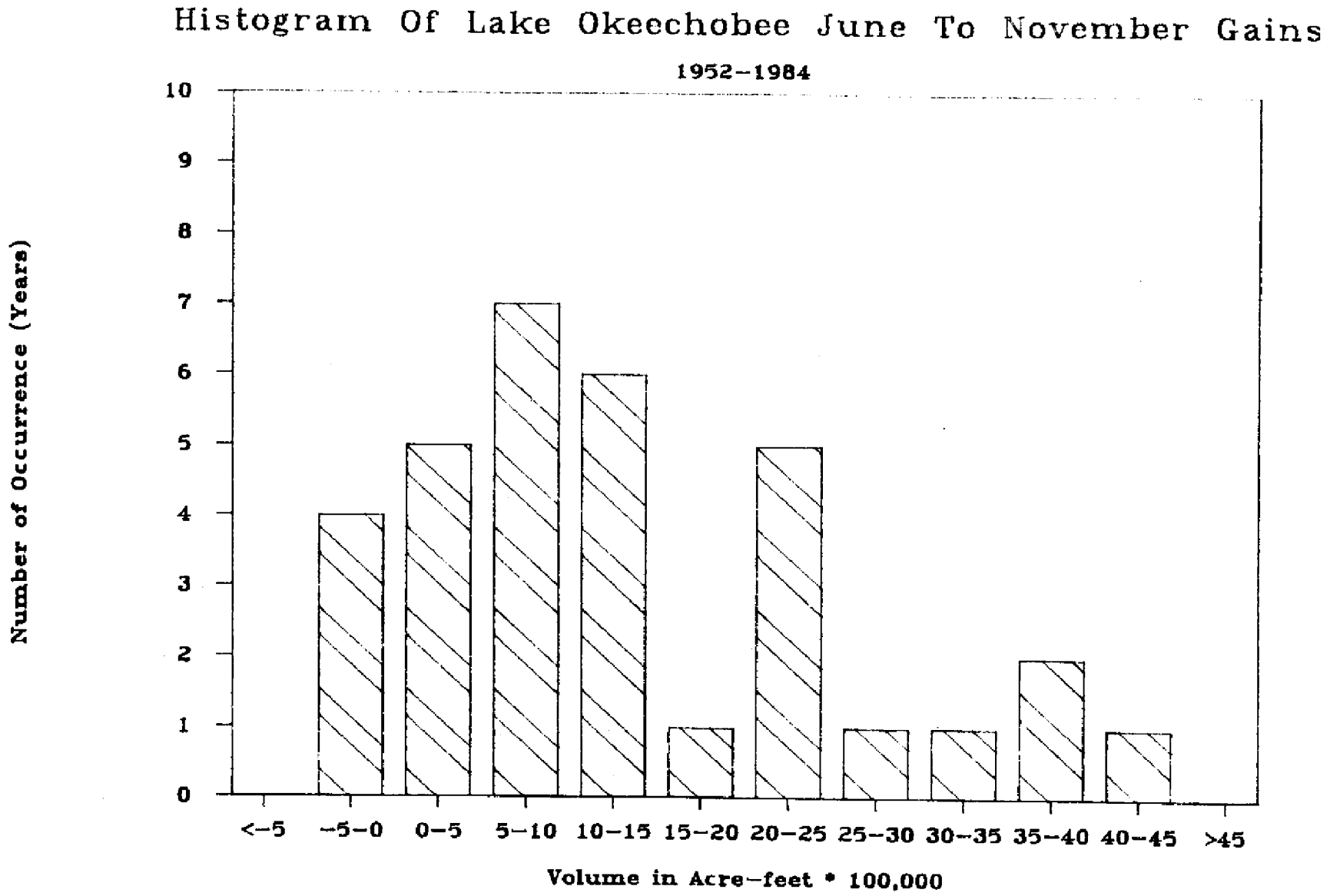


FIGURE 9a. HISTOGRAM OF JUNE TO NOVEMBER STORAGE GAINS

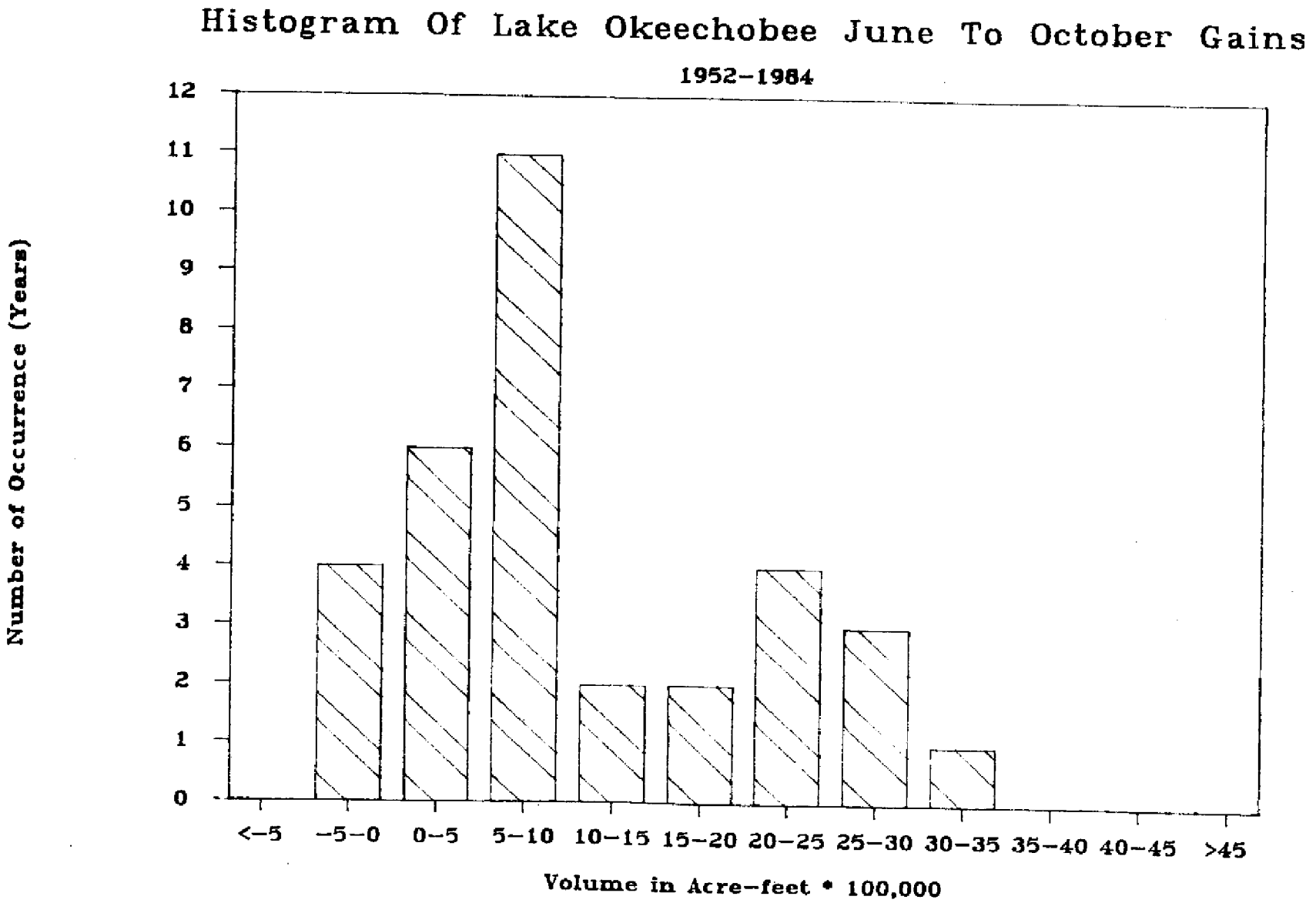


FIGURE 9b. HISTOGRAM OF JUNE TO OCTOBER STORAGE GAINS

IV. METHODOLOGY AND ASSUMPTIONS

The South Florida Regional Routing Model (Trimble, 1986) was used to test a variety of alternative schedules for Lake Okeechobee. These schedules were analyzed in an effort to find one that may better suit the multi-objective needs of water management of the lake. This model was able to simulate historical stages very well. Figure 10 illustrates the simulated stages compared to historical stages for the lake for the period 1981 through June 1983. The simulated minimum stage of the severe drought of 1981 and the number of days of Zone A discharges in 1983 very closely match those that actually occurred.

Summary sheets for each of the schedules tested are included in Appendix A. On the first page of the summary sheet is a schematic diagram and a description of the schedule with general comments regarding its advantages and disadvantages. The second page includes a summary of the simulated stage and discharge data for Lake Okeechobee that would occur if this schedule was in operation during the historical rainfall conditions. The information on the second page gives a measure of how well the proposed schedule meets each one of the objectives of water management. These values include a summary of the number of days that different levels of regulatory releases were made, the minimum and maximum lake stages estimated for each year modeled, the water level at the end of each dry season, the amount of water use requirements not satisfied (demand not met) during critical dry years and for the entire study period, the mean and maximum stage calculated just prior to peak hurricane season (September 1), and the overall stage-frequency curve for the lake. The results of each of these schedules may be compared to those obtained from a simulation with the current 15.5-17.5 regulation schedule in effect for the same historical rainfall conditions. This simulation includes present water use requirements and conveyance limitation for the entire hydrologic period modeled and was used as a base line to measure the advantages and disadvantages of the alternative schedules.

The following assumptions were included in all the model simulations:

- Runoff from the Everglades Agricultural Area is routed southward away from Lake Okeechobee when possible without increasing the potential for flooding in the Everglades Agricultural Area.
- The Water Conservation Area 2A present drawdown schedule is in effect.
- The rainfall-driven discharge formula is in effect for Water Conservation Area 3A.
- Present day water use requirements for Lake Okeechobee and the lower east coast service areas are in existence for the entire hydrologic period modeled. (See Appendix B for the assumption used in estimating these water use requirements.)
- Present day conveyance capabilities are available for making discharges between regions. These conveyance capacities along with other assumptions in the model are documented in Technical Publication 86-3 (Trimble).
- The South Dade Conveyance System is in operation.
- Historical rainfall conditions that occurred between 1952 and 1984 would occur with the proposed schedule in operation.

The historical rainfall conditions that occurred between 1952 and 1984 contain many periods of extreme rainfall. Key dry years during this study period included 1956, 1961-1964, 1967, 1971-1977, and 1980-1982. During 1956, 1962, 1971, 1974, and 1981 the lake stage fell below 11 ft (msl). Interestingly, in 4 out of these 5 years the lake stage was at regulation schedule the previous year.

Critical wet periods in which it would be required to make regulatory releases include 1952-1955, 1957-1960, 1966, 1968-1970, 1974, 1978-1980 and 1982-1984. Zone A releases would be required the years of 1953, 1958, 1959, 1969-1970, and 1983. Annual departures from normal rainfall for each year are illustrated in Figures 11a, 11b, and 11c for Lake Okeechobee, the Kissimmee River basin, and the Everglades Agricultural Area.

Figures 12a, 12b, and 12c show the departures for the wet seasons (June-October), while Figures 13a, 13b, and 13c indicate the departures for the dry seasons for the same basins respectively. Also included on Figures 11-13 are the 5-, 10-, 20-, 50-and 100- year return periods for above and below normal rainfall. Departures from normal rainfall for other

basins within the District during this study period may be obtained from South Florida Water Management District Technical Publication 86-6 (Shawn P. Sculley).

In Section VI, four evaluation criteria or objective functions are chosen in order to summarize the multi-objective performance of each regulation schedule. These criteria are defined as follows:

1. The mean and maximum September 1 lake levels reached during the study period. These quantities represents a measure of flood protection during hurricane season. It is desirable that these levels not exceed the levels reached with the present schedule in operation during this period when the potential for heavy rains and large storm surges exist.

2. The demands not met during the study period. Performance during individual drought periods were also considered and evaluated in this study. The most severe drought of this period was the 1980-1982 drought. Lake Okeechobee stage fell to a record low level of 9.75 feet (msl) during this period. Other critical periods include the 1956, 1962, 1971, and 1974 low water level periods within the lake.

3. The number of days of Zone A discharges for the study period. This quantity represents a level of estuary protection. Zone A discharges are very harmful to the estuary's habitat and it is desirable to minimize this number.

4. The percentage of days the simulated lake levels exceed 15 feet (msl) during the study period. This quantity is a measure of the protection of the lake's littoral zone. Extended periods of high water levels are undesirable for the littoral zone. It is, therefore, important to minimize the frequency of high stages.

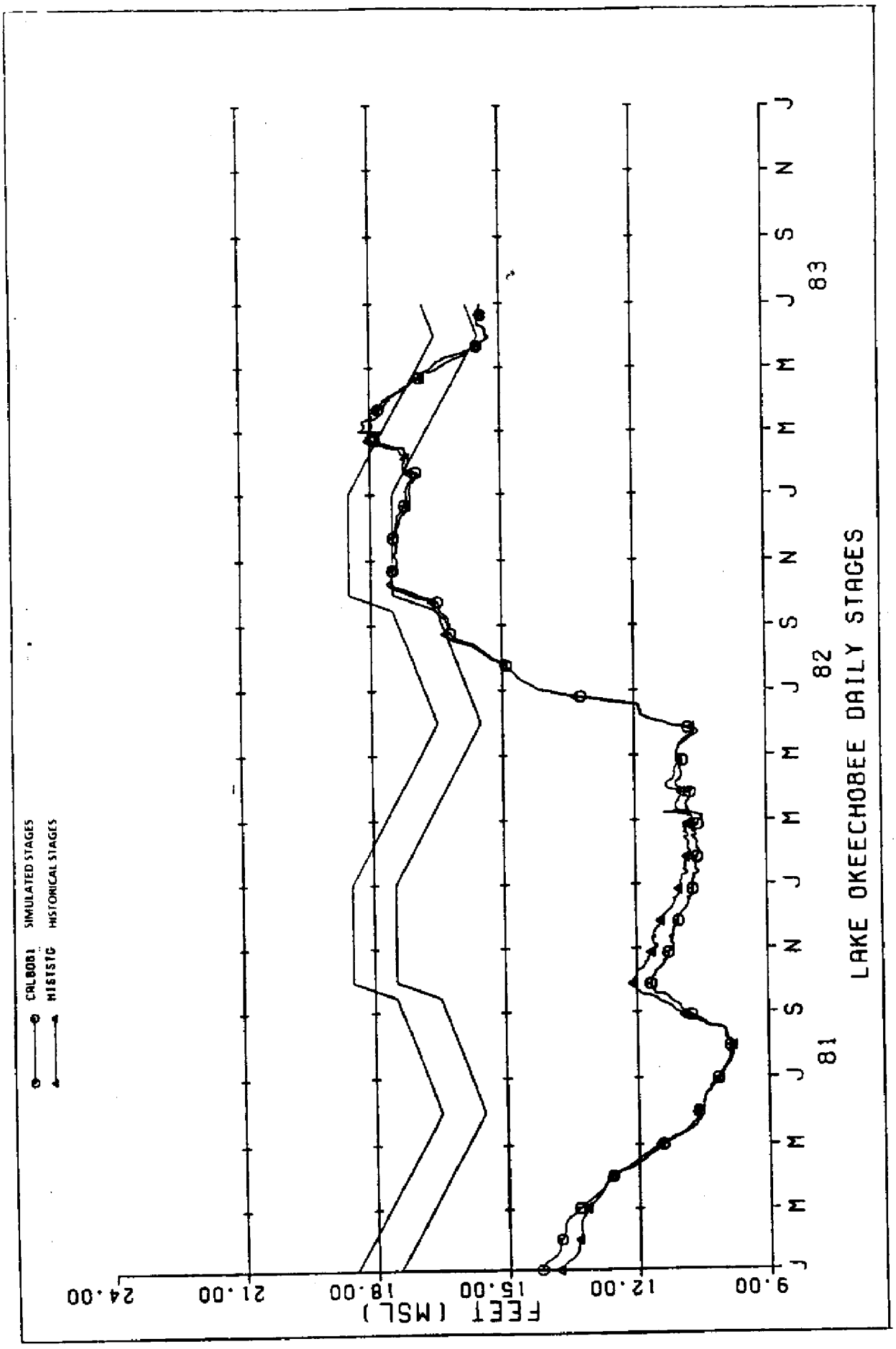


FIGURE 10 SIMULATED VERSUS HISTORICAL STAGE

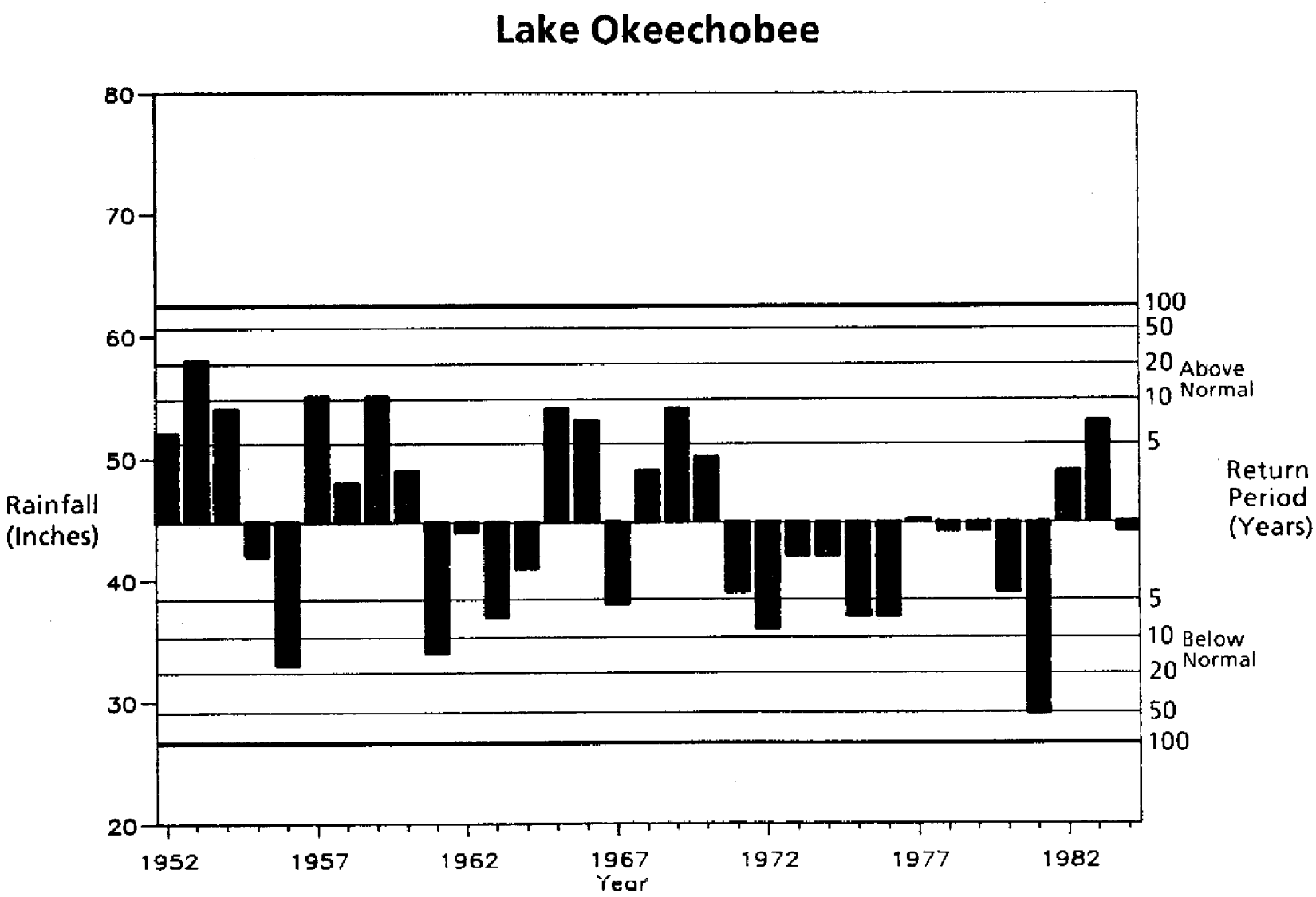


FIGURE 11a. DEPARTURE FROM MEAN ANNUAL RAINFALL

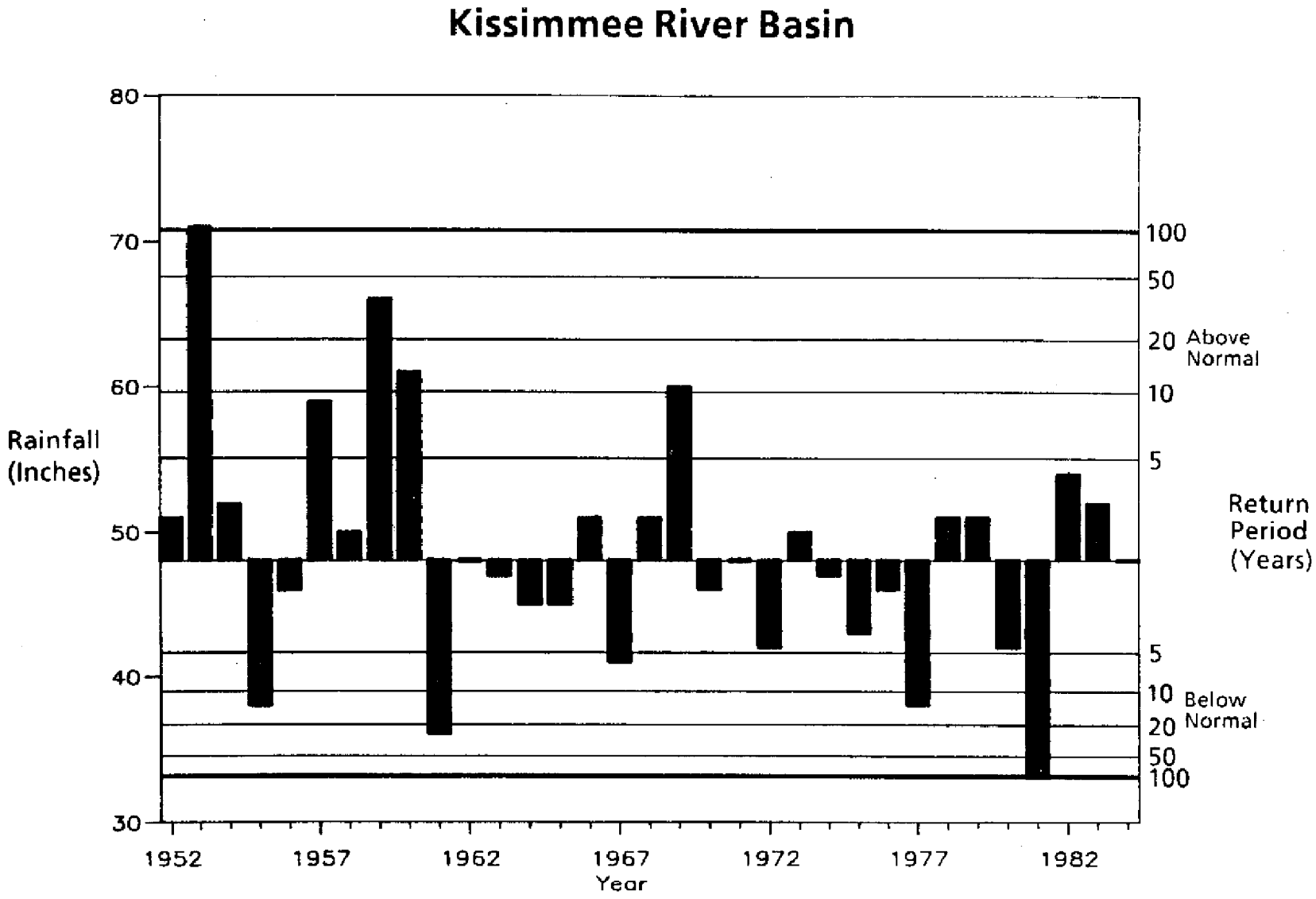


FIGURE 11b. DEPARTURE FROM MEAN ANNUAL RAINFALL

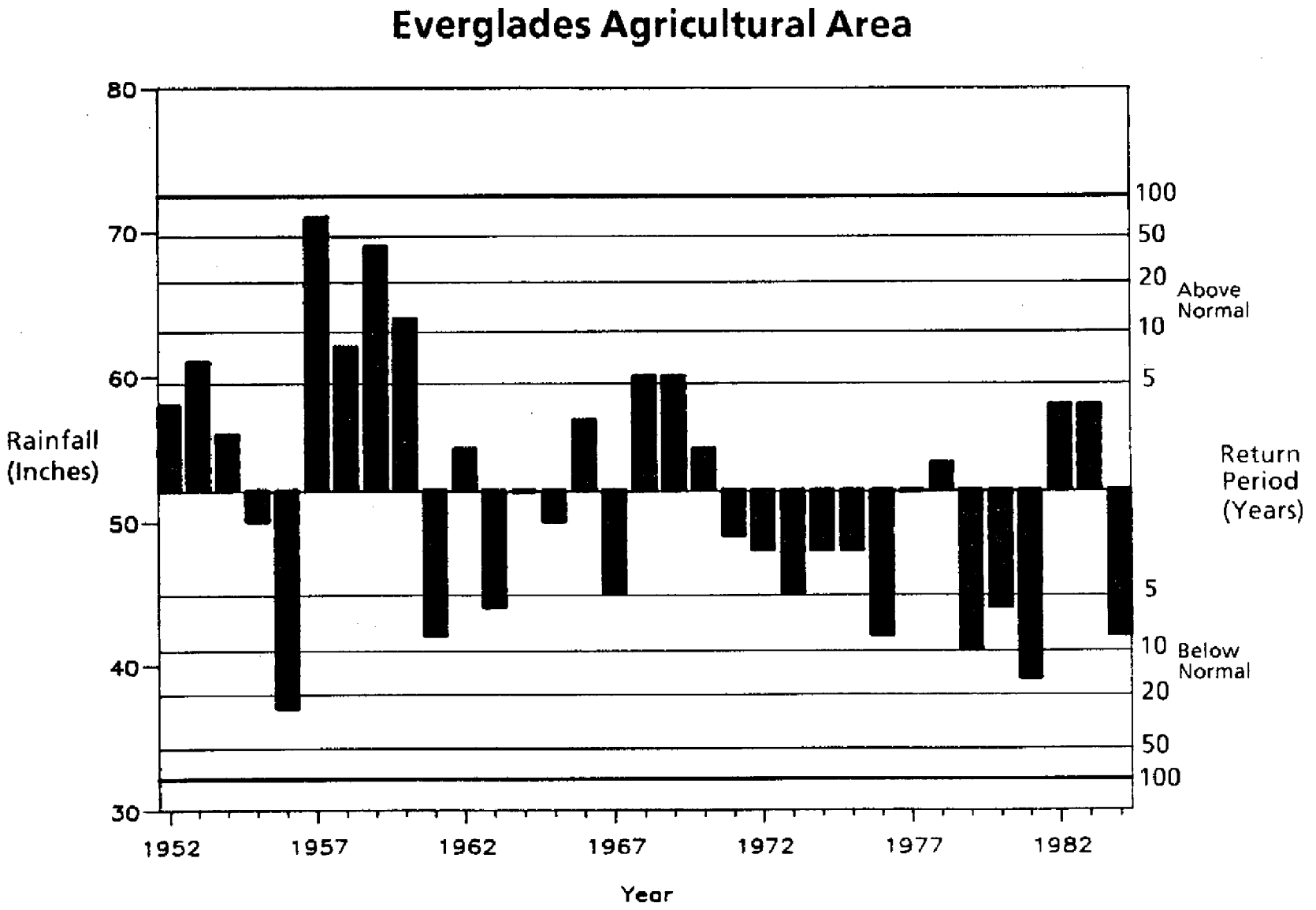


FIGURE 11c. DEPARTURE FROM MEAN ANNUAL RAINFALL

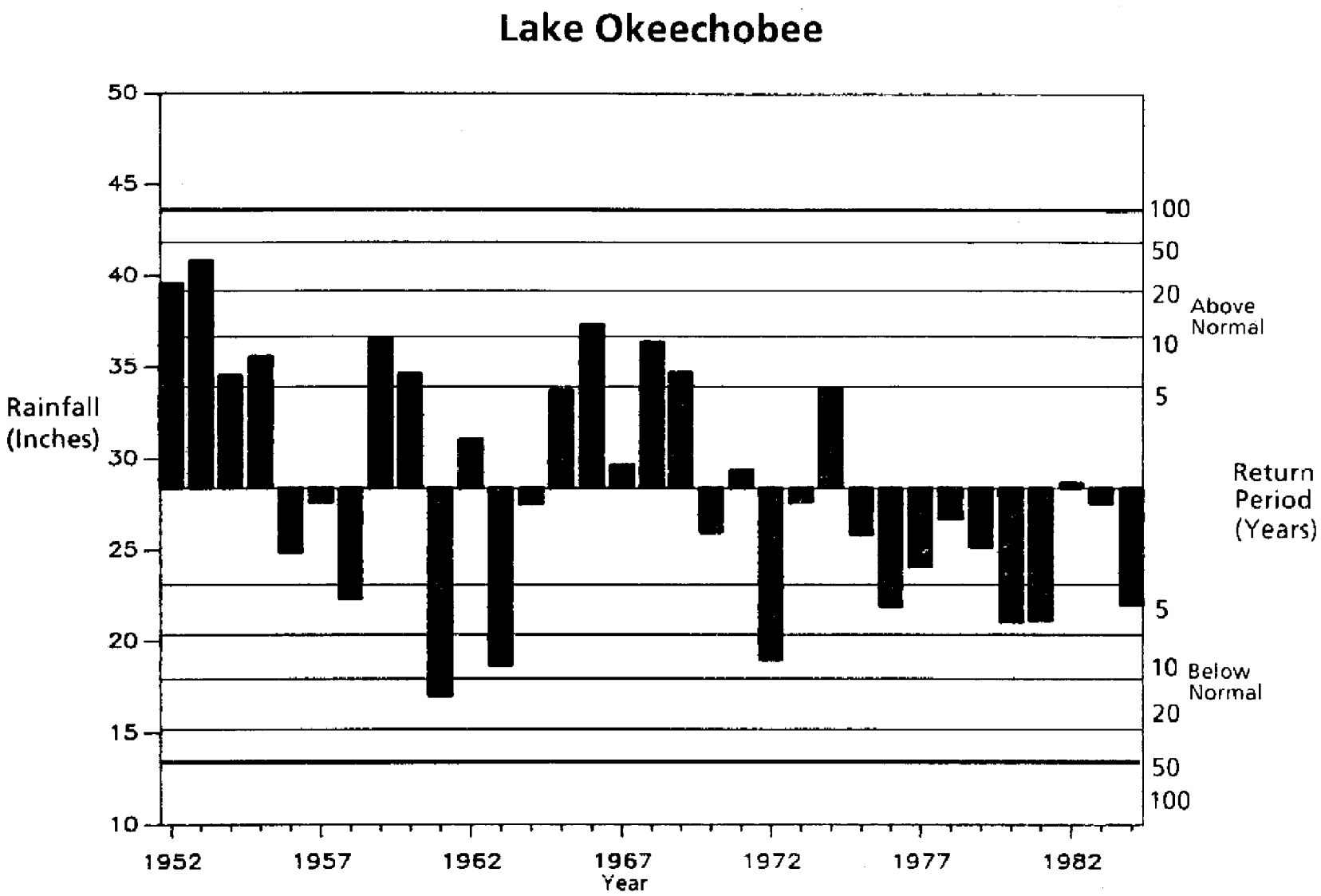


FIGURE 12a. DEPARTURE FROM MEAN WET SEASON RAINFALL

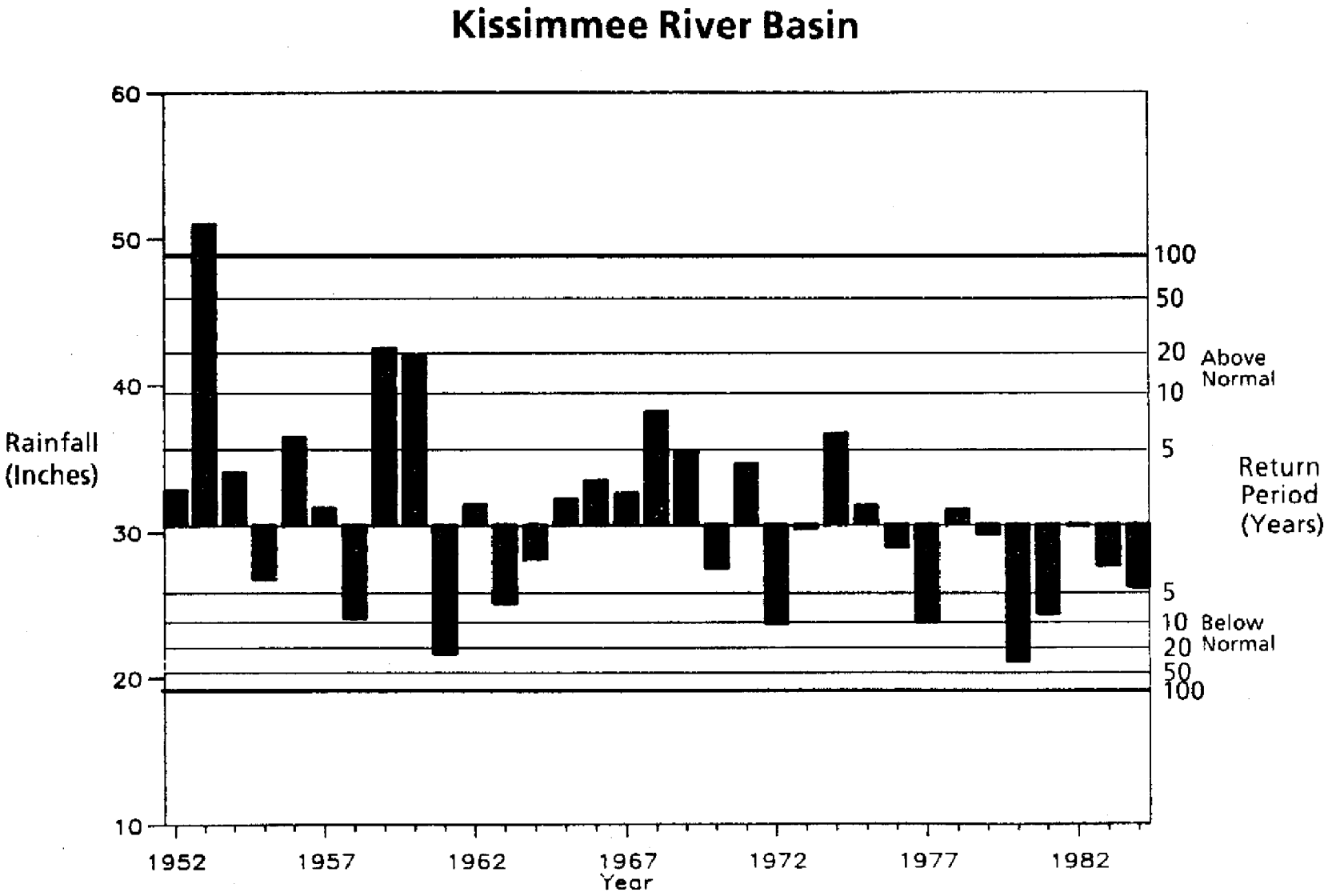


FIGURE 12b. DEPARTURE FROM MEAN WET SEASON RAINFALL

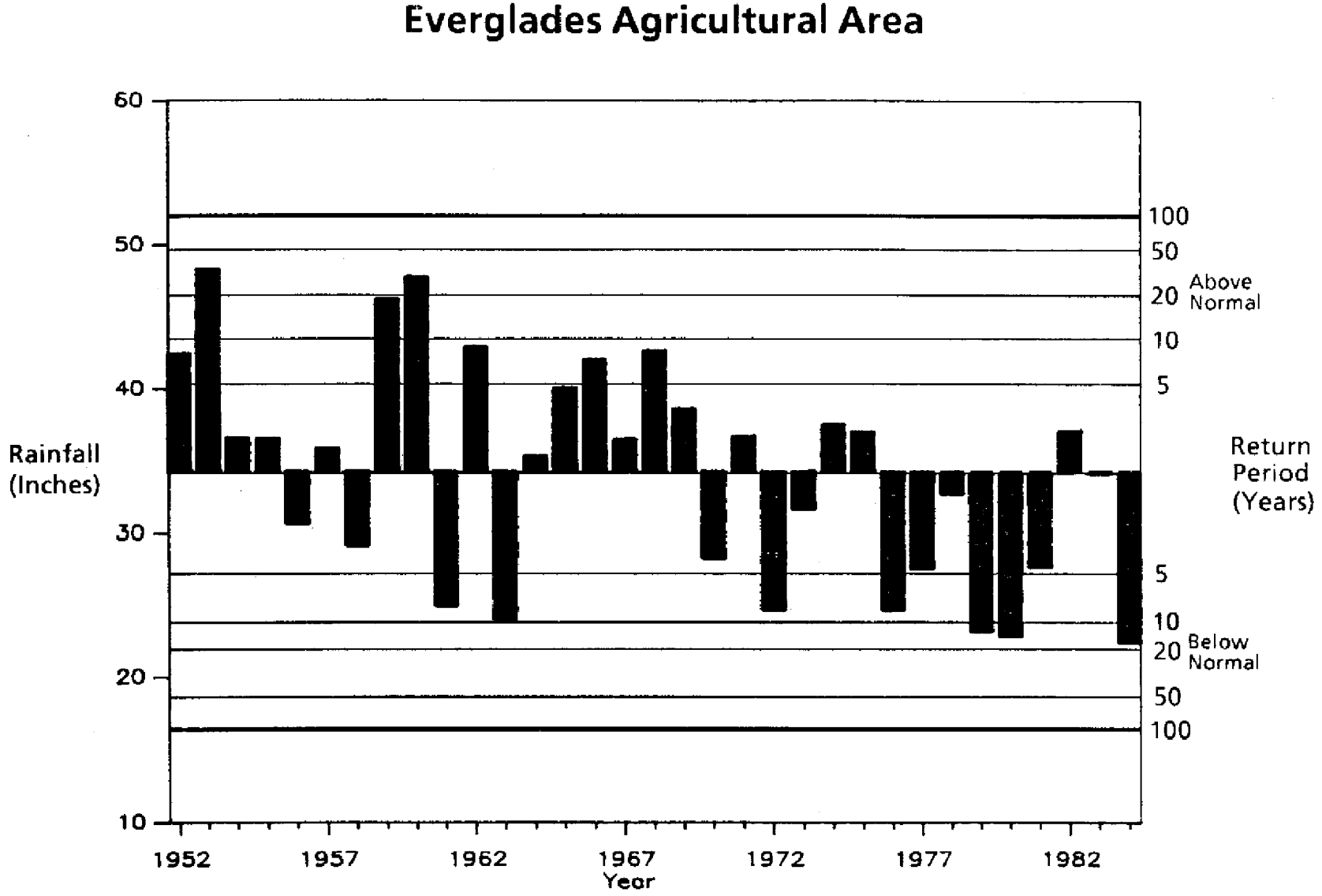


FIGURE 12c. DEPARTURE FROM MEAN WET SEASON RAINFALL

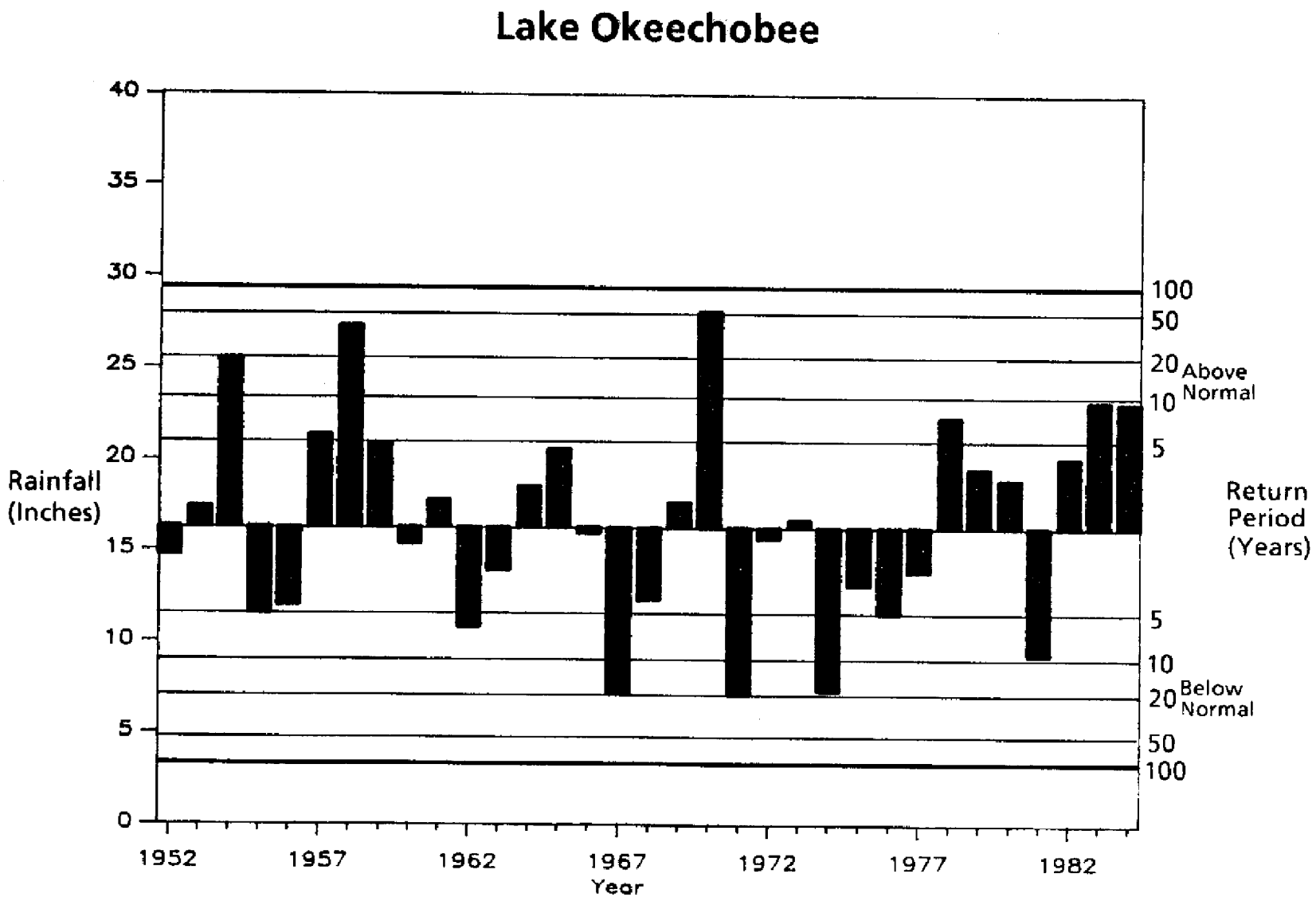


FIGURE 13a. DEPARTURE FROM MEAN DRY SEASON RAINFALL

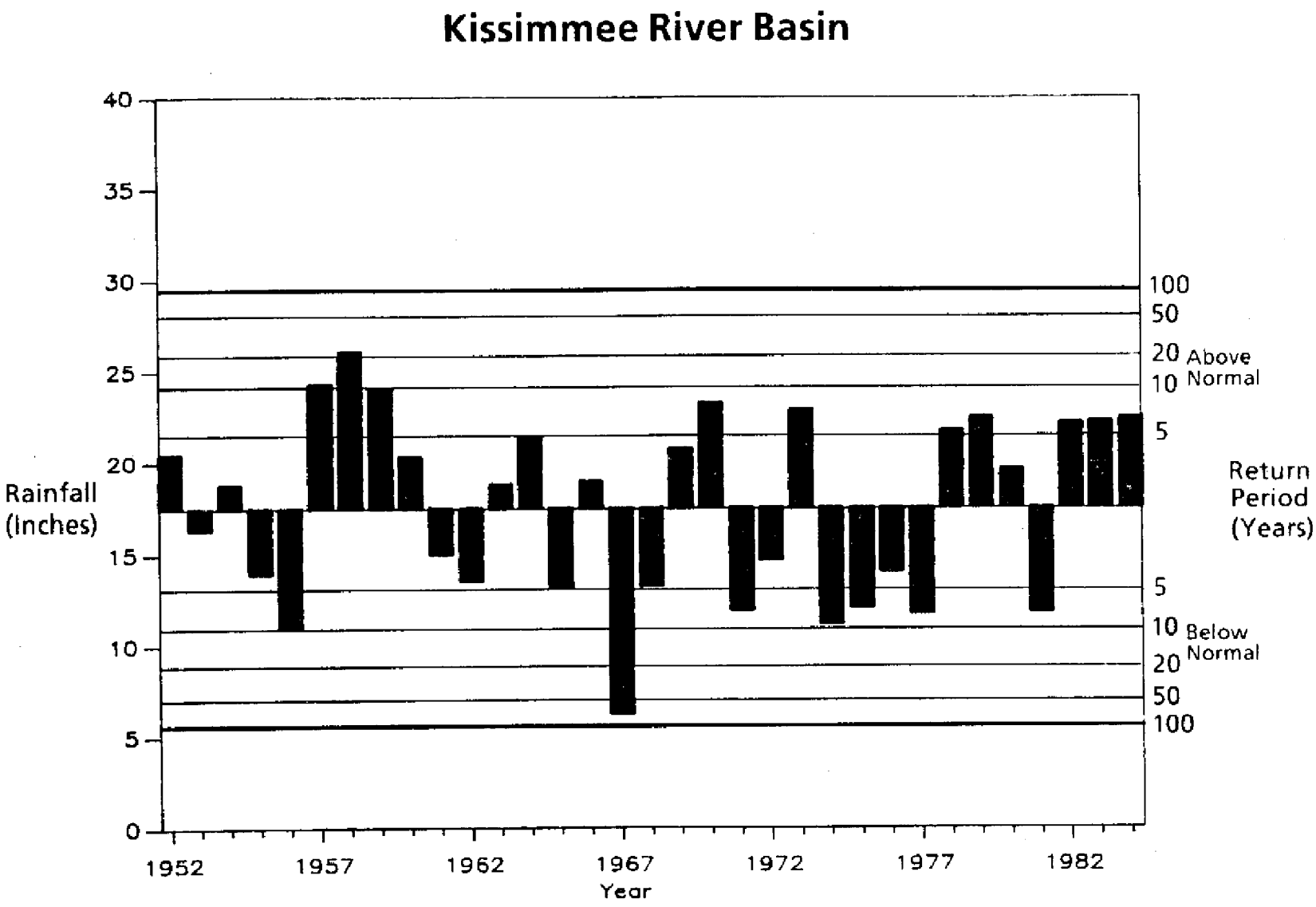


FIGURE 13b. DEPARTURE FROM MEAN DRY SEASON RAINFALL

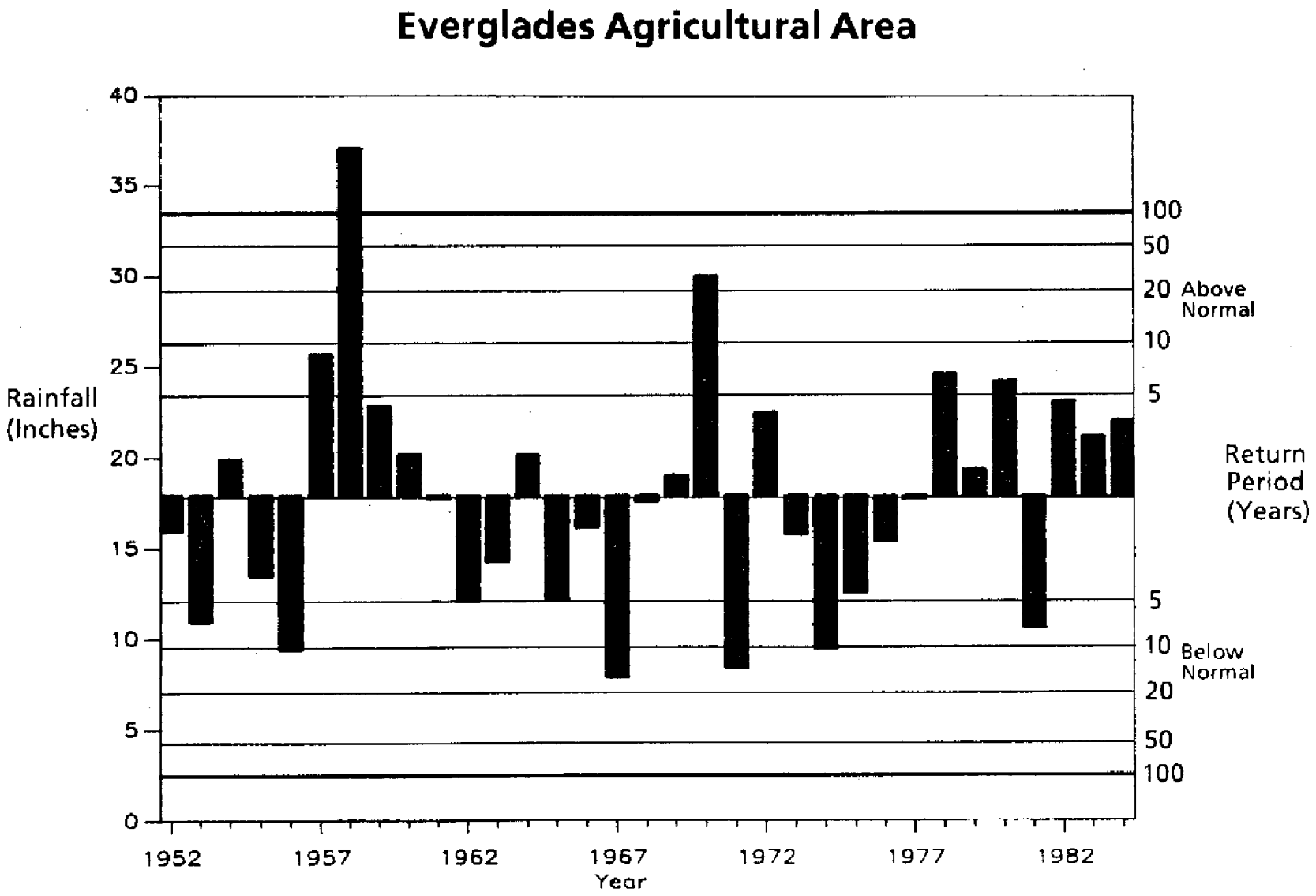


FIGURE 13c. DEPARTURE FROM MEAN DRY SEASON RAINFALL

V. RESULTS

A. Early Proposals

Detailed summary sheets for each schedule that was analyzed appear in Appendix A. Stage-exceedance curves for each schedule tested versus the simulated base line stages and the historical stages appear in Appendix C. Simulated stages for the critical period of the 80's for several of the alternative schedules versus the simulated stages for the current schedule are illustrated in the context of the report. The first schedule that appears in the appendix is the current operational schedule. This schedule, as explained in the previous section, is used as the base line for comparing the alternative schedules. Schedules 2 through 8 were proposed primarily in an effort to ease the erosion problem that occurred with Zone A discharges in the St. Lucie Canal during the winter and spring of 1983. Significant erosion normally does not occur until discharges reach near 4,000 cfs; therefore, in an effort to reduce the chances of reaching Zone A, it was proposed on several schedules that the Zone B discharge be raised to 3,500 cfs through the S-80 structure in an effort to discharge more water at lower stages and still not create significant erosion. For each schedule tested with Zone B discharges of 3,500 cfs through the S-80 structure, a comparable schedule was tested with Zone B discharges of 2,500 cfs.

The first alternative proposed was, in fact, to use the present operational schedule, but to simply increase Zone B discharges through the St. Lucie Canal to 3,500 cfs. This reduced simulated Zone A discharges from 235 days, with the present schedule in effect, to 192 days with the proposed schedule for the hydrologic period between 1952 to 1984. Raising the Zone B discharges to 3,500 cfs did help reduce the Zone A discharges. However, a significantly larger reduction in the number of days of Zone A discharges is desired.

Regulation schedules 3 and 4 initiate Zone B releases when the lake level is 17 feet (msl) instead of 17.5 feet (msl) during the winter months. When lake water levels are in Zone B, regulation schedule 3 calls for a discharge of 3,500 cfs to be released through the S-80 structure while schedule 4 calls for a discharge of 2,500 cfs through the same structure. Schedule 4 decreased Zone A discharges to 211 days. This was only a reduction of about 10% in the total number of Zone A releases. When this schedule is combined with the 3,500 cfs releases to the St. Lucie estuary, as in Regulation Schedule 3, Zone A releases are reduced to 167 days. Demands met were not substantially reduced with these schedules. The number of Zone A releases are not, however, reduced nearly enough to protect the estuaries.

Regulation schedules 5 and 6 look at the possibility of beginning Zone A releases at higher water levels during the spring months in an effort to reduce the number of Zone A releases. This proposed alteration in the schedule had about an equal effect as the previous adjustment of lowering the starting point of Zone B releases.

Regulation schedules 7 and 8 introduced the concept of three zones. With lower releases similar to Zone B of the present schedule in Zone C, and then higher releases in the new proposed Zone B. These schedules reduced Zone A releases substantially to the St. Lucie Canal, but actually increased maximum discharges to the Caloosahatchee River. This approach will not likely be acceptable as it may cause additional damage to the Caloosahatchee River and estuary system.

Schedules 9 and 10 were the first schedules which introduced the concept of early minimal environmental impact discharges to the St. Lucie and Caloosahatchee estuaries in an effort to prevent larger regulatory discharges from being made. These schedules included three zones in which deliveries were increased proportionally for both outlets as stages rose. A new zone of low flow releases were proposed as minimal environmental impact discharges to the estuaries. Originally these releases ranged between 1,000 and 1,500 cfs through the S-80 structure and about 2,500 cfs through the S-77. These discharge levels were later modified after a more detailed understanding of the environmental response to flow were determined and a numerical model of the St. Lucie estuary was completed by the Resource Planning Department of the South Florida Water Management District. The modified low flow discharge limits were incorporated into a final version of these proposed schedules. The number of days of Zone A discharges were substantially reduced; however, there was still a significant number of Zone A discharges so that some damage would still be likely to the estuaries. Water use requirements were increased slightly by the early releases. Simulated water use requirements not met with schedule 10 in operation as compared to those with the present schedule appear in Figure 15.

Other early experiments with the regulation schedules included simple variations of the slopes of the schedules without varying the discharges within the given discharge zones from the present regulation schedule. In regulation schedule 11, the May 31 regulation stage was raised by one-half of one foot in both the upper and lower schedules in an attempt to increase water supply and also to minimize Zone A releases by decreasing the downward slope of the spring decline in the regulation schedule. Comparing results with the base run, this schedule reduced Zone A releases during the dry season from 125 days to 103 days, but increased Zone A discharges during the wet season by an almost equivalent amount so that there was no overall reduction in the number of days of Zone A discharges. This schedule did increase water use requirements satisfied. In the 1981 dry season, water use requirements satisfied increased by about 65,000 acre-feet. The water levels during the peak hurricane season averaged about three-tenths of one foot higher under this schedule. This schedule, therefore, failed the criteria of maintaining the same level of flood protection.

Schedule 12 starts Zone B releases whenever the lake stage exceeds 16 feet throughout the year. The Zone A discharges began when stages reached water levels defined by the present Zone A schedule. This schedule eliminates the buildup of storage during the autumn months which helps prevent the need for Zone A discharges during the spring months. Water supply was only slightly altered with this schedule and mean stages were lowered by one-fourth of one foot during peak hurricane season. The stage-frequency curve was favorable for the littoral zone as the frequency that water levels were above 16 was decreased. This run indicates that it is not necessary to allow for the buildup of storage during the autumn and early winter months for water supply purposes during the late spring.

Regulation schedule 13 begins Zone A discharges at higher levels during the late winter and spring months similar to regulation schedule 6. This helps reduce the number of days of Zone A discharges especially during the months between January and May. The mean stage during the hurricane season remain about the same as the base run, although the maximum stage calculated was one-tenth of one foot higher.

Regulation Schedule 14 decreases Zone A discharges substantially, lowers average stages during peak hurricane season by one-half of one foot, and has a favorable stage frequency curve for the littoral zone. However, 93,000 less acre feet of demand was met in the Lake Okeechobee service area during the 1981 and 1982 dry seasons. This is one of the more promising early schedules proposed. Results of Schedule 14 are displayed in Figure 16.

Schedules 15 and 16 introduced an intermediate moderately high discharge zone. These schedules discontinue discharges in the lowest zone when stages were falling. This allowed for these regulation schedules to meet more demands even though releases may actually be begun at lower levels than the base schedule. Zone B releases are 4500 cfs through the St. Lucie Canal which may be near the limits which would cause erosion.

Many of these early schedules illustrate useful principles that may be applied to choose the appropriate final schedule.

B. Beginning Zone B Discharges at Lower Levels

Regulation schedule 17 began Zone B discharges 2 feet lower in an attempt to decrease the number of days of Zone A discharges and to return lake stages back to more favorable stages for the littoral zone. The number of Zone A releases were substantially reduced. The stage frequency curve was more favorable for the littoral zone as it reduced frequency of high water periods. However, with the higher water use requirements, stages may drop below historical lows more often. Water use requirements not satisfied during the 1981 dry season rose from 9.3 percent under base conditions to 38.9 percent under this proposed schedule. Also, the number of years 10 percent or more of the Lake Okeechobee service area demand was not met for the hydrologic period of 1952 to 1984 increased from 2 years in the base run to 8 years with this schedule. In the years 1962, 1971, 1974 and 1982 only 60 to 80 percent of the Lake Okeechobee service area demands were met. Figure 17 illustrates the simulated stages for Regulation Schedule 17.

Schedule 18 will obviously have similar problems to Schedule 17 but with more frequent Zone A releases since the Zone A releases began at lower levels.

Schedule 19 was similar to schedule 6 in that it did not build up as much storage during the fall and early winter months in an effort to decrease Zone A discharges. This schedule is unique in that it starts the decline of the lower schedule in October. This early decline helped reduce Zone A discharges by an additional 14 days over schedule 4, and reduced total Zone A discharges from a base run total of 235 days to

198 days for the total hydrologic period modeled. The stage results of Schedule 19 appear in Figure 18.

C. Concept of a Low Flow Release Zone

Numerical modeling in conjunction with biological studies of the St. Lucie Estuary were conducted by the Resource Planning Department (RPD) of the South Florida Water Management District. These studies determined the levels of discharges through the S-80 structure that could occur with minimum environmental impact. Discharges were estimated for monthly dry, normal and wet conditions. Similar estimates were made for the Caloosahatchee estuary. The allowable discharges under normal conditions were incorporated into the South Florida Regional Routing Model. These low flow releases were made at levels below the existing Zone B discharges in an effort to reduce the likelihood of making extended Zone B discharges, or large Zone A releases to the estuaries. Most recent research from RPD indicate that these low flow releases should simulate natural stormwater runoff which occurs in a pulsing discharge manner. Pulse discharges from S-80 would be of 8-day duration with a maximum daily release of 1600 cfs. (Haunert, 1987). Table 3 includes the average flow values allowed for each month of the year for each estuary.

Table 3. Allowable Monthly Discharges to the Estuaries for Low Flow ReleaseZone C (AF)

Month	S-80	S-77
January	1,468	2,507
February	1,190	2,411
March	1,666	2,253
April	1,566	2,253
May	892	1,555
June	753	95
July	793	286
August	733	476
September	0	0
October	753	1,872
November	1,408	2,602
December	1,666	2,602

In order to estimate the proper width of Low Flow Release Zone, an analysis was made on the probability of reaching the regulation schedule at any time when the lake levels are below the schedule Such analysis is illustrated in Figures 19a and 19b. The fifty percent line was chosen as a guideline to start a sensitivity analysis on different Low Flow Release Zone slopes. The concept is to have a zone that will not jeopardize the water supply capabilities of the lake and at the same time will minimize the risk of high regulatory discharges to the St. Lucie and Caloosahatchee estuaries.

Management of the Low Flow Release Zone requires consideration of hydrologic conditions in the rest of the system particularly the Upper Kissimmee Basin Lakes and the Water Conservation Areas. For example, if the Water Conservation Areas are significantly below schedule and in need of water, discharges from the lake should go to the Water Conservation Areas rather than the St. Lucie and/or Caloosahatchee estuaries. If the lake stage is in a declining mode, rainfall conditions are forecasted to be dry, and there are no anticipated inflows from the Upper Kissimmee Basin Lakes then it might be advisable not to make any releases to the estuaries even though the lake is in the Low Flow Release Zone. These two examples illustrate that the management of the low flow (pulse) releases require consideration of hydrologic conditions not only in the lake, but in the rest of the system as well as monitoring of salinity conditions in both the Caloosahatchee and the St. Lucie estuaries.

Regulation Schedule 20 illustrates an example of an application of the Low Flow Release Zone concept. In this schedule, Zone A discharges are begun at higher water levels in the spring. With this schedule in operation average water levels during the peak hurricane season are about thirty-five hundredths of one foot lower than with the present schedule while the maximum stage during the hurricane season is about the same as the base run. Zone A and Zone B releases are substantially reduced with this schedule, although the number of Zone A releases are still larger than desired. Water use requirements increased from 9.3 percent to 14.6 percent during the 1981 dry season for the Lake Okeechobee service areas. This was still 5 percent less than those projected during the 1974 and 1982 drought years. Changes to the stage-duration curves were favorable. Other model simulations were made beginning the downward slope of the lower line on November 15 and December 1. This only altered the overall results slightly. The simulated stage results for Regulation Schedule 20 appear in Figure 20.

D. Four Zone Concept

Many of the regulation schedules tested in earlier sections of this report show a great deal of potential for reducing the large discharges made to the estuaries without reducing flood protection or water supply. However, these proposed regulation schedules, although an important improvement to the present schedule, still predict extended periods of Zone A releases are going to be required if these schedules were put into operation. In this section, a new discharge Zone is introduced which allows for increased discharges over the present Zone B discharges, but limits the discharge velocities so that substantial erosion does not occur in the canal. These releases will be larger than the present Zone B releases but less than the maximum discharge capacity of the Caloosahatchee River and the St. Lucie canal. The regulation schedules in this section include four zones:

- Zone A - maximum releases necessary for flood protection
- Zone B - maximum releases that will still result in limited sediment transport
- Zone C - discharges made at the same discharge level as Zone B of the present base run
- Zone D - discharges made to the estuary for extended periods of time without harming the estuarine environment.

Zone B and C discharges are not desirable, but at times need to be made to decrease the likelihood of the necessity to make Zone A discharges. Schedules 21 through 31 all define the same levels of discharges for each of the corresponding discharge zones. These schedules also include the modified upper schedule during the late winter and spring months which require Zone A discharges to begin at a higher lake stage.

Schedule 21 substantially reduces Zone A discharges particularly during the spring months. It would be helpful to the littoral zone habitat because it reduces by the number of times the stages in the lake are over 16 feet (msl) by 16% when compared with simulations with the current schedule in effect; therefore, it also increases flood protection for those in the areas immediately adjacent to the lake. Water use requirements satisfied are, however, reduced with this schedule in operation. Figure 21 displays the magnitude of the demands not met with regulation schedule 21 in effect compared to those simulated with the present schedule in effect.

Schedules 22 and 23 create serious deficits in water requirements satisfied particularly during the 1981 drought. Several other years also have serious water shortages occurring with these schedules in operation. Figure 22 plainly illustrates the possible drawbacks to water supply of returning to the 13.5-15.5 regulation schedule.

Schedule 24 increased water supply and flood protection benefits over the present schedule while it was also a desirable schedule for reducing Zone A discharges during the spring months. By not allowing a large buildup of water during the months of September to December, it is also an improvement for the habitat of the littoral zone.

Schedule 25 is very similar to Schedule 24, however, the decline of lines 2 and 3 begins earlier in the dry season. This decreased Zone A releases still further. Water use requirements satisfied decreased a bit from schedule 24 but were at the same level as the present schedule during the severe droughts of 1974 and 1980-1982. Figure 23 shows the demand not met for Schedule 25. The mean and maximum stages for September 1 were lower for this schedule than the present schedule or Schedule 24. The hydrographs for the entire study period for these two schedules are included in Appendix D. During 1956, 1962, 1967 and 1968, the water supply available was decreased by Schedules 24 and 25. Water supply was not as critical, however, during these years as it was during 1974, 1981 and 1982.

Schedule 26 through Schedule 29 have zones A, B, and C discharge zones defined exactly the same. These schedules included a smaller Zone B and Zone C range so that there were a larger number of days of Zone A discharges required for these schedules. The different variations in the lowest regulation schedule did not significantly alter the number of days of Zone A releases or the amount of water use requirements not satisfied in this study.

Schedules 30 and 31 are also similar to 25, but begin Zones C and D releases at a lower elevation in an effort to protect the Lake Okeechobee littoral zone. The effects these schedules have on demands not met can be seen in Figure 24 and Figure 25.

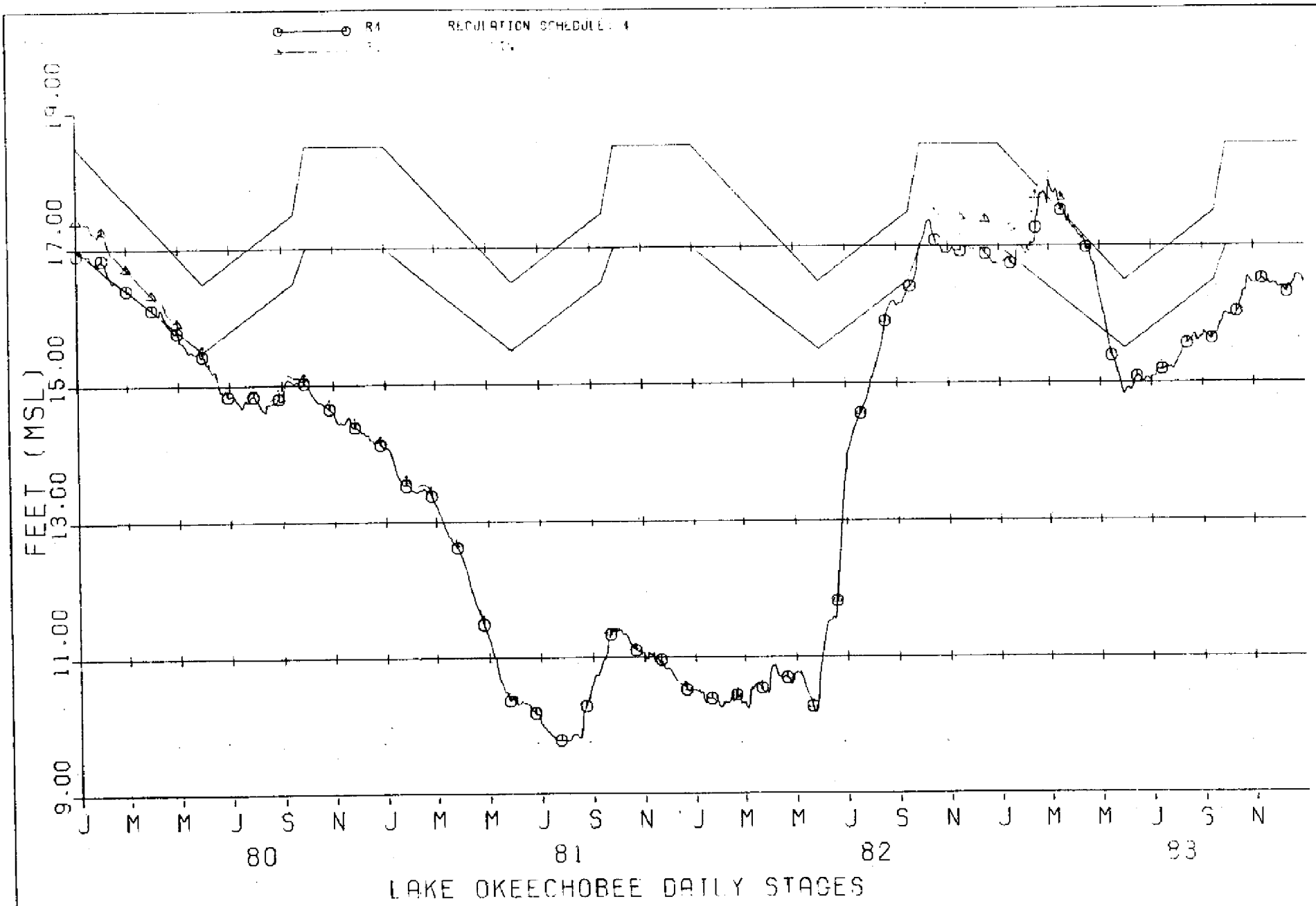
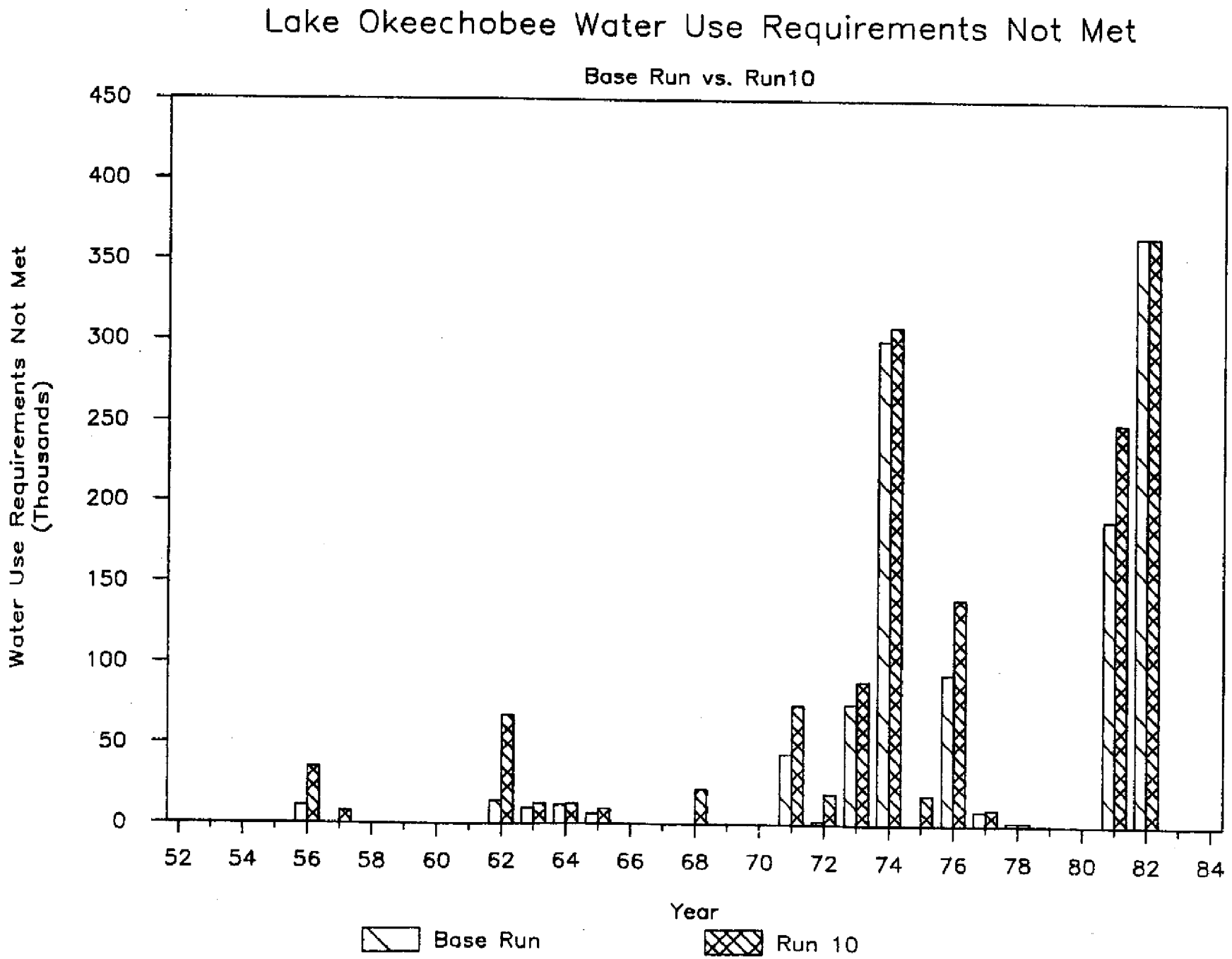


FIGURE 14. SIMULATED STAGES FOR SCHEDULE 4


Lake Okeechobee Water Use Requirements Not Met
Base Run vs. Run10
Water Use Requirements Not Met (Thousands)
450
400
350
300
250
200
150
100
50
0
52
54
56
58
60
62
64
66
68
70
72
74
76
78
80
82
84
Year
Base Run
Run 10

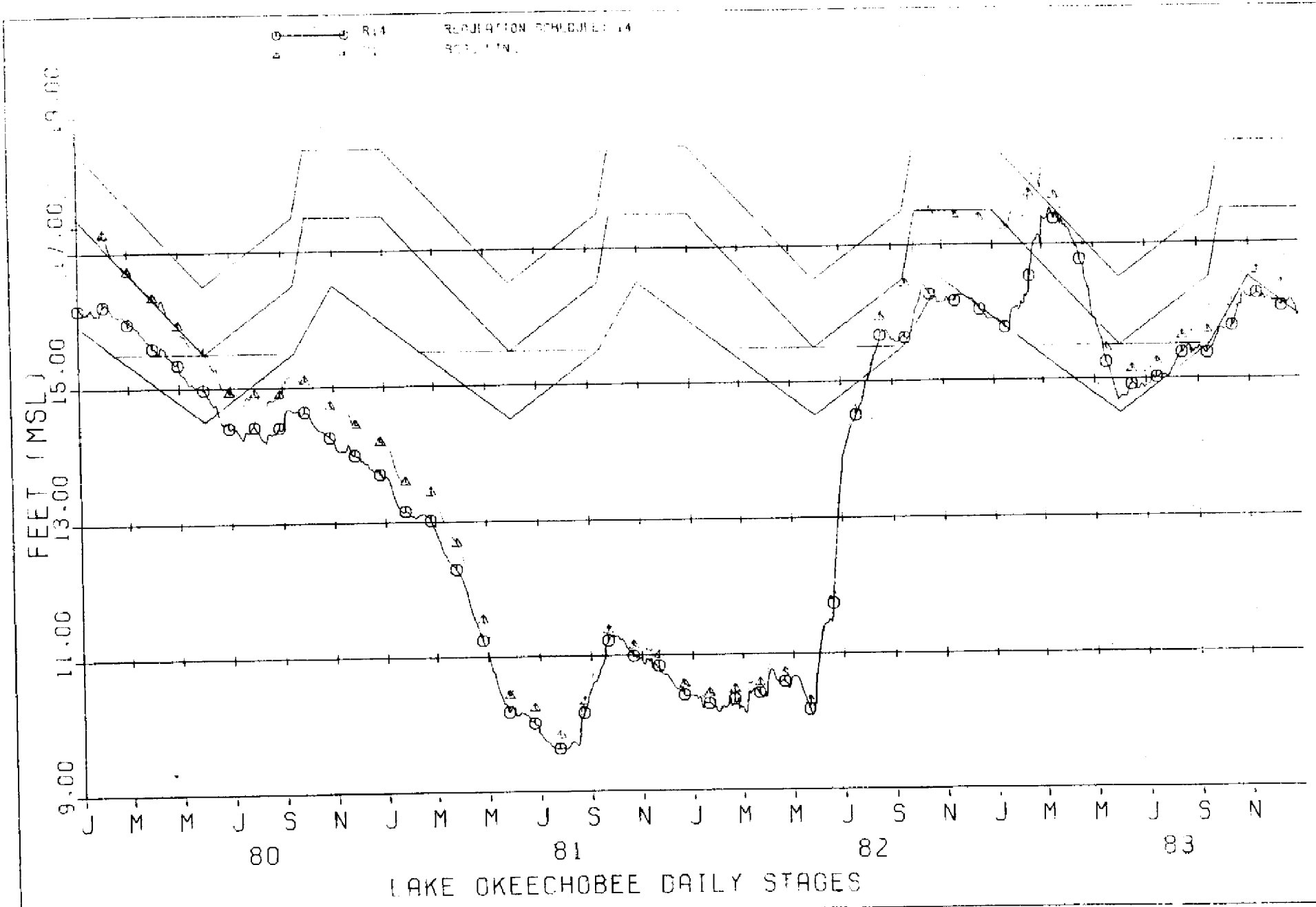


FIGURE 16. SIMULATED STAGES FOR SCHEDULE 14

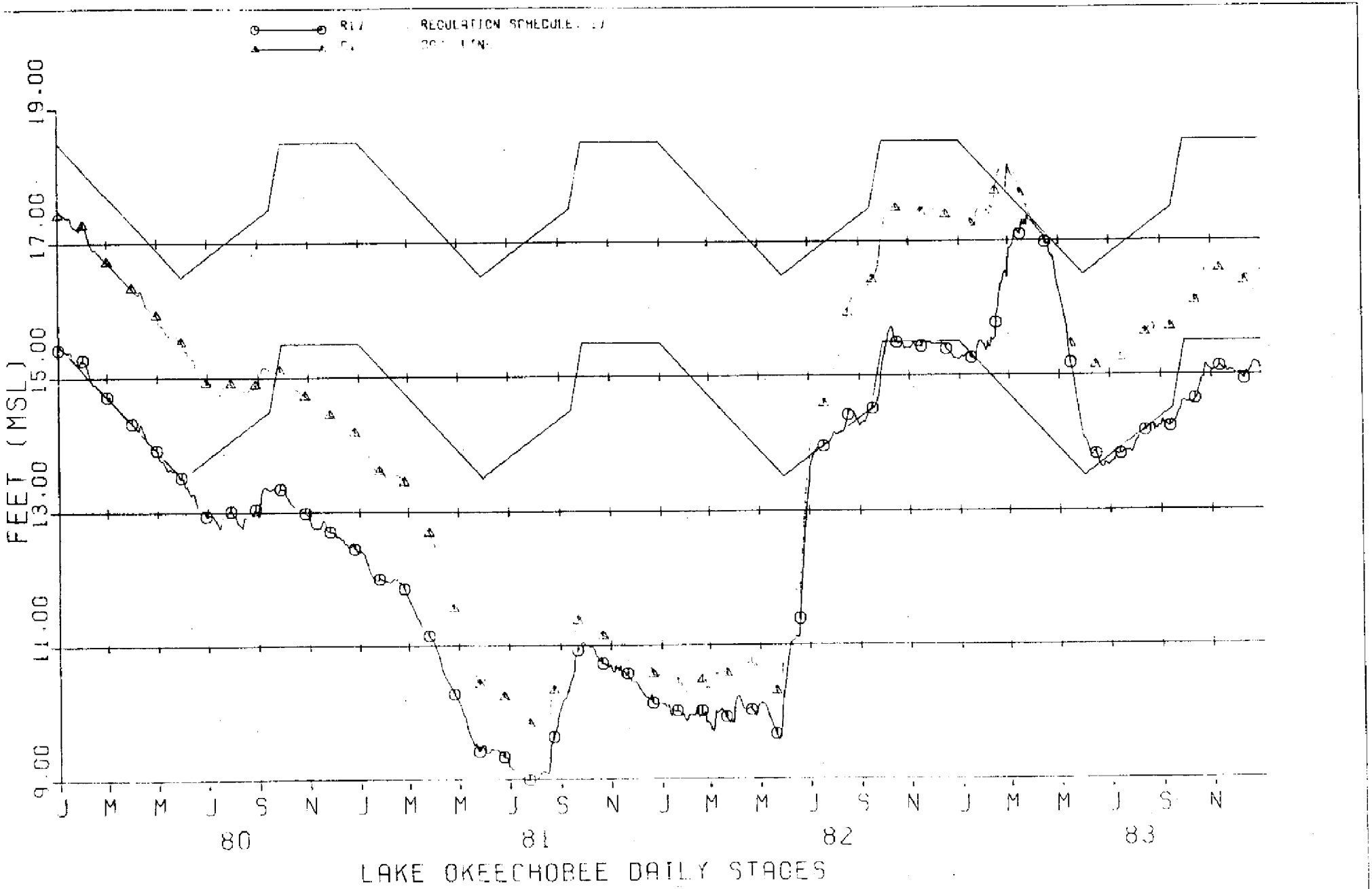


FIGURE 17. SIMULATED STAGES FOR SCHEDULE 17

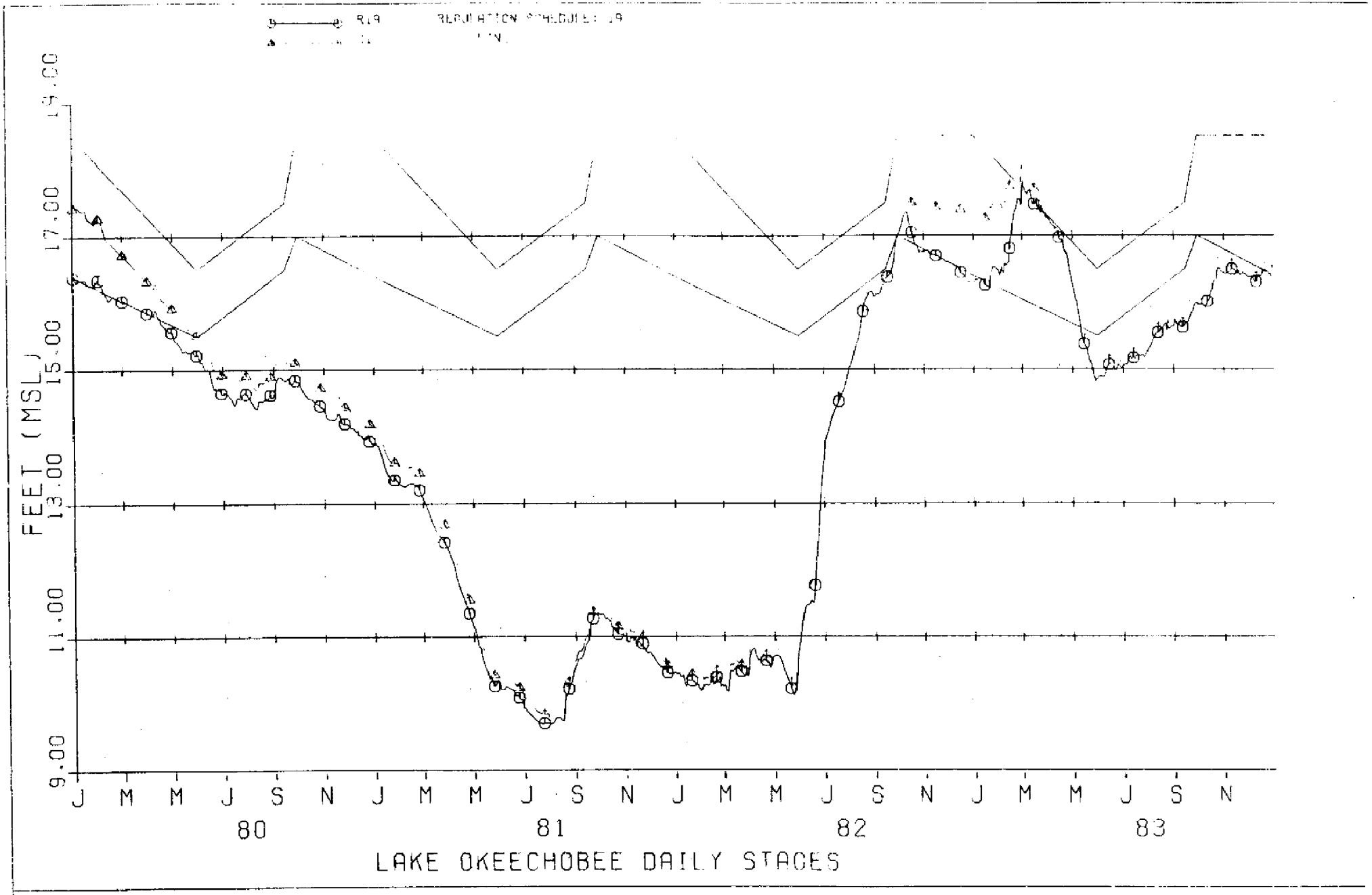


FIGURE 18. SIMULATED STAGES FOR SCHEDULE 19

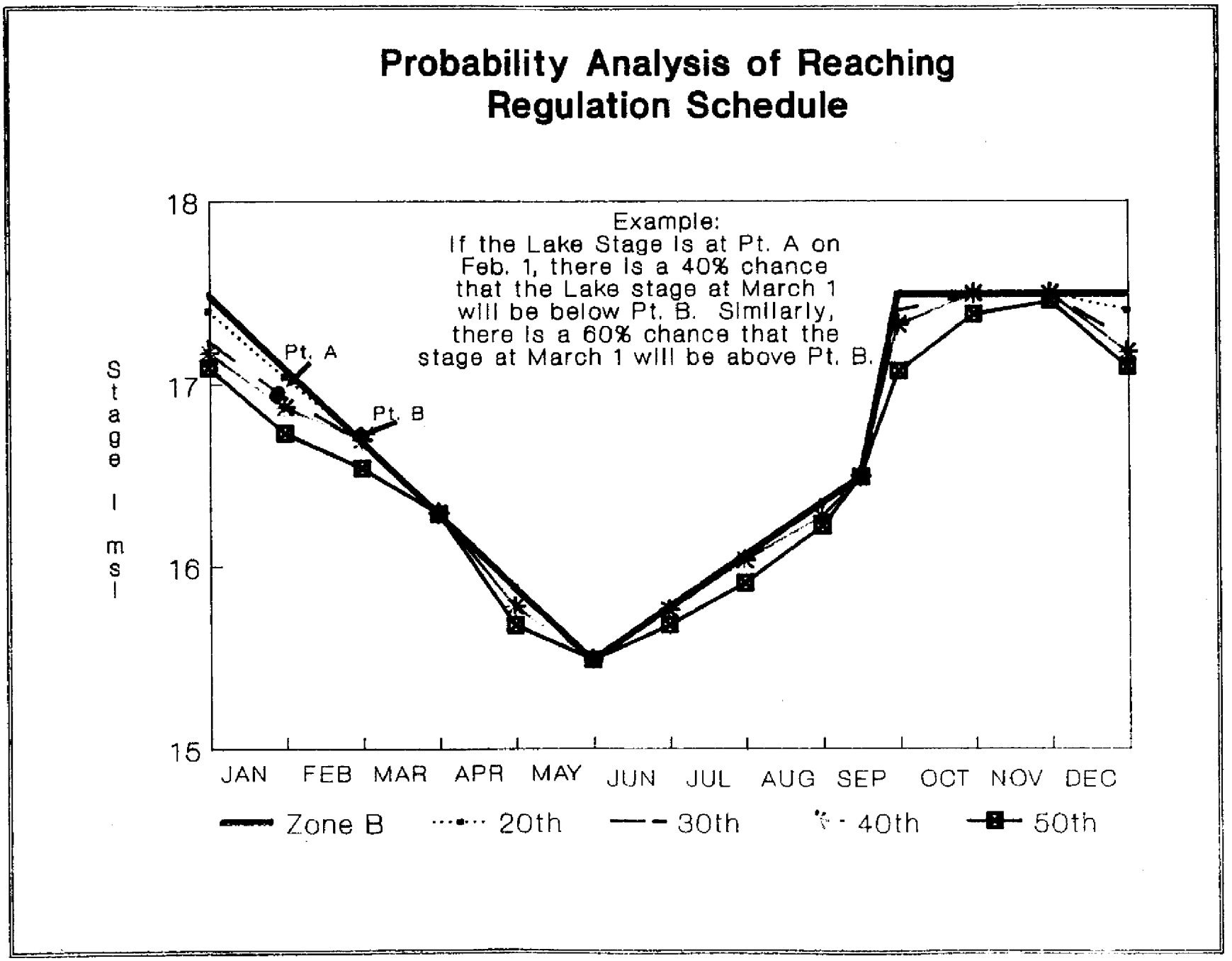


FIGURE 19a. PROBABILITY ANALYSIS OF REACHING REGULATION SCHEDULE

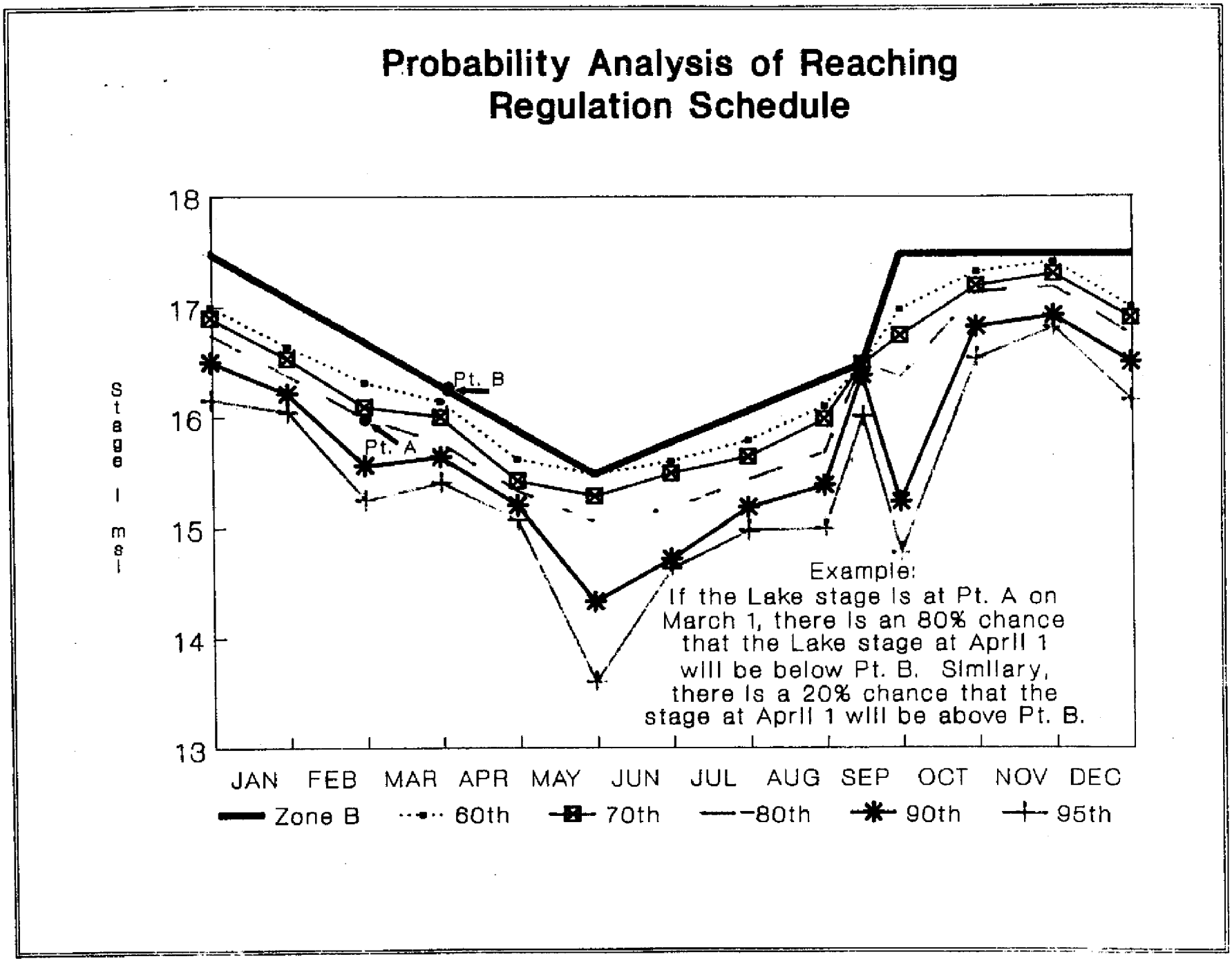


FIGURE 19b. PROBABILITY ANALYSIS OF REACHING REGULATION SCHEDULE

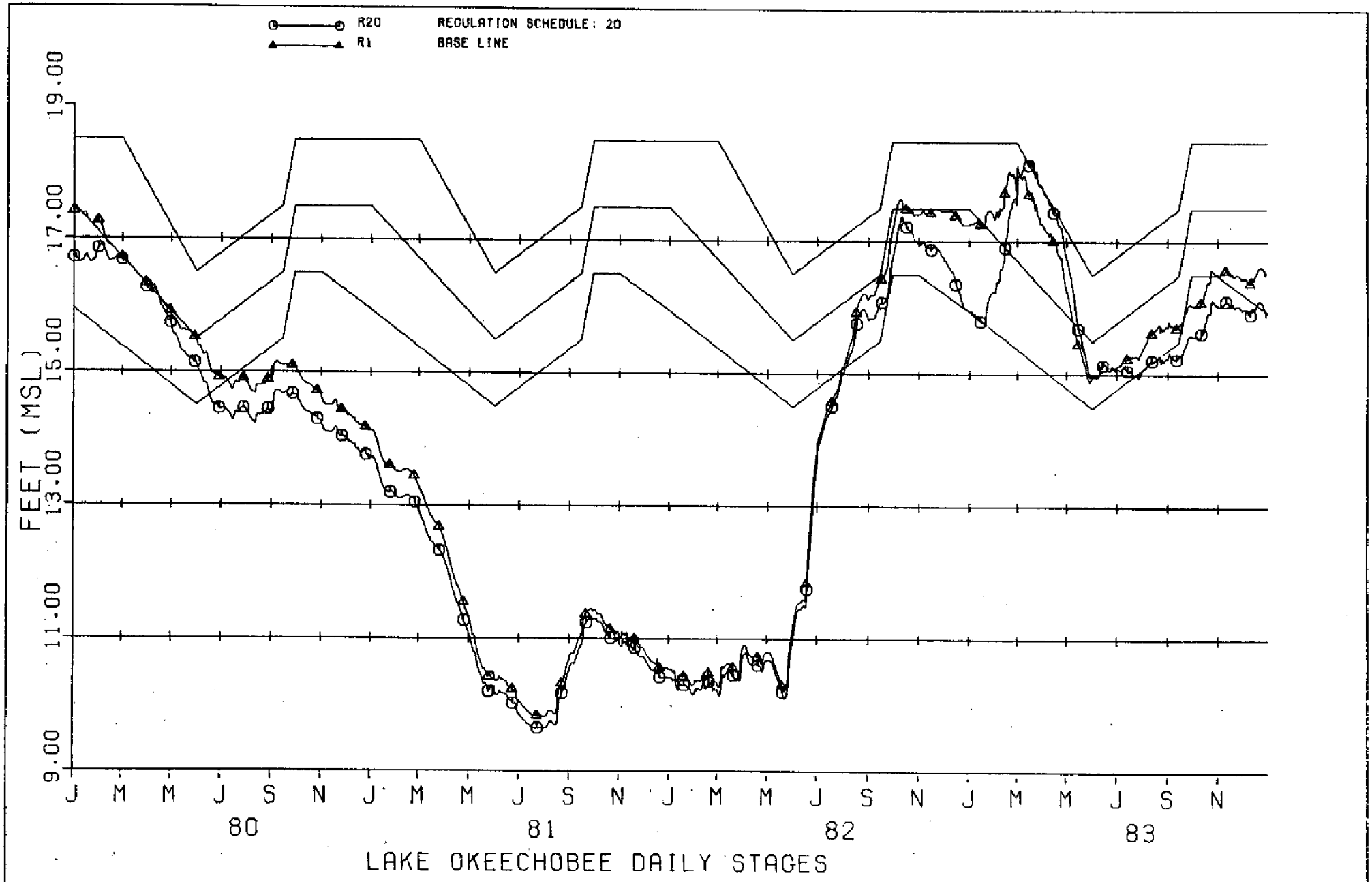


FIGURE 20. SIMULATED STAGES FOR SCHEDULE 20

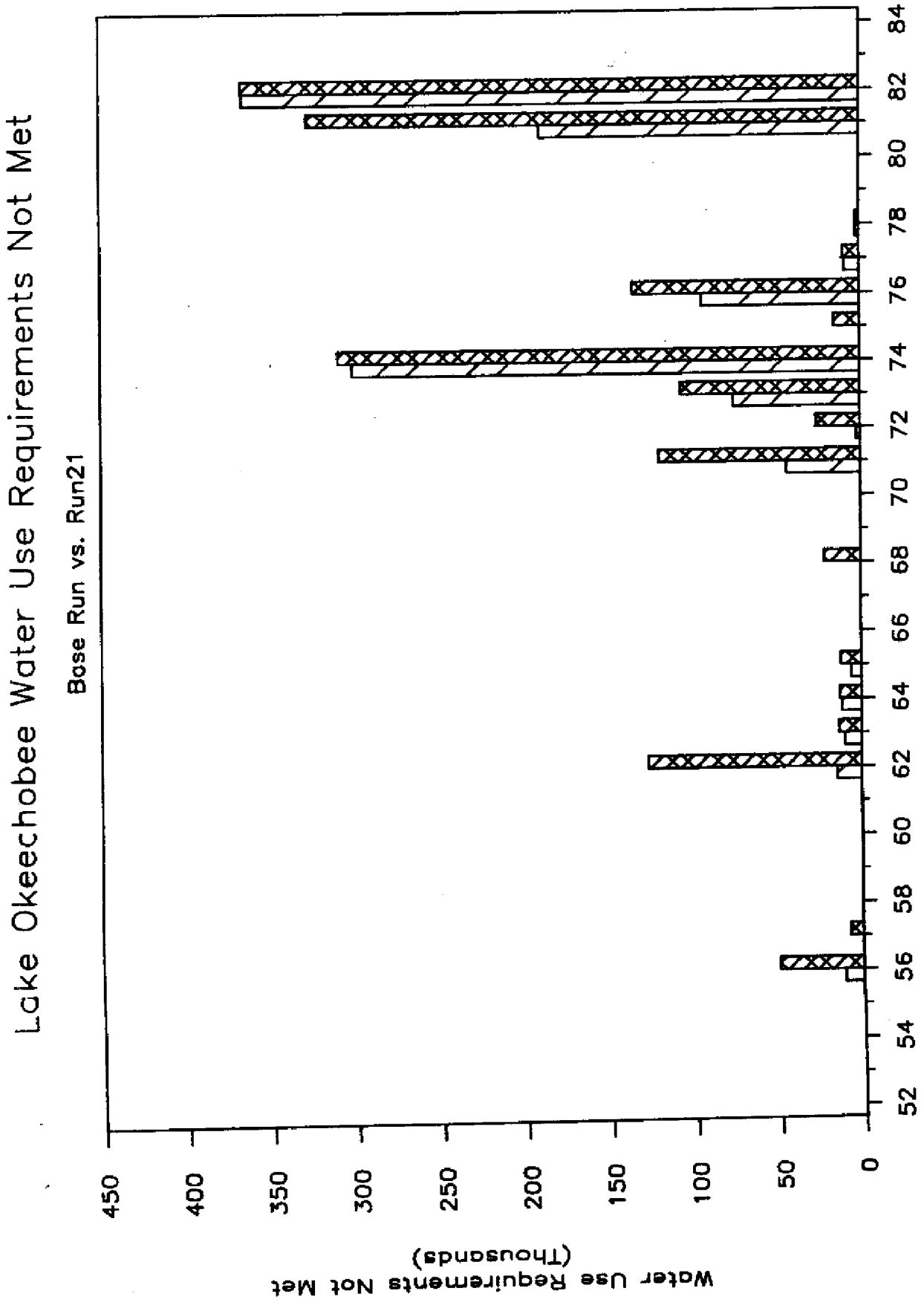
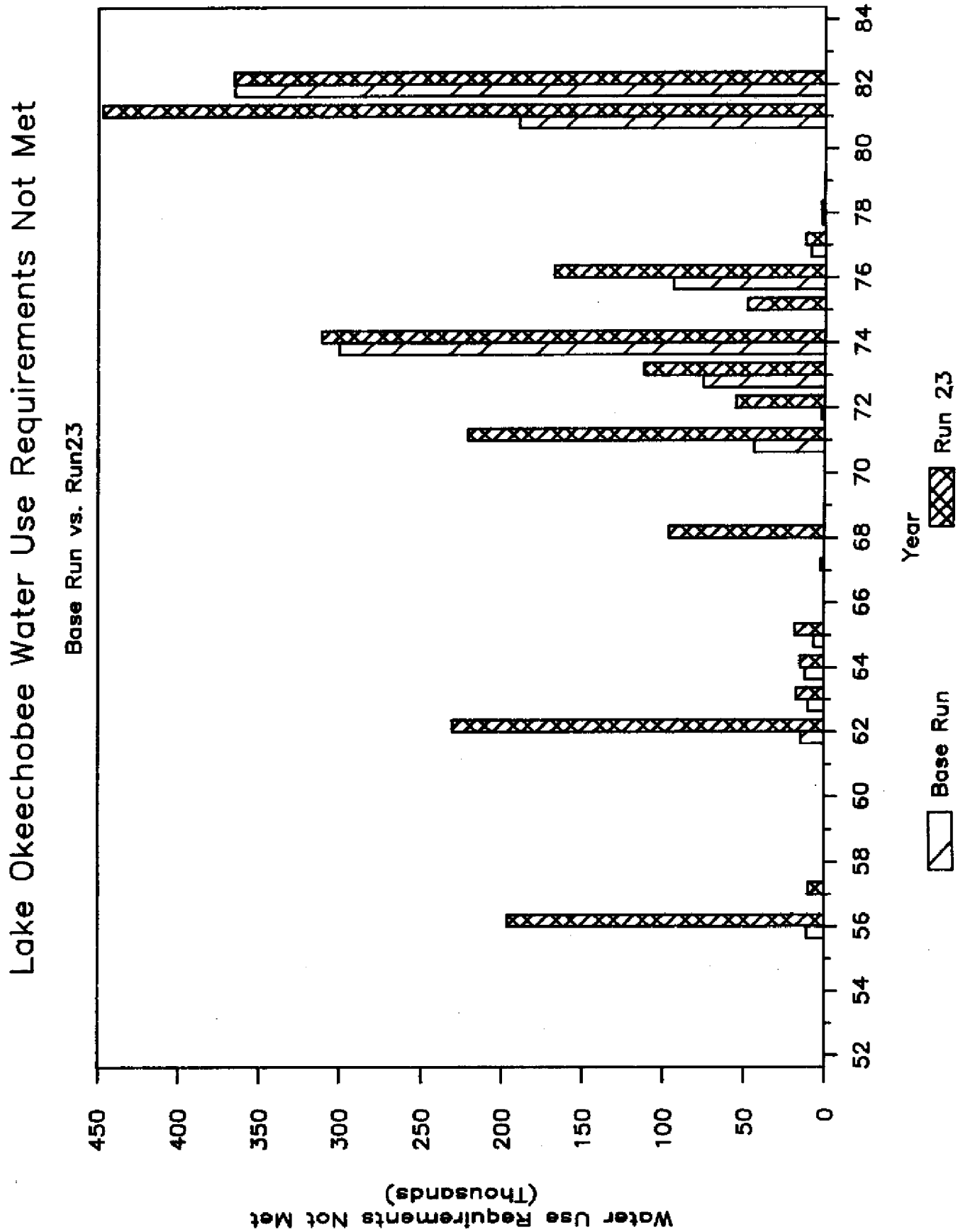


FIGURE 21. WATER USE REQUIREMENTS NOT MET FOR SCHEDULE 21


Lake Okeechobee Water Use Requirements Not Met
Base Run vs. Run23
Water Use Requirements Not Met
(Thousands)
450
400
350
300
250
200
150
100
50
0
52
54
56
58
60
62
64
66
68
70
72
74
76
78
80
82
84
Year
Base Run
Run 23

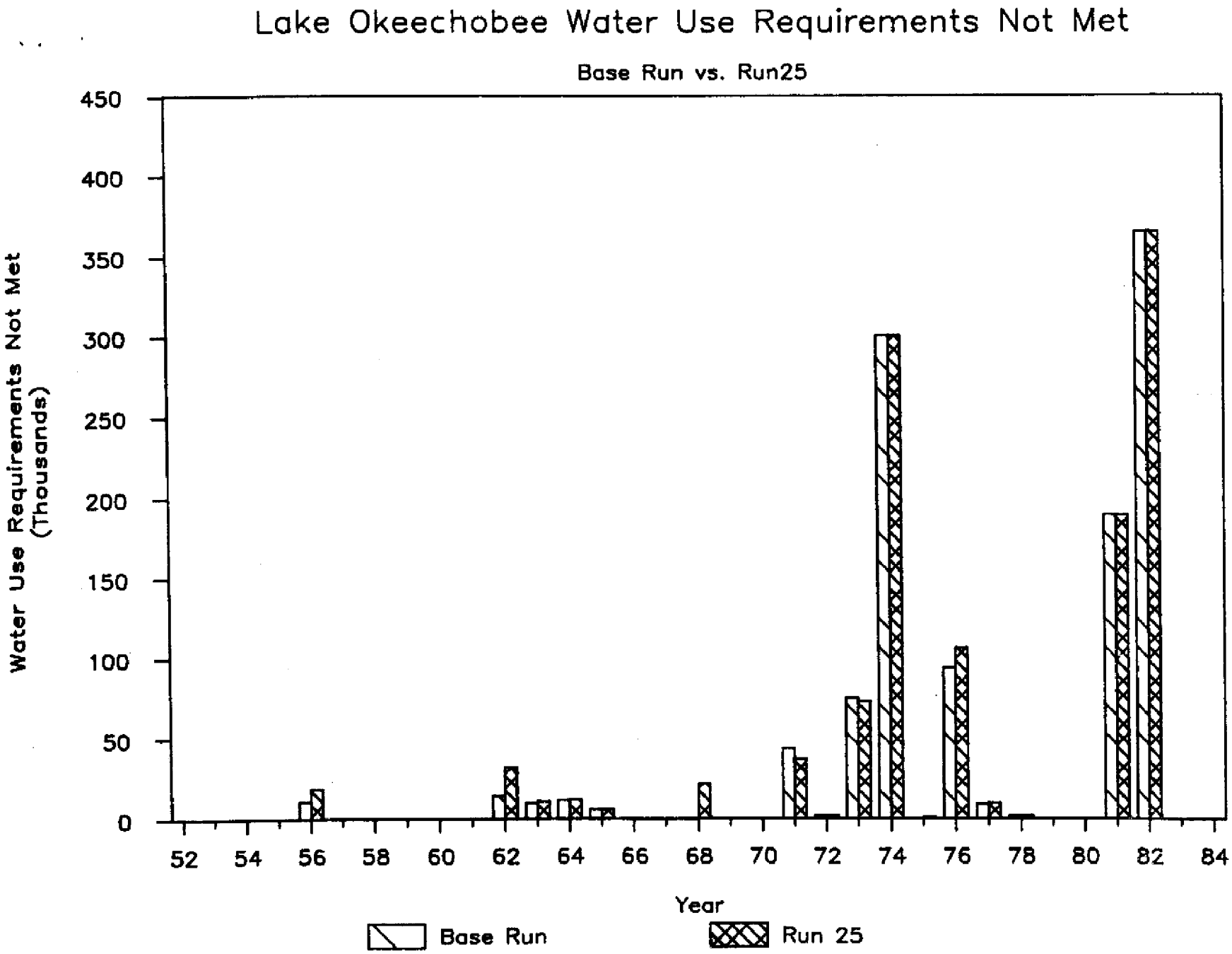


FIGURE 23. WATER USE REQUIREMENTS NOT MET FOR SCHEDULE 25

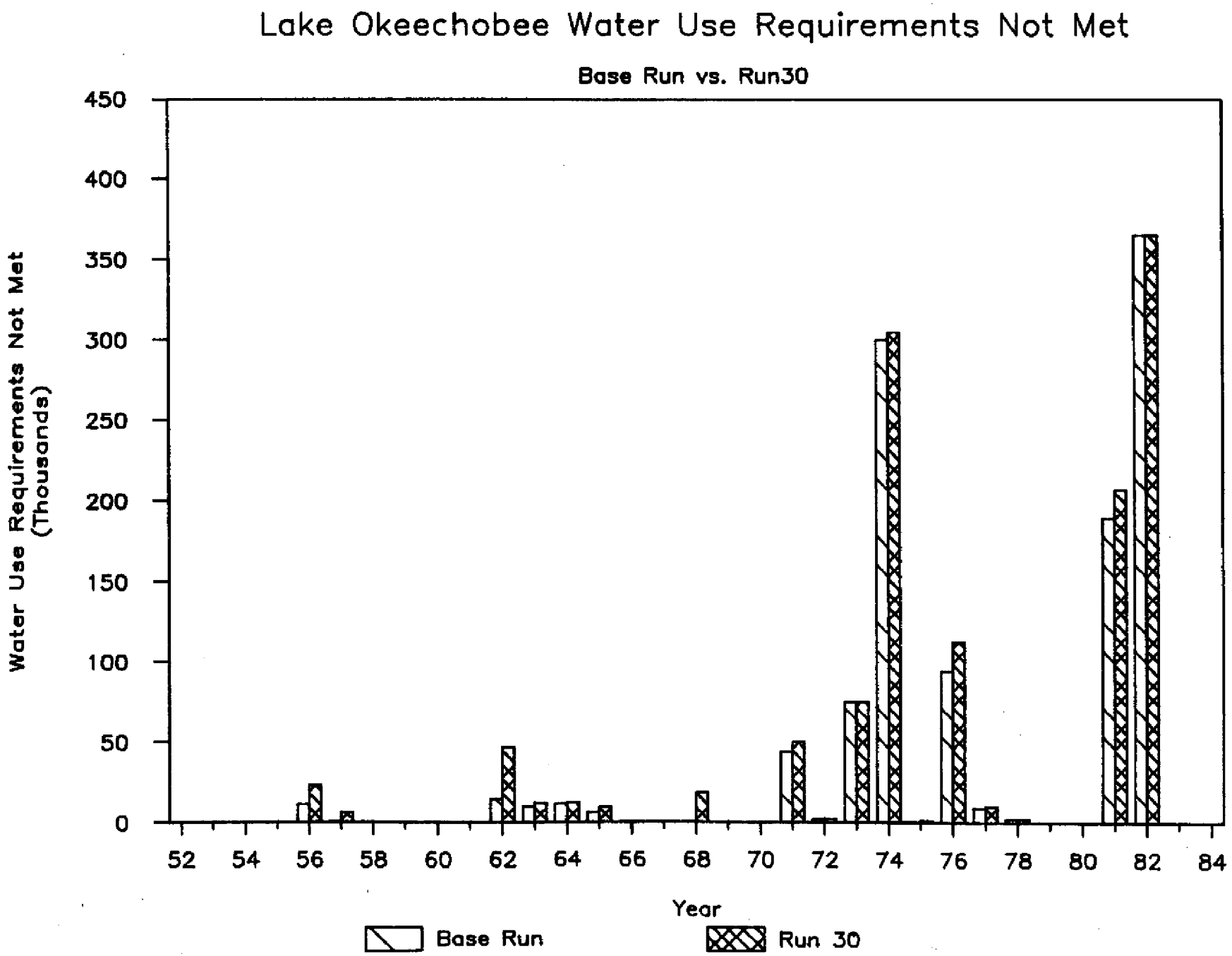


FIGURE 24. WATER USE REQUIREMENTS NOT MET FOR SCHEDULE 30

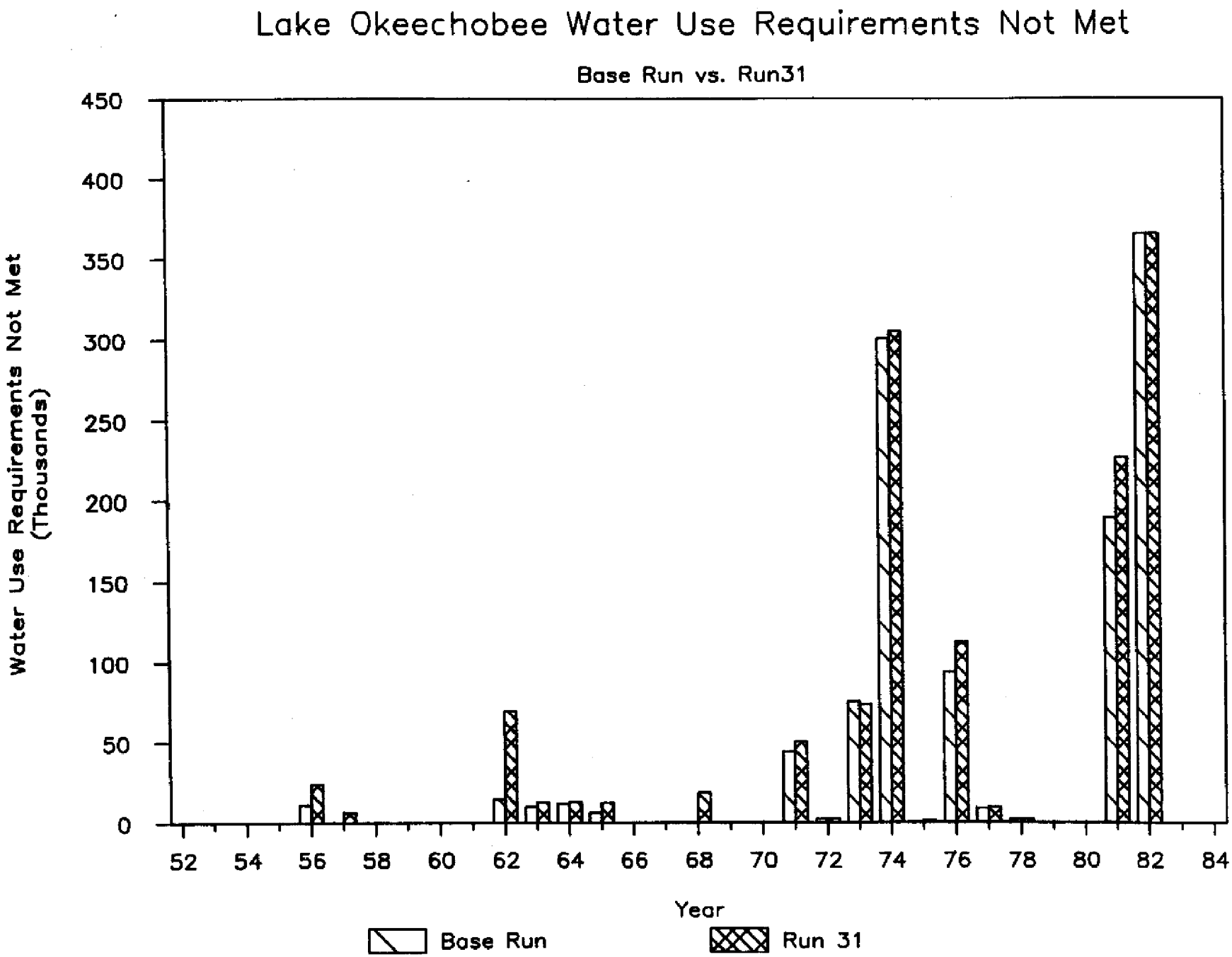


FIGURE 25. WATER USE REQUIREMENTS NOT MET FOR SCHEDULE 31

VI. SUMMARY

Table 4 includes an overall summary of the criteria used in the evaluation of the regulation schedules. Included in this table are:

1. The number of days the lake was in a given discharge zone as defined by the S-80 discharges.

2. The water use requirements of the Lake Okeechobee service areas not satisfied during the study period in units of acre feet.

3. The mean and maximum stages (msl) prior to the peak hurricane season for the hydrological period including 1952 through 1984.

4. The stage frequency curve for the lake during periods when stages exceed 15 feet (msl).

This table summarizes the critical information for the evaluation of each schedule. All these schedules except Schedule 18 reduce Zone A discharges. Some of these schedules, however, may cause additional water shortages to occur, not meet

Table 4. Summary of Results of Proposed Schedules

RUN #	St. Lucie Discharge (days) MAX	3500 (cfs)	2500 (cfs)	MIN	Demand not met (AF)	Sept 1 Stage (ft) MEAN	MAX	Stage Exceeded 14 ft	15 ft	16 ft	17 ft	18 ft
1	235		2265		1139500	14.76	16.94	67	54	35	15	3
2	192	2211			1139700	14.74	16.65	67	53	34	14	3
3	167	2246			1173400	14.74	16.65	66	52	32	8	2
4	211		2332		1163000	14.71	16.97	66	52	33	10	3
5	174	2220			1139500	14.75	16.65	67	54	34	14	3
6	214		2326		1133700	14.76	16.94	67	54	35	15	3
7	136	311	1997		1128600	14.62	16.97	64	49	29	6	2
8	140	303	2036		1283600	14.75	16.73	67	54	34	14	3
9	139	1179		3090	1422400	14.46	16.35	63	47	24	10	2
10	136	1128		3014	1450200	14.45	16.38	62	46	23	9	2
11	233		2261		951600	14.93	17.20	69	55	41	17	4
12	182		2452		1333000	14.51	16.96	63	47	22	6	3
13	212		2330		1133700	14.77	17.04	67	54	35	15	4
14	82	765	2484	1126	1482600	14.37	16.31	63	47	19	6	1
15	128	680	2724		1231400	14.66	16.74	65	51	31	8	1
16	116	806	2373		1263900	14.61	16.70	65	50	29	4	1
17	37		3015		3438800	13.39	15.24	42	19	7	3	1
18	284		2538		3451300	13.37	15.13	41	16	4	0	0
19	197		2379		1264000	14.63	16.97	64	48	28	8	3
20	181	1378		2832	1520600	14.41	16.97	62	44	26	11	3
21	70	572	1319	2210	1665100	14.23	16.09	61	42	19	6	1
22	28	310	1909	2186	3218900	13.58	15.55	47	23	8	3	1
23	27	306	1891	1404	2333800	13.56	15.54	47	22	8	3	1
24	124	440	1296	1890	1123300	14.72	16.78	65	52	34	7	2
25	113	478	1238	1965	1193900	14.61	16.55	65	51	29	9	2
26	149	391	1322	1589	1029900	14.82	16.80	67	54	38	13	2
27	147	384	1267	1933	1040400	14.80	16.78	67	54	37	12	2
28	146	387	1239	2210	1066500	14.78	16.78	66	53	36	12	2
29	146	388	1252	2080	1046100	14.79	16.78	66	53	37	12	0
30	106	478	1253	1998	1262900	14.55	16.49	64	50	28	8	2
31	102	436	1378	1827	1308600	14.52	16.45	64	48	26	8	2
HISTORICAL								43	16	3	1	0

the flood protection criteria or may not be an improvement for the littoral zone.

Figure 26 illustrates the tradeoff that occurs between decreasing Zone A discharges and, therefore, in certain cases increasing the quantity of demand not met during critical dry periods. Regulation schedules which fall within the rectangle formed by drawing perpendicular lines from each axis to the base run (R1) are helpful in reducing Zone A discharges and at the same time reduce the quantity of water requirements not satisfied.

A similar trade off analysis can be made between the number of days Zone A discharges that are needed compared to the maximum stage reached on September 1st. The results of this analysis appear in Figure 27. It can be seen that by comparing Figure 26 and Figure 27 that certain regulation schedules that were improvements for the water use requirements satisfied and the reduction in Zone A discharges may not be favorable for flood protection. Schedule 13 is an example of this situation. In general, however, reducing the stage on September 1 also decreases the potential for Zone A discharges as would be expected.

Earlier in this report (Section II) the criteria for the protection of the lake littoral zone was described to be a function of the stage frequency curve. A schedule that reduces high stages would generally be favorable for both flood protection and the littoral zone habitat. Schedule 18 is the exception to this relationship as it lowers both the upper and lower schedules equally and, therefore, actually increases the number of Zone A discharges. Figure 28 illustrates the relationship between the need for Zone A discharges to the percentage of days the stage exceeds 15 feet. The only four schedules that approximate historical conditions are Schedules 17, 18, 22 and 23. However, all of these schedules substantially increase the demands not met. This will be an item for consideration when choosing a final schedule. Figure 29 illustrates the trade off between water use requirements satisfied and the number days lake levels exceed 15 feet. The huge discrepancy between the base run and the historical exceedence of 15 feet in the lake can easily be seen.

Table 5 takes the difference between the values for Schedule 1 (base run) and each of the other schedules in Table 3. This table indicates an improvement in a certain value when the value is negative. Therefore in Schedule 2 in column 1 the -43 indicates a decrease of 43 days in the number of Zone A discharges. In this case, if we review the Schedule the actual tradeoff was simply having Zone B discharges of 3500 cfs. If all the parameters are negative this indicates that this Schedule is favorable from all the criteria listed in the Table. There still may be other details of the Schedule that need to be further evaluated. For instance, the number of days and type of Zone B discharges (3500 or 4500 cfs through S-80) that need to be made.

Table 6 summarizes the demands not met during critical dry periods. The 1971-1974 and the 1980-1982 extended droughts were by far the most serious situations. The demands not met during the 1971-1974 extended dry period ranged from 378,000 to 1,006,600 acre feet while during the 1980-1982 drought, the demands not met ranged from 501,200 acre-feet to 1,022,000. In comparison, during the 1956 drought the demands not met ranged from 7,300 to 315,400 acre-feet, and even during the extended dry period of 1962 through 1965 demands not met only ranged between 43,600 to 558,000 acre-feet. Most of the schedules had less than 100,000 acre-feet of demand not met during the 1956 and the 1962-1965 dry periods.

Figure 30 shows the results of the trade off between protection of the littoral zone (reduction in the days that the lake exceeds 15 feet (msl)) versus the demands not met during the 1971 drought. Likewise, the trade off between the protection of the littoral zone versus the 1980-1982 demands not met have been plotted in Figure 31. Finally, the overall results of this study can be summarized pictorially in Figures 32 and 33. These trade off plots include all four evaluation criteria on one plot. Each axis expresses the degree to which each objective is being satisfied compared to the present schedule. The center point of the diagram is the ideal for each axis.

Figure 32 summarizes the results of Schedules 1, 10, 21, and 23. Run 10 illustrates the results of initiating a low flow concept at lower elevations than the present schedule. This run illustrates the benefits to the flood protection, littoral zone, and the estuaries at the cost of water use requirements not being met. Schedule 21 includes the four zone concept with releases beginning even at lower elevation. This run further illustrates the benefits to littoral zone, flood protection, and estuaries at the cost of demands being satisfied. Schedule 23 illustrates the effect of a 13.5-15.5 schedule. This schedule increases water use requirements not met by 100 percent. Again, it does help the other objectives significantly.

The exact needs of the littoral zone have not been completely documented. Until these needs are completely documented an interim schedule which will not impact water supply while greatly helping the estuaries could be adopted. Figure 33 illustrates the

Table 5. Comparison of Proposed Schedules with Base Run

Run #	# Days Zone A	Demand Not Met (AF)	Sept 1 Stage (ft) Mean	Sept 1 Stage (ft) Max	Stage Exceeded 14 ft	15 ft	16 ft	17 ft	18 ft
1	0	0	0.00	0.00	0	0	0	0	0
2	-43	200	-0.02	-0.29	0	-1	-1	-1	0
3	-68	33900	-0.02	-0.29	-1	-2	-3	-7	-1
4	-24	23500	-0.05	0.03	-1	-2	-2	-5	0
5	-61	0	-0.01	-0.29	0	0	-1	-1	0
6	-21	-5800	0.00	0.00	0	0	0	0	0
7	-99	-10900	-0.14	0.03	-3	-5	-6	-9	-1
8	-95	144100	-0.01	-0.21	0	0	-1	-1	0
9	-96	282900	-0.30	-0.59	-4	-7	-11	-5	-1
10	-99	310700	-0.31	-0.56	-5	-8	-12	-6	-1
11	-2	-187900	0.17	0.26	2	1	6	2	1
12	-53	193500	-0.25	0.02	-4	-7	-13	-9	0
13	-23	-5800	0.01	0.10	0	0	0	0	1
14	-153	343100	-0.39	-0.63	-4	-7	-16	-9	-2
15	-107	91900	-0.10	-0.20	-2	-3	-4	-7	-2
16	-119	124400	-0.15	-0.24	-2	-4	-6	-11	-2
17	-198	2299300	-1.37	-1.70	-25	-35	-28	-12	-2
18	49	2311800	-1.39	-1.81	-26	-38	-31	-15	-3
19	-38	124500	-0.13	0.03	-3	-6	-7	-7	0
20	-54	381100	-0.35	0.03	-5	-10	-9	-4	0
21	-165	525600	-0.53	-0.85	-6	-12	-16	-9	-2
22	-207	2079400	-1.18	-1.39	-20	-31	-27	-12	-2
23	-208	1193400	-1.20	-1.40	-20	-32	-27	-12	-2
24	-111	-16200	-0.04	-0.16	-2	-2	-1	-8	-1
25	-122	54400	-0.15	-0.39	-2	-3	-6	-6	-1
26	-86	-109600	0.06	-0.14	0	0	3	-2	-1
27	-88	-99100	0.04	-0.16	0	0	2	-3	-1
28	-89	-73000	0.02	-0.16	-1	-1	1	-3	-1
29	-89	-93400	0.03	-0.16	-1	-1	2	-3	-3
30	-129	123400	-.21	-.45	-3	-4	-7	-7	-1
31	-133	169100	-.24	-.49	-3	-6	-9	-7	-1

trade off analysis between regulation schedules 24, 25, 30, and 31. These schedules, in general, would also improve the conditions for the littoral zone and flood protection. Schedule 25 appears to be the most favorable schedule since it reduces the frequency of Zone A discharges substantially without increasing the demands not met during critical dry periods. This schedule also improves flood protection and slightly reduces the frequency of high stages. Figure 34 plots results of schedule 25 against the base run.

Stage plots for the entire study period appear in Appendix D for Schedules 24 and 25 in addition to those that were simulated with the current operation schedule.

TABLE 6. Lake Okeechobee Demands Not Met (in acre-feet) During Critical Dry Periods

	1956	1962	1963	1964	1965	Total 62-65	1971	1972	1973	1974	Total 71-74	1981	1982	Total 81-82
Run 1	11200	14900	10300	12100	6300	43600	44300	2300	75800	300700	423100	189900	365700	555600
Run 2	11200	14900	10300	12100	6300	43600	44300	2300	76000	300700	423300	189900	365700	555600
Run 3	12000	27500	10700	12400	6300	56900	44300	2400	78500	300700	425900	206700	365700	572400
Run 4	12000	27400	10700	12200	6300	56600	44300	2300	75800	300700	423100	199400	365700	565100
Run 5	11200	14900	10300	12100	6300	43600	44300	2300	75800	300700	423100	189900	365700	555600
Run 6	11200	14900	10300	12100	6300	43600	40900	2300	73400	300700	417300	189900	365700	555600
Run 7	11200	18500	10400	12400	6300	47600	44200	2200	64100	300700	411200	186900	365700	552600
Run 8	22100	61400	12800	13100	12500	99800	50600	2300	75800	305300	434000	224200	365700	589900
Run 9	35300	59600	12800	12800	9600	94800	74500	16900	89600	309400	490400	240000	365700	605700
Run 10	35300	67900	12900	12900	9600	103300	74900	19400	86900	309400	493300	250400	365700	616100
Run 11	7300	0	7400	11200	3600	22200	27700	2200	35400	298700	364000	119800	342400	462200
Run 12	32700	76800	13000	13000	9600	112400	31700	2200	61300	300700	395900	199000	363500	562500
Run 13	11200	14900	10300	12100	6300	43600	40900	2300	73400	300700	417300	189900	365700	555600
Run 14	61000	24100	10700	12200	6300	53300	70200	14200	89500	304800	478700	288200	365700	653900
Run 15	28300	18400	10400	12300	6300	47400	47300	2300	71600	300700	421900	221600	365700	587300
Run 16	28300	39100	11700	12800	9600	73200	50500	2300	72400	300700	425900	221600	365700	587300
Run 17	305400	450700	22100	48900	36300	558000	430100	55300	179100	339900	1004400	643500	378500	1022000
Run 18	315400	450700	22100	49100	36300	558200	434800	57600	179100	335100	1006600	643500	378500	1022000
Run 19	24800	64600	12900	12900	9600	100000	44300	2300	75900	300700	423200	231900	365700	597600
Run 20	58100	126800	14100	13600	12600	167100	79900	19600	93300	309400	502200	274500	365700	640200
Run 21	50200	126700	13600	13400	12600	166300	119900	26600	106900	309400	562800	327300	365800	693100
Run 22	300000	438600	23000	52900	39500	554000	364600	45000	179000	333000	921600	579700	374400	954100
Run 23	196800	231200	17300	15400	18400	282300	221500	55500	112500	311400	700900	447100	365900	813000
Run 24	22700	22400	10700	12200	6300	51600	31500	2200	53400	300700	387800	152900	361000	513900
Run 25	19200	32600	11300	12400	6300	62600	37700	2300	73400	300700	414100	189900	365700	555600
Run 26	11700	3300	9700	12000	6000	31000	30900	2200	46900	298700	378700	144500	356700	501200
Run 27	1200	9300	10000	12100	6200	37600	30900	2200	46900	298700	378700	144500	357100	501600
Run 28	13700	16500	10400	12100	6300	45300	30900	2200	46900	298700	378700	149700	358200	507900
Run 29	12000	11100	10000	12100	6200	39400	30900	2200	46900	298700	378700	144600	358200	502800
Run 30	23200	47100	12200	12800	9600	81700	50600	2300	75800	305300	434000	207300	365700	573000
Run 31	24300	69700	12900	13200	12600	108400	50600	2300	73800	305300	432000	227100	365700	592800

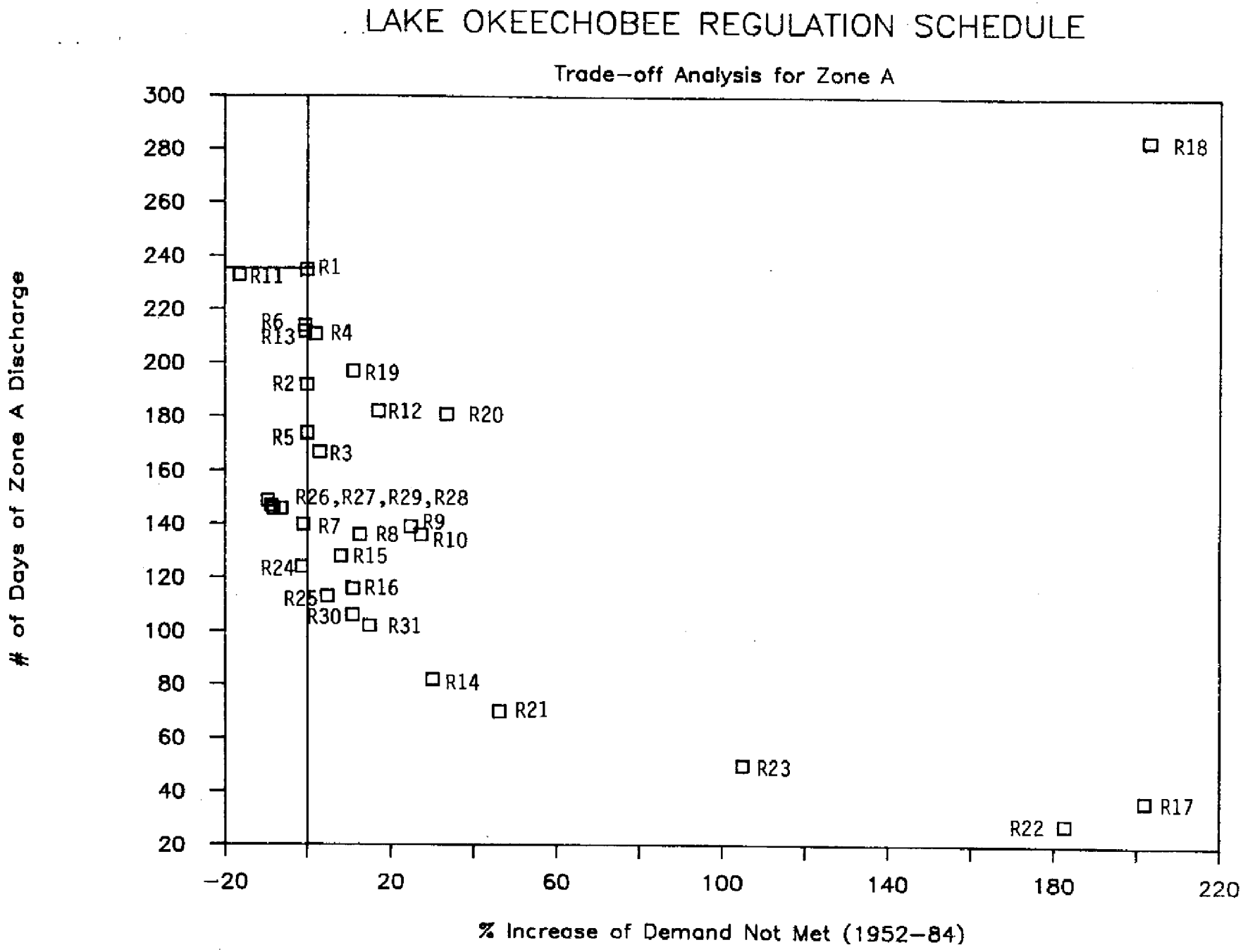


FIGURE 26 TRADE OFF ANALYSIS - ZONE A DISCHARGES VERSUS DEMAND NOT MET

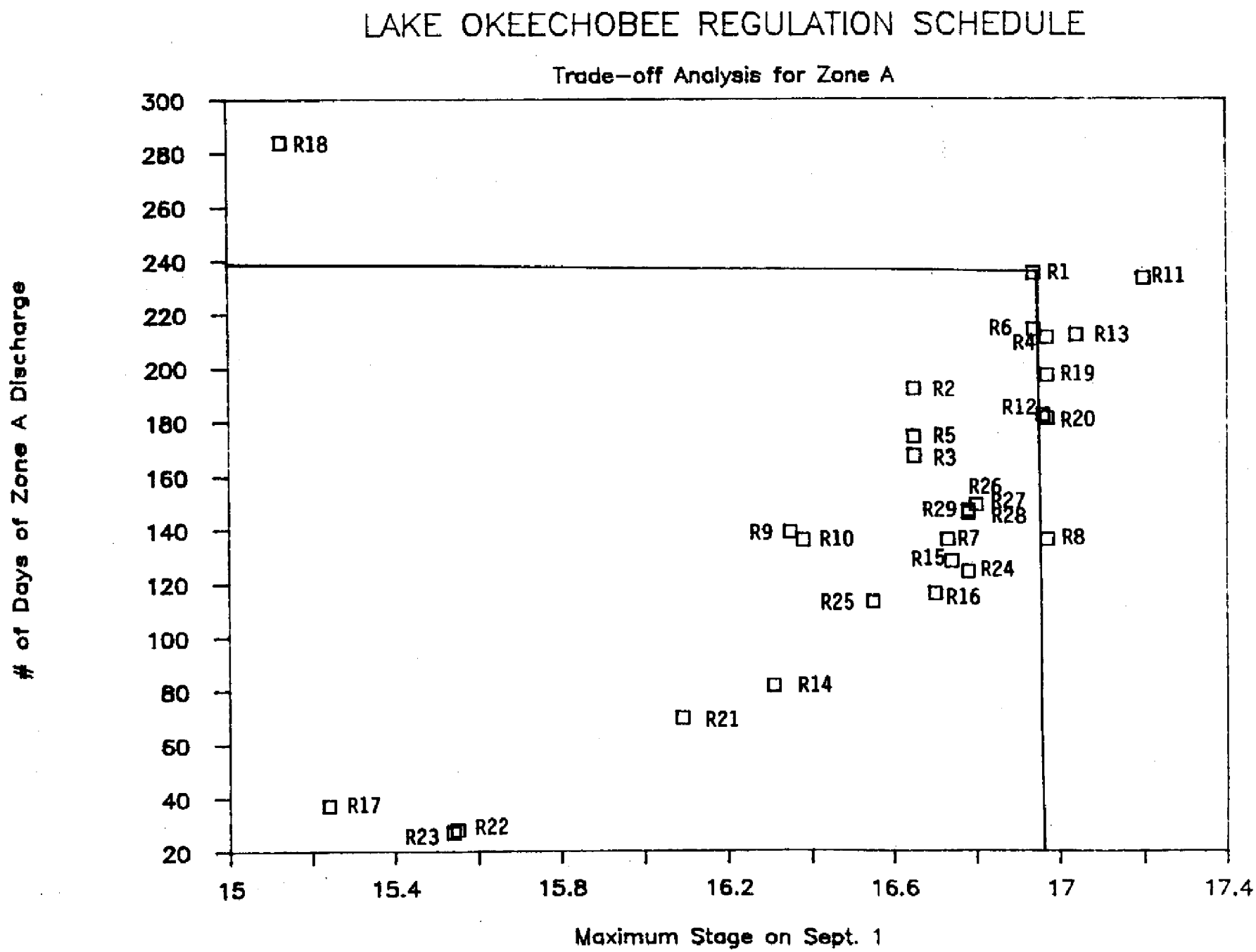


FIGURE 27 TRADE OFF ANALYSIS - ZONE A DISCHARGES VERSUS MAXIMUM STAGE ON SEPTEMBER 1

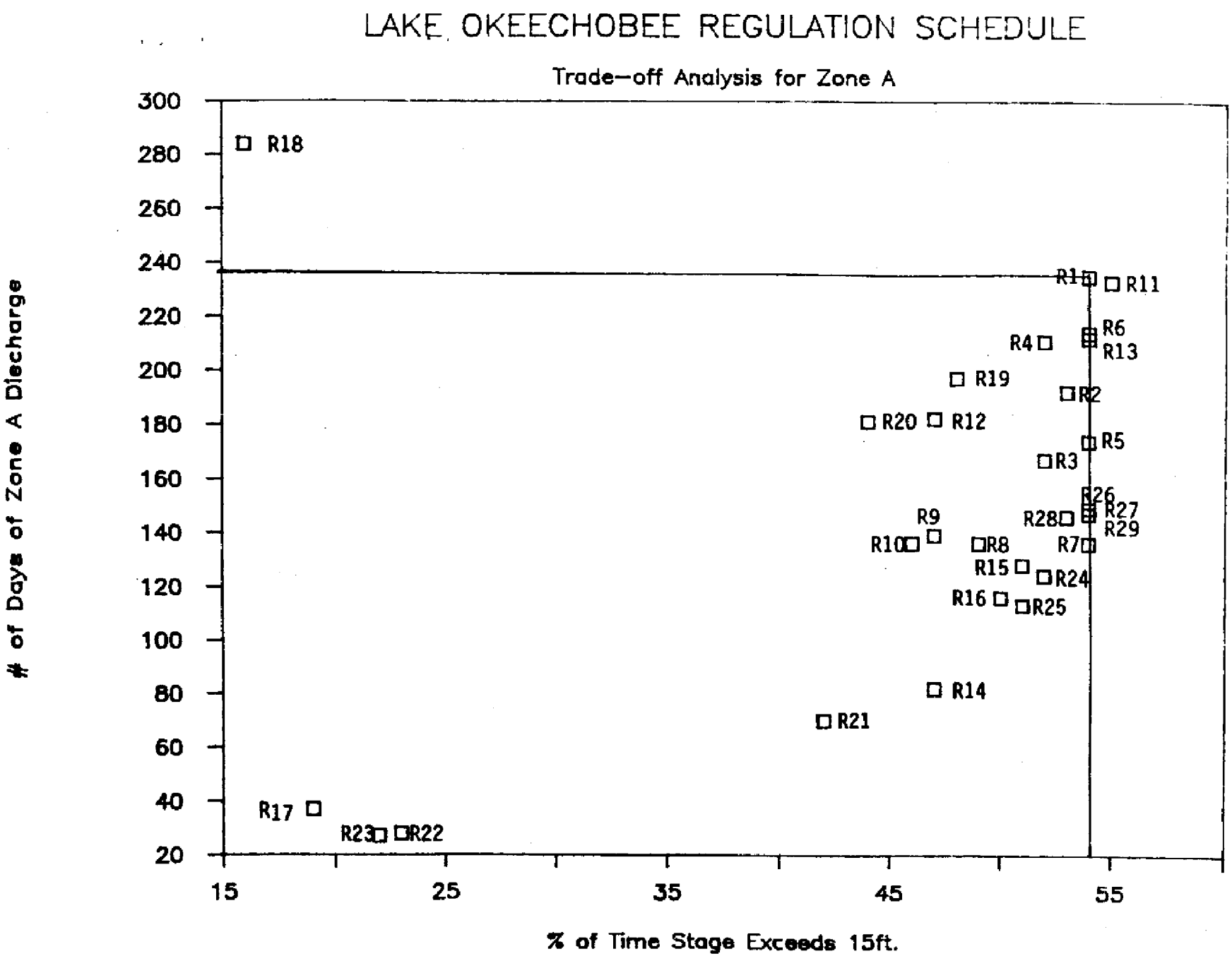


FIGURE 28 TRADE OFF ANALYSIS - ZONE A DISCHARGE VERSUS PERCENTAGE OF DAYS STAGE EXCEEDS 15 FEET

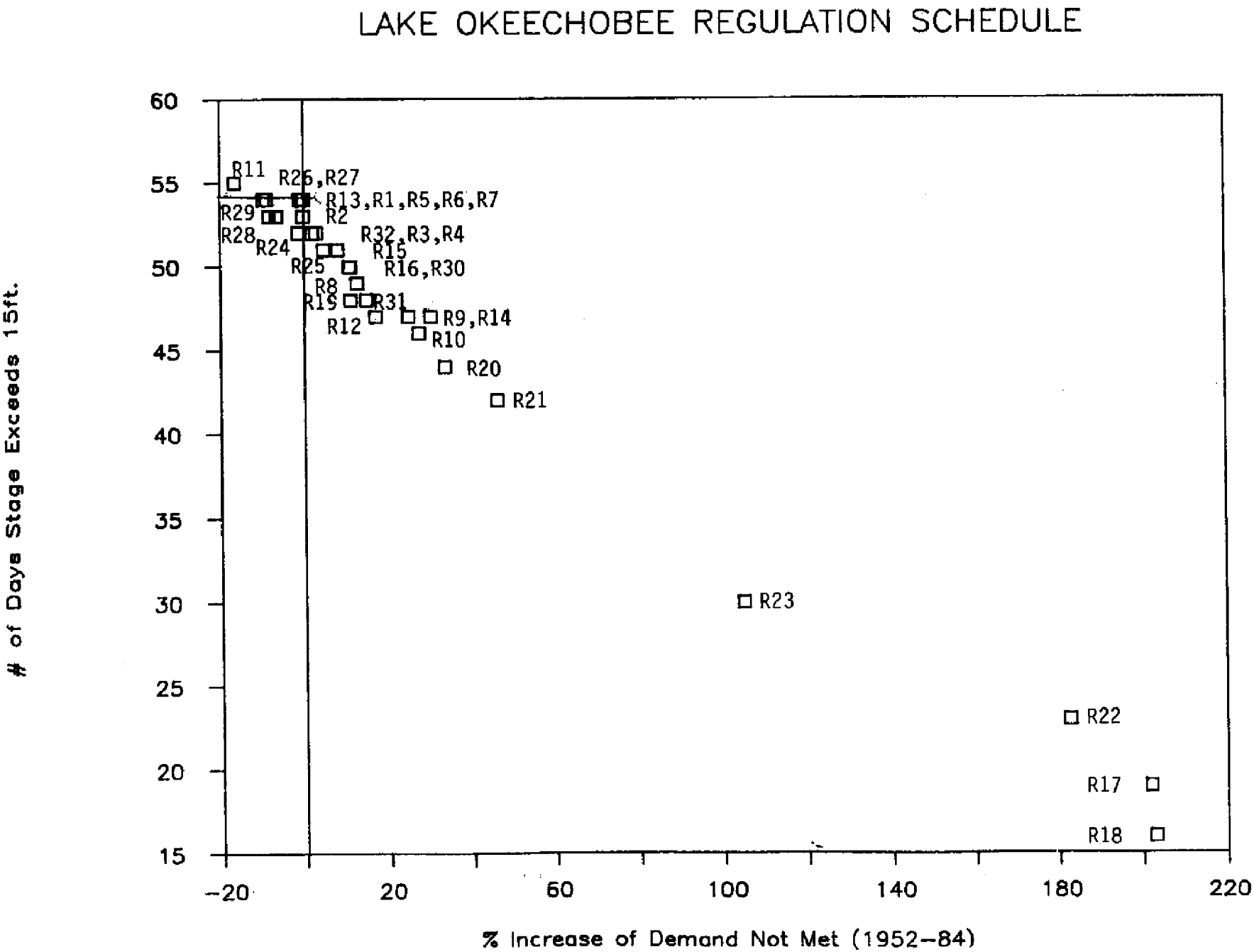


FIGURE 29 TRADE OFF ANALYSIS - PERCENTAGE OF DAYS STAGE EXCEEDS 15 FEET VERSUS DEMAND NOT MET FOR STUDY PERIOD

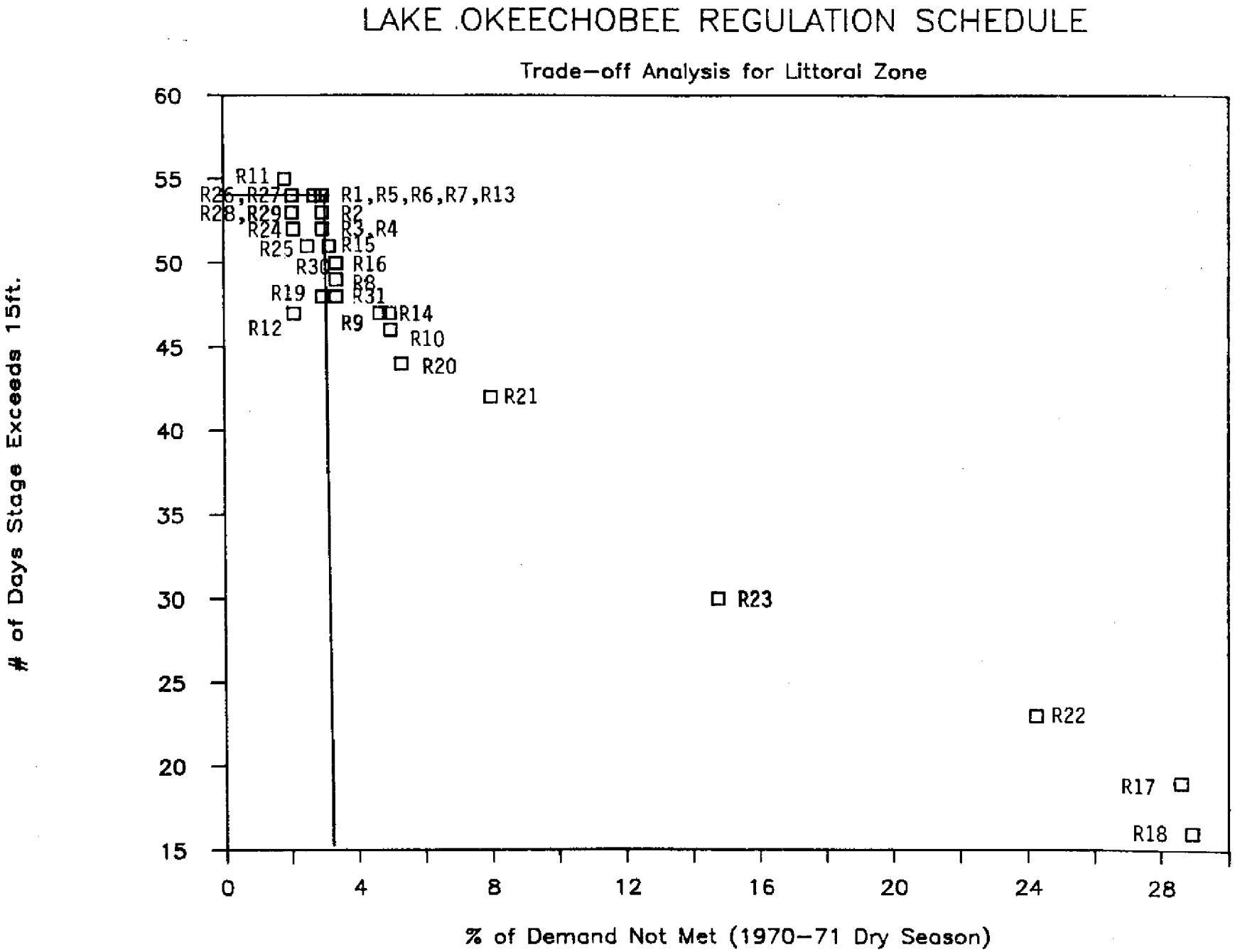


FIGURE 30 TRADE OFF ANALYSIS - PERCENTAGE OF DAYS STAGE EXCEEDS 15 FEET VERSUS DEMAND NOT MET 1970 - 1971 DROUGHT

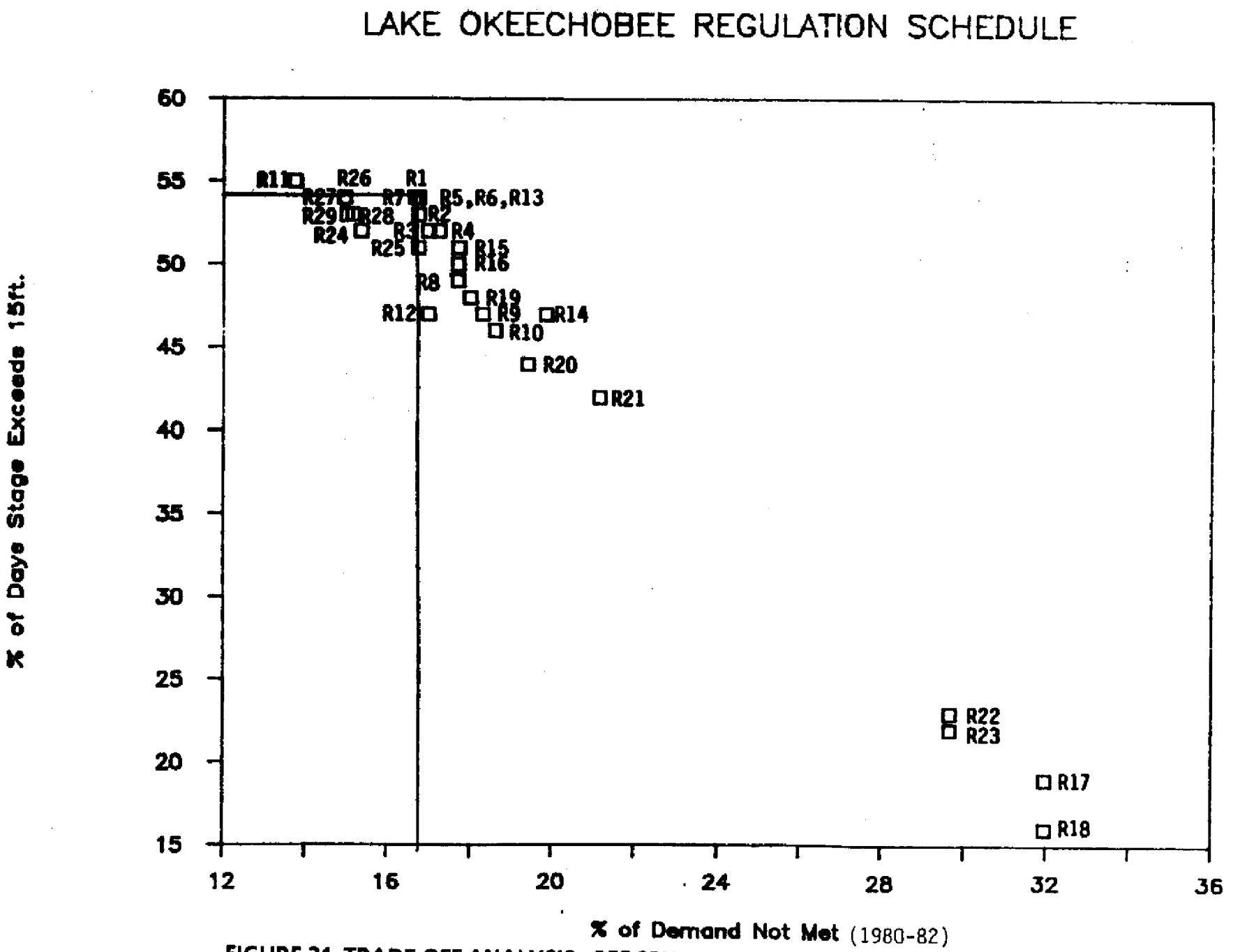


FIGURE 31 TRADE OFF ANALYSIS - PERCENTAGE OF DAYS STAGE EXCEEDS 15 FEET VERSUS DEMAND NOT MET 1980 - 1982 DROUGHT

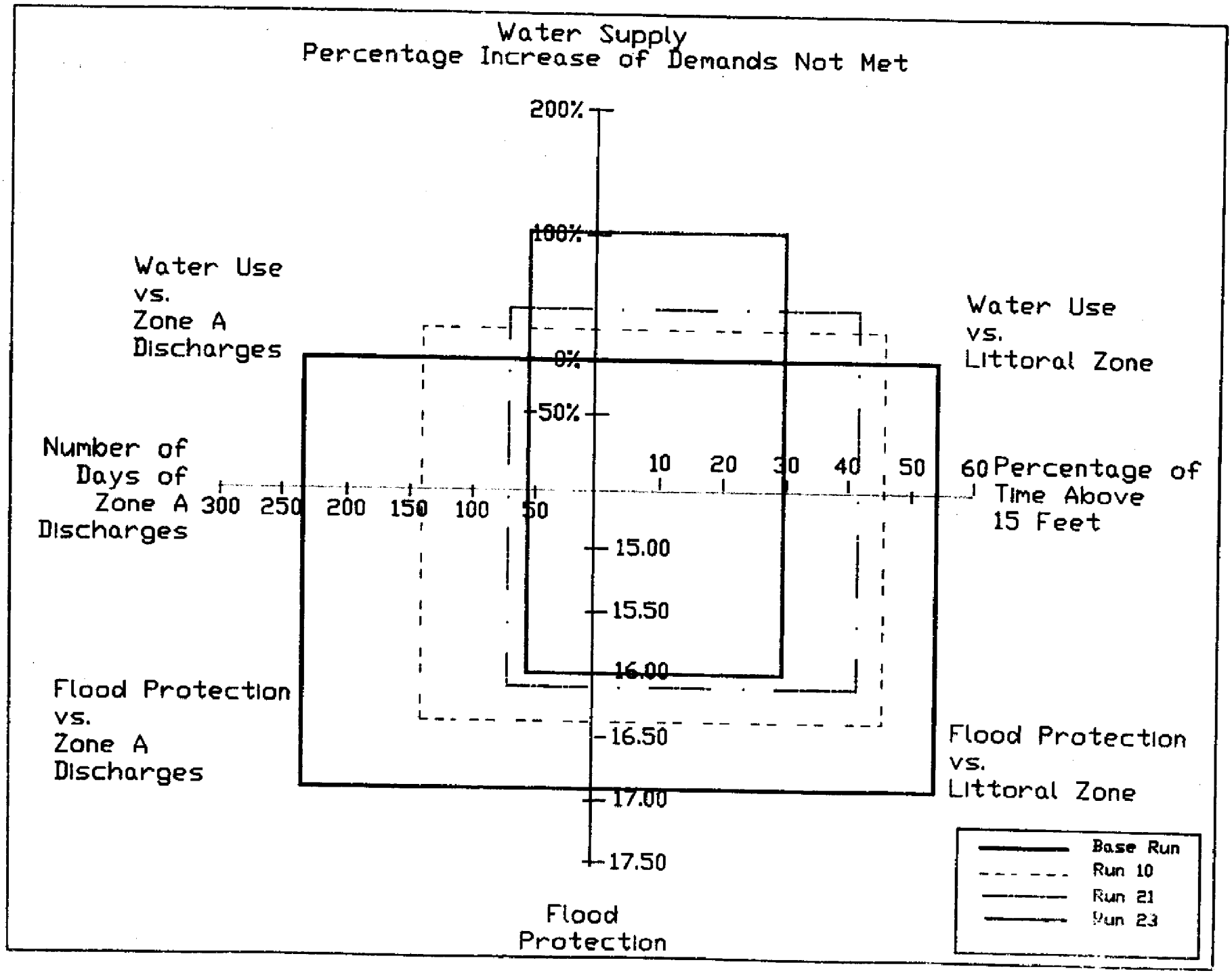


FIGURE 32 TRADE OFF ANALYSIS - COMPARING A VARIETY OF SCHEDULES TESTED

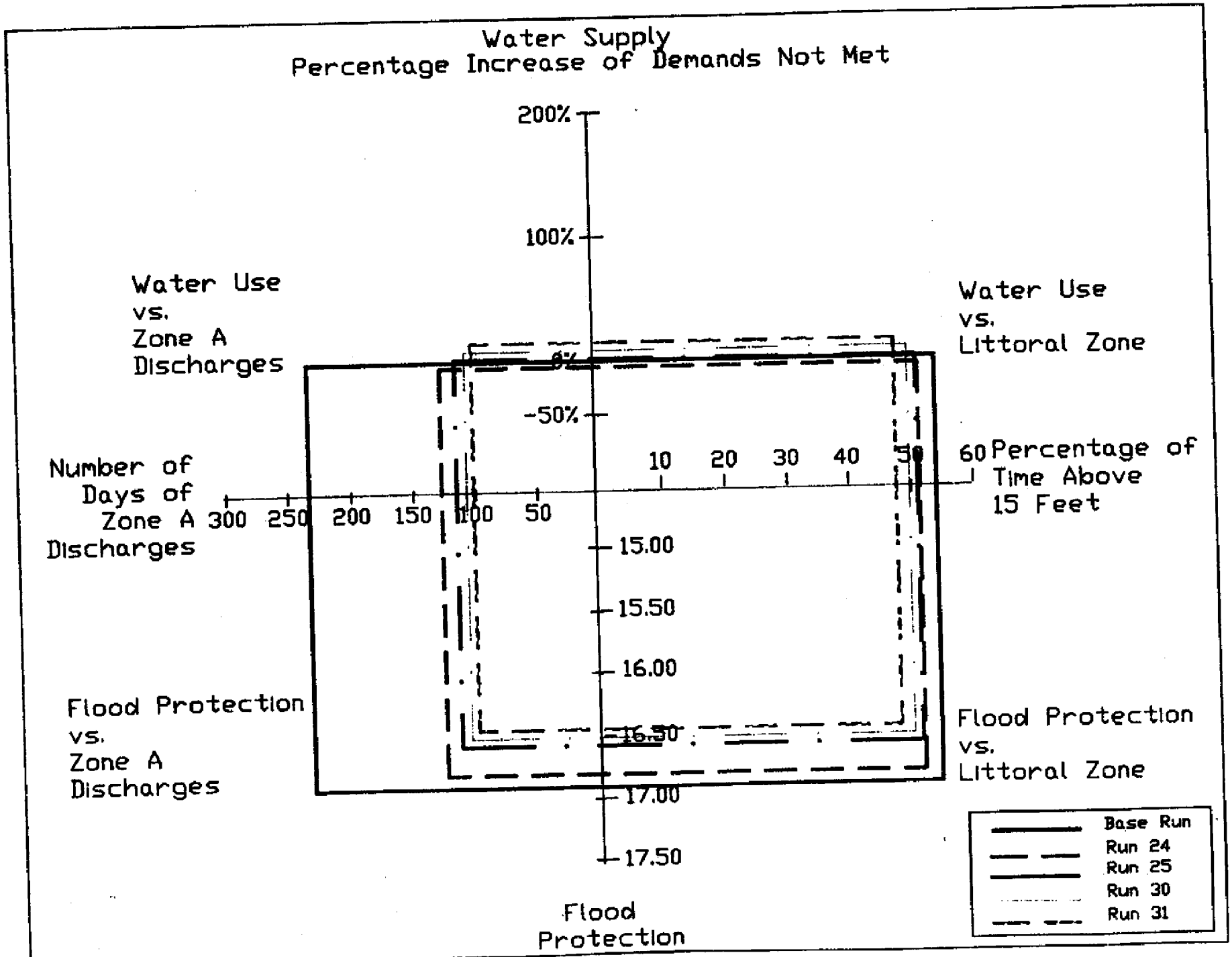


FIGURE 33 TRADE OFF ANALYSIS - COMPARING FAVORABLE SCHEDULES

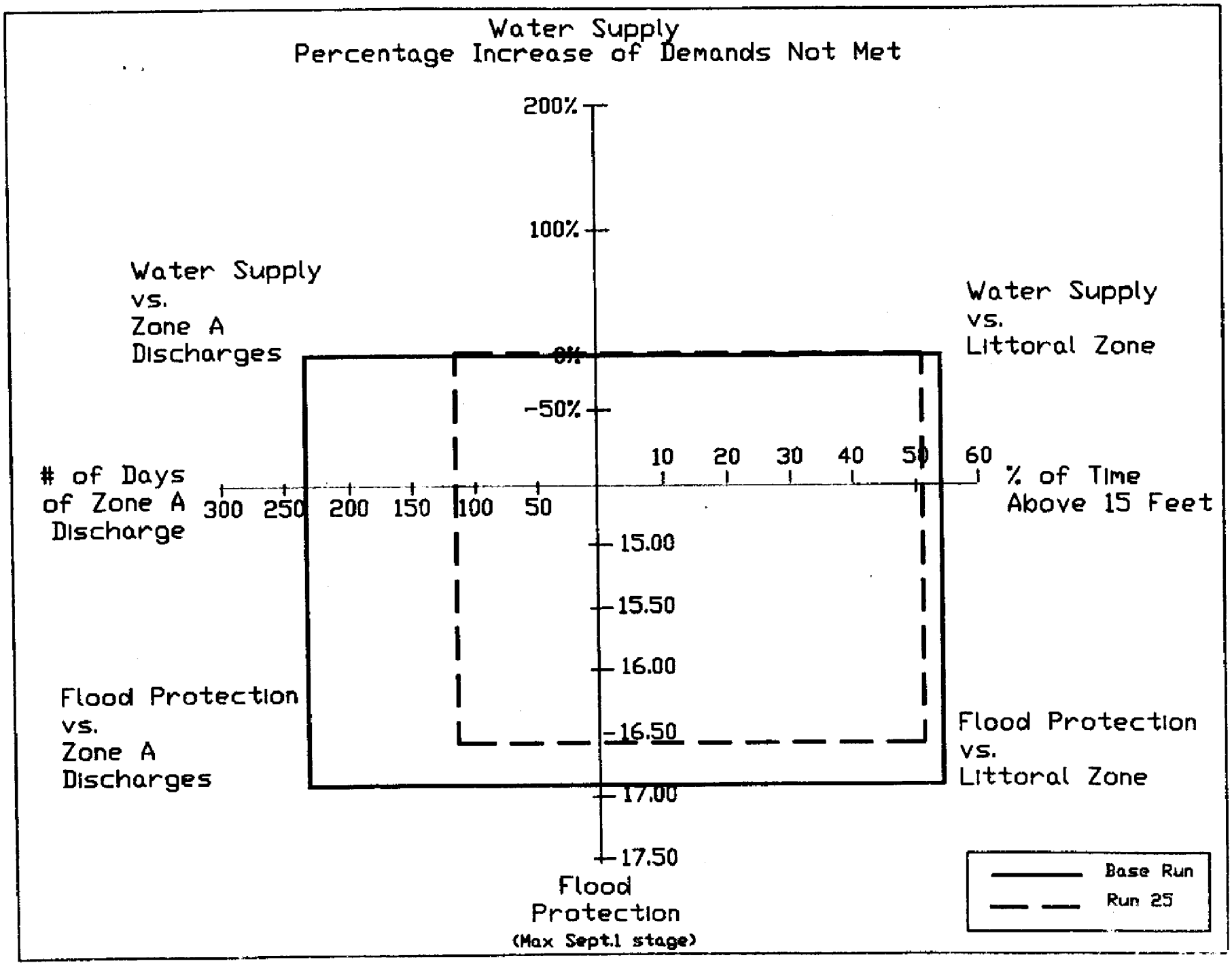


FIGURE 34 TRADE OFF ANALYSIS - REGULATION SCHEDULE 25 VERSUS PRESENT SCHEDULE

VII. CONCLUSIONS

A few important conclusions can be made from this study based on the hydrological data simulations performed for the rainfall period 1952 to 1984. These are as follows:

1. It is not normally necessary to have the two feet of storage buildup in the lake in order to satisfy water use requirements. This buildup does significantly enhance the likelihood of Zone A releases during the Spring.

2. It is possible to raise the upper schedule in the Spring without increasing the mean and maximum stage during the peak hurricane season if a new zone of slightly higher Zone B discharges is introduced. These new releases are higher than the present zone B discharges but will not generate velocities that would cause erosion and sediment transport into the estuaries.

3. With this new Zone B introduced, the lake schedule on May 31 could be raised slightly without raising mean and maximum stages for peak hurricane season. This change will help meet additional water use requirements plus reduce the number of Zone A releases required.

4. Although some improvements are made for the littoral zone by not allowing the buildup of water in the fall and winter months, the stage frequency curve generated in the majority of the schedules tested is still well above what occurred historically prior to 1978. To achieve the same stage-frequency curve that occurred between 1952-1978 would cause large and frequent water shortages. This may be an area where some trade offs might be needed.

Schedules 24 and 25 appear to be generally favorable schedules for flood protection, the littoral zone and the estuaries, and do not impact water supply during the major droughts that occurred during the study period.

REFERENCES

Department of the Army, Jacksonville District. 1978. Central and Southern Florida Project, Rules Curves and Key Operation Criteria, Master Regulation Manual. Volume 2, Appendix D. Jacksonville District, Corps of Engineers, Jacksonville, Florida. November 22, 1978.

Haunert, D. E. and J. R. Startzman. 1985. Short Term Effects of a Freshwater Discharge on the Biota of the St. Lucie Estuary, Florida. South Florida Water Management District. Technical Publication 85-1.

Haunert, D. E. 1987. A proposed Supplemental Water Management Strategy to Enhance Fisheries in the St. Lucie Estuary, Florida. South Florida Water Management District. November, 1987.

Neumann, C. J., G. W. Cry, E. L. Caso and B. R. Jarvinen. 1978. Tropical Cyclones of the North Atlantic Ocean. Page 19. National Climate Center, Asheville, North Carolina. June 1978.

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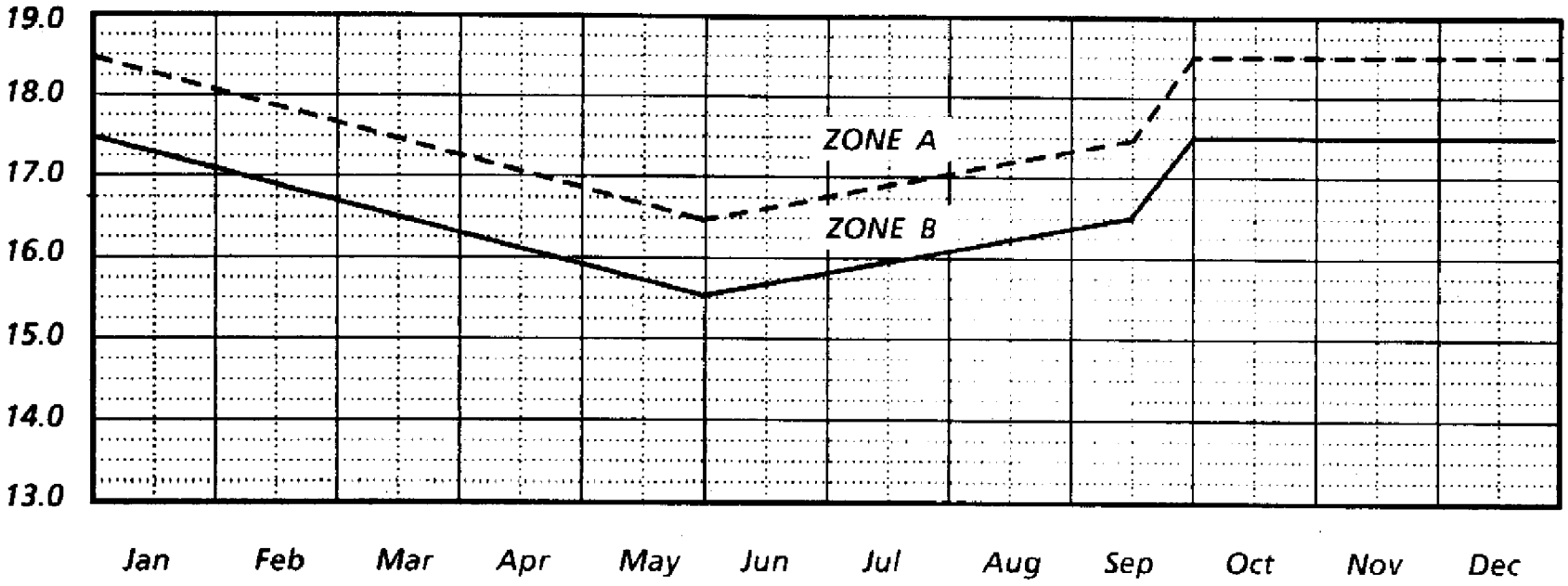
APPENDIX A

Summary Sheets for Regulation Schedules Tested

Regulation Schedule: RUN 1

Description: Present operational schedule.

Comment: This is the base for comparision for other schedules analyzed in this report



A - 1

Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Pump maximum practicable to WCA's	Up to 4500 cfs at S-77	Up to 2500 cfs at S-80

Run 1 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		47				19			18.08	15.13	15.38
1953		101			31	66			19.05	14.92	14.94
1954	16	159				96			18.33	15.51	15.52
1955		40				18			17.45	15.15	15.17
1956									15.87	11.27	12.37
1957						71			17.68	13.76	15.07
1958	14	159				34			18.18	15.68	16.16
1959		93			16	137			18.57	15.23	15.62
1960	7	206			53	82			18.57	15.60	15.51
1961	2	129							17.53	13.06	15.51
1962									15.98	11.39	13.37
1963									15.49	11.42	13.07
1964									14.49	12.23	12.40
1965									14.65	11.38	11.71
1966						82			17.59	16.40	15.10
1967									16.88	13.25	13.43
1968						44			12.36	12.08	12.61
1969		92			10	32			18.78	15.25	15.46
1970	40	144				4			18.44	14.87	15.69
1971									14.87	10.84	11.01
1972									13.61	12.11	12.56
1973									14.32	11.28	11.36
1974						13			16.62	9.96	10.00
1975									15.92	11.99	12.13
1976									14.29	11.60	12.23
1977									14.25	11.69	12.06
1978						10			16.81	13.90	14.06
1979		56				28			18.00	14.29	15.46
1980		109							17.49	14.13	15.51
1981									14.14	9.82	10.49
1982						12			17.65	10.20	10.96
1983	46	67							18.15	14.88	14.91
1984		80				35			17.04	15.28	15.61
Totals	125	1482			110	783					

Flood Protection

Maximum Sept. 1 stage: 16.94 feet NGVD
Mean Sept. 1 stage: 14.76 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	91	79	67	54	35	15	3

Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	514300	5.6	1139500	1.2
1971	117800	22.3	44300	2.9
1974	91800	30.8	294803	19.6
1981	33000	12.6	139881	9.3
1982	1800	0.8	363992	24.2

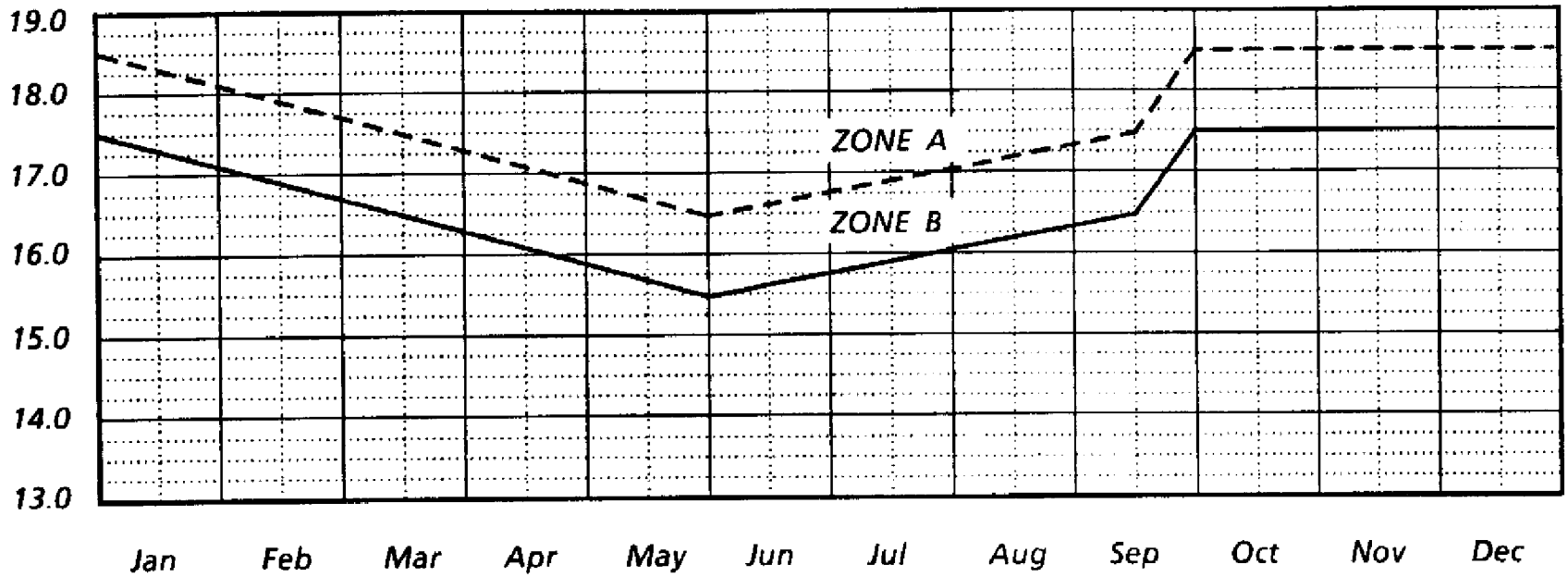
*Total Study Period

Run 2 Summary Sheet 1 of 2

Regulation Schedule: RUN 2

Description: Same as base run except with 3500 cfs releases at S-80 when lake is in zone B.

Comment: Reduced zone A discharges from 233 days to 192 days for the model period. 3500 cfs releases are not desirable over extended periods.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	4500 cfs	3500 cfs

Run 2 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		46				19			17.99	15.13	15.37
1953		96			28	68			19.05	14.92	14.94
1954	15	159				89			18.14	15.50	15.52
1955		36				18			17.45	15.15	15.17
1956									15.82	11.27	12.37
1957						67			11.65	13.76	15.07
1958	5	168				24			18.05	15.58	15.87
1959		91			6	142			18.51	15.50	15.51
1960	4	209			50	85			18.53	15.50	15.51
1961	2	127							17.52	14.46	15.21
1962									15.98	11.38	11.41
1963									15.49	11.77	13.07
1964									14.49	12.23	12.43
1965									14.65	11.38	11.71
1966						77			17.55	14.40	15.10
1967									16.88	13.25	13.42
1968						40			17.29	12.07	12.61
1969		81			8	33			18.78	15.25	15.46
1970		151				1			18.24	14.86	15.56
1971	31								14.86	10.82	11.00
1972									13.60	12.11	12.55
1973									14.32	11.28	11.35
1974						13			16.62	9.96	10.00
1975									15.92	11.99	12.13
1976									14.29	11.60	12.23
1977									14.25	11.69	12.06
1978						10			16.81	13.90	14.06
1979		54				23			17.95	14.28	15.45
1980		104							17.49	14.13	15.51
1981									14.14	9.82	10.49
1982						8			17.62	10.20	14.85
1983	43	68							18.09	14.81	14.85
1984		71				33			16.99	15.23	15.57
Totals	100	1461			92	92					

Flood Protection

Maximum Sept. 1 stage: 16.65 feet NGVD
Mean Sept. 1 stage: 14.74 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	91	79	67	53	34	14	3

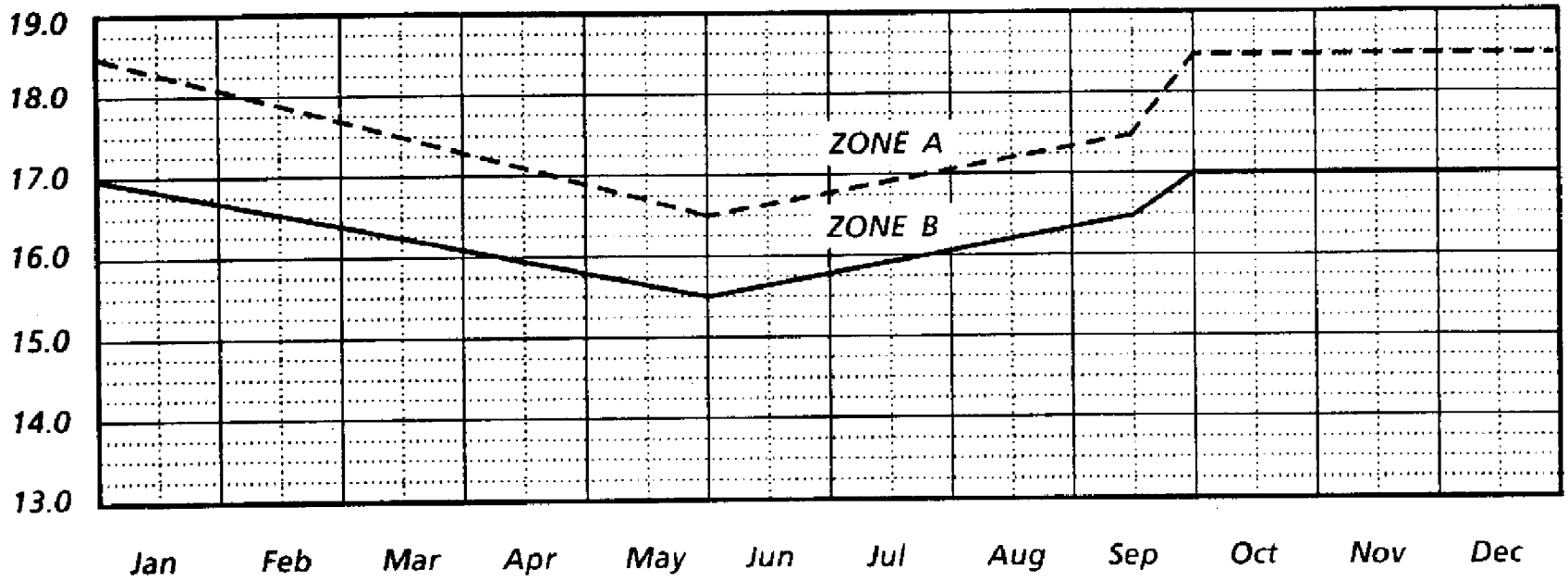
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	514500	5.6	1139700	1.2
1971	118000	22.4	44300	2.9
1974	91800	30.8	294803	19.6
1981	33000	12.6	139881	9.3
1982	1800	0.8	363992	24.2

*Total Study Period

Description: This schedule starts Zone B regulatory releases at lower stages during the period of September 15 thru June 1. Zone B discharges are increased to 3500 cfs at S-80.

Comment: This has the obvious advantage of reducing zone A discharges, although the larger zone B discharges are not desirable for the St. Lucie Estuary.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	4500 cfs	3500 cfs

Run 3 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		49			28	22			17.65	14.89	15.37
1953		87				60			19.05	14.78	14.94
1954	15	145				107			18.14	15.50	15.52
1955		32				5			16.95	14.81	15.17
1956									15.87	11.24	12.37
1957						75			17.25	13.73	15.07
1958		173				14			17.71	15.52	15.87
1959		96			3	150			18.46	15.5	15.51
1960	2	210			60	85			18.53	15.5	15.51
1961	2	114							17.02	14.34	15.51
1962									15.89	11.28	11.41
1963									15.41	11.69	13.07
1964									14.45	12.16	12.46
1965									14.64	11.33	11.71
1966						95			17.13	14.39	15.10
1967									16.37	12.75	13.12
1968						36			17.05	11.69	12.61
1969		78			5	40			18.77	15.22	5.46
1970	30	152							18.15	14.84	15.56
1971									14.85	10.81	11.00
1972									13.60	12.10	12.55
1973									14.32	11.28	11.35
1974						13			16.62	9.96	10.00
1975									15.92	11.99	12.13
1976									14.29	11.60	12.23
1977									14.25	11.69	12.06
1978						10			16.81	13.90	14.06
1979		62				31			17.61	14.00	15.45
1980		94							16.99	14.05	15.51
1981									14.07	9.79	10.49
1982						24			17.33	10.18	10.96
1983	32	79							17.95	14.77	14.85
1984		80				28			16.77	15.15	15.57
Totals	81	1451			86	795					

Flood Protection

Maximum Sept. 1 stage: 16.65 feet NGVD
Mean Sept. 1 stage: 14.74 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	91	79	67	53	34	14	3

Demands Not Met

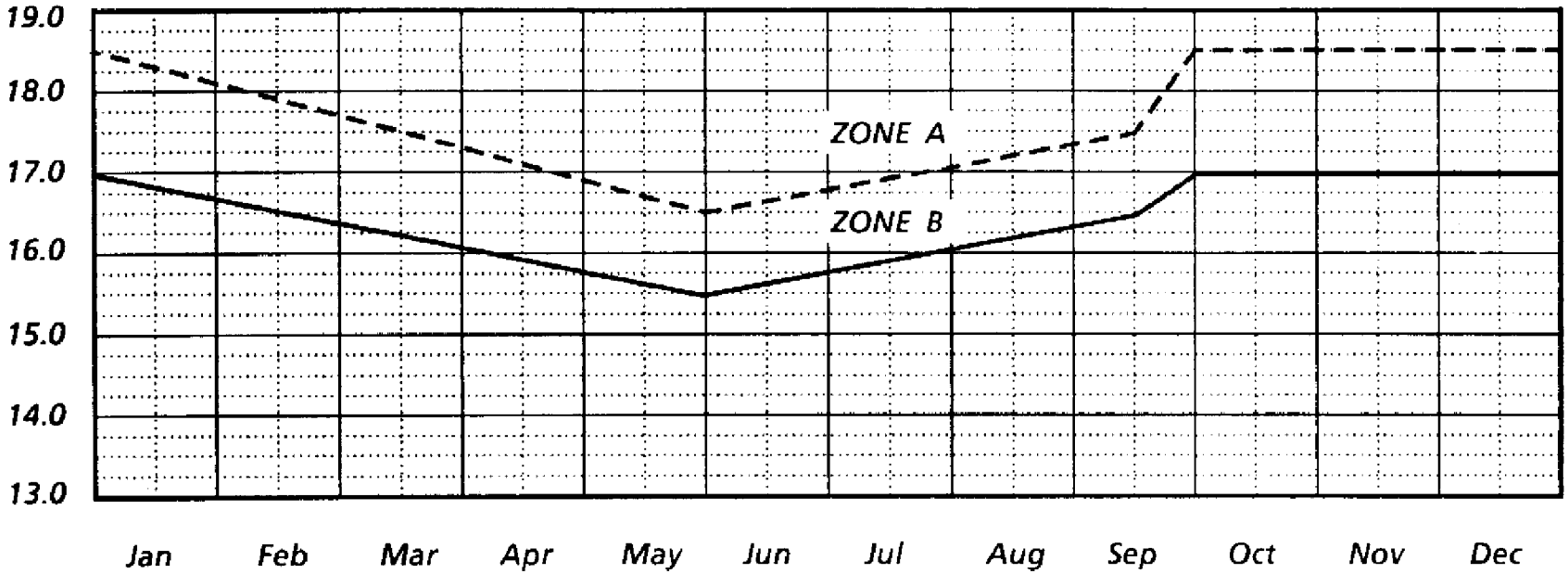
Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	518000	5.6	1173400	1.3
1971	118200	22.4	44300	2.9
1974	91800	30.8	294803	19.6
1981	34300	13.1	139881	9.3
1982	1800	0.8	363992	24.2

*Total study period

Regulation Schedule: RUN 4

Description: Same as schedule 2 except 2500 cfs discharges are made through S-80 in zone B.

Comment: This illustrates the effect of a one and a half foot fluctuation in the lower schedule compared to a two foot fluctuation as is present under base conditions.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	4500 cfs	2500 cfs

Run 4 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		55				23			17.75	14.93	15.16
1953		90			31	58			19.05	14.78	14.80
1954	16	167				116			18.33	15.50	15.51
1955		30				5			16.95	14.81	14.84
1956									15.87	11.24	12.34
1957						80			17.38	13.73	15.25
1958	3	172				34			17.93	15.68	15.16
1959		97			16	137			18.49	15.50	15.51
1960	6	207			53	82			18.57	15.50	15.51
1961	7	117							17.27	14.34	15.37
1962									15.90	11.28	12.31
1963									15.41	11.70	12.99
1964									14.45	12.17	12.41
1965									14.63	11.34	11.68
1966						99			17.36	14.39	15.09
1967									16.37	12.76	12.93
1968						43			17.06	11.69	12.25
1969		86			8	38			18.76	15.22	15.43
1970	39	147				4			18.46	14.87	15.64
1971									14.87	10.84	11.01
1972									13.61	12.11	12.56
1973									14.32	11.28	11.36
1974						13			16.62	9.96	10.00
1975									15.92	11.99	12.13
1976									14.29	11.60	12.23
1977									14.25	11.69	12.06
1978						10			16.81	13.90	14.06
1979		65				32			17.68	14.03	15.19
1980		104							16.99	14.07	15.43
1981									14.08	9.78	10.44
1982						26			17.39	10.18	10.93
1983	37	76							17.69	14.82	14.86
1984		88				31			16.80	15.21	15.51
Totals	103	1501			108	831					

Flood Protection

Maximum Sept. 1 stage: 16.97 feet NGVD
Mean Sept. 1 stage: 14.72 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	96	91	79	66	52	33	10	3

Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	516400	5.6	1163000	1.3
1971	117800	22.3	44300	2.9
1974	91800	30.8	294803	19.6
1981	33300	12.7	154922	10.3
1982	1800	0.8	363992	24.2

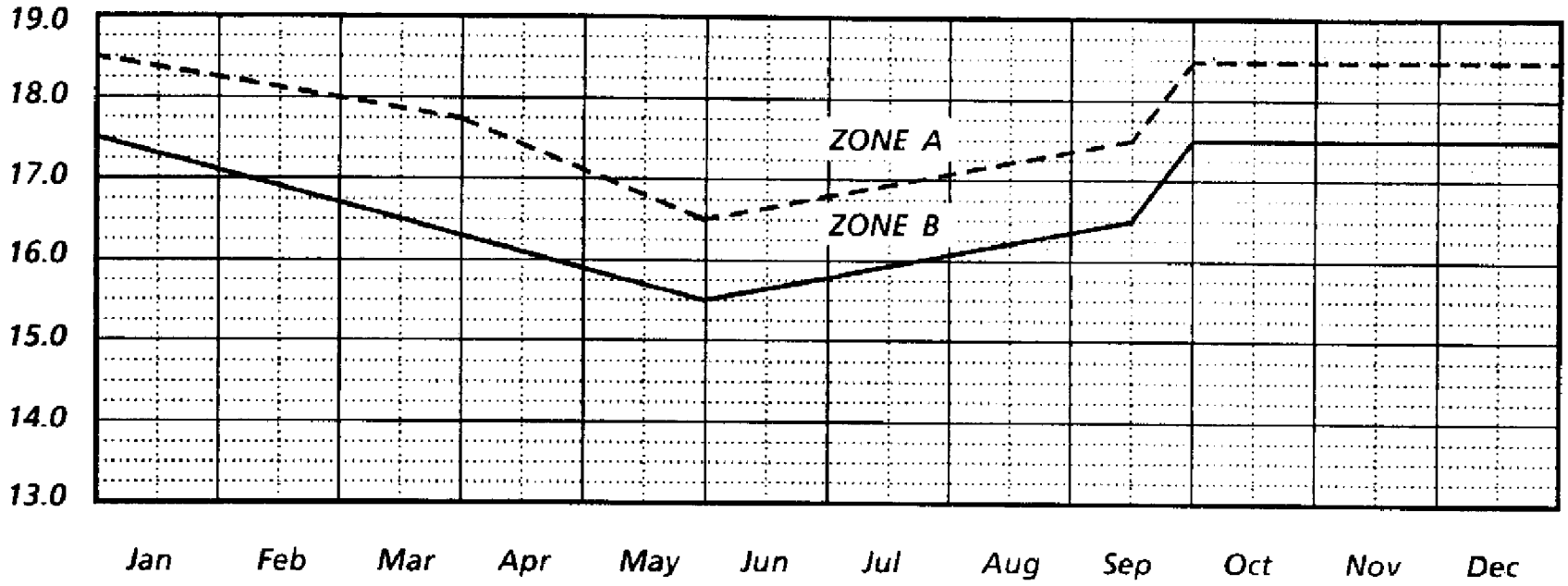
*Total study period

Run 5 Summary Sheet 1 of 2

Regulation Schedule: RUN 5

Description: Start Zone A releases at higher stages during the spring months and define Zone B discharges through S-80 to be 3500 cfs.

Comment: This schedule substantially reduces Zone A discharges while the maximum stages at the beginning of the hurricane season are also reduced. 3500 cfs releases to the St. Lucie estuary are not desirable over extended periods.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	4500 cfs	3500 cfs

Run 5 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		46			28	19			17.99	15.13	15.37
1953		96				68			19.05	14.92	14.94
1954	15	159				89			18.14	15.50	15.52
1955		36				18			17.45	15.15	15.17
1956									15.87	11.27	12.37
1957						67			17.65	13.76	15.07
1958	2	171				28			18.17	15.62	16.00
1959		91			6	142			18.53	15.50	15.51
1960	1	209			50	85			18.53	15.50	15.51
1961	2	127							17.52	14.16	15.51
1962									15.98	11.38	11.47
1963									15.49	11.77	13.07
1964									14.49	12.23	12.46
1965									14.65	11.38	11.71
1966						77			17.55	14.40	15.10
1967									16.88	13.25	13.42
1968						40			17.29	12.07	12.61
1969		81			8	37			18.78	15.25	15.46
1970	26	159				4			18.28	14.87	15.69
1971									14.87	10.84	11.01
1972									13.61	12.11	12.56
1973									14.38	11.28	11.36
1974						13			16.62	9.96	10.00
1975									15.92	11.99	12.13
1976									14.29	11.60	12.23
1977									14.25	11.69	12.06
1978						10			16.81	13.90	14.06
1979		54				23			17.95	14.28	15.45
1980		104							17.49	14.13	15.51
1981									14.14	9.82	10.49
1982						8			17.62	10.20	10.96
1983	33	83							18.25	15.05	15.08
1984		79				33			17.13	15.23	15.57
Totals	82	1459			92	761					

Flood Protection

Maximum Sept. 1 stage: 16.65 feet NGVD
Mean Sept. 1 stage: 14.75 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	91	79	67	54	34	14	3

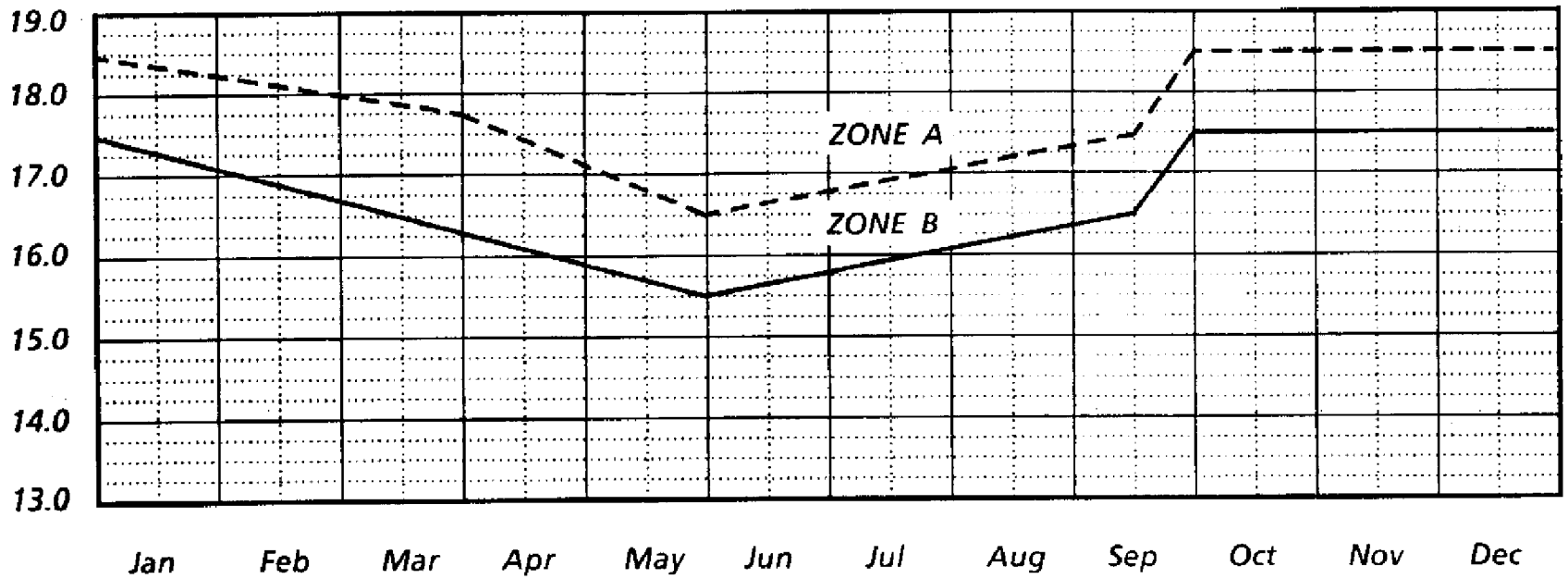
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	514200	5.6	1139500	1.2
1971	117800	22.3	44300	2.9
1974	91800	30.8	294803	19.6
1981	33000	12.6	139881	9.3
1982	1800	0.8	363992	24.2

*Total study period

Description: Same as Run 5 except 2500 cfs discharges are made through S-80 when lake stages are in Zone B.

Comment: This schedule illustrates the effects of starting Zone A releases at higher stages in the spring. No substantial changes occur in the mean or maximum stage at the beginning of the hurricane season.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	4500 cfs	2500 cfs

Run 6 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		47				19			18.08	15.13	15.38
1953		101			31	66			19.05	14.92	14.94
1954	16	166				96			18.33	15.51	15.52
1955		40				18			17.45	15.15	15.17
1956									15.87	11.27	12.37
1957						71			17.68	13.76	14.46
1958	9	164				44			18.25	15.74	16.39
1959		93			16	137			18.5	15.51	15.52
1960	7	206			53	82			18.57	15.50	15.51
1961	2	129							17.53	15.16	15.51
1962									15.98	11.38	11.41
1963									15.49	11.77	13.07
1964									14.49	12.23	12.46
1965									14.65	11.18	11.71
1966						82			17.59	14.40	15.10
1967									16.88	13.25	13.43
1968						44			17.36	12.08	12.61
1969		92			10	32			18.78	15.25	15.46
1970	32	159				7			18.74	14.91	15.80
1971									14.91	10.86	11.03
1972									13.63	12.13	12.57
1973									14.32	11.28	11.36
1974						13			16.62	9.96	10.00
1975									15.92	11.99	12.13
1976									14.29	11.60	12.23
1977									14.25	11.69	12.06
1978						10			16.81	13.90	14.06
1979		56				28			18.00	14.29	15.46
1980		109							17.49	14.13	15.51
1981									14.14	9.82	10.49
1982						12			17.65	10.20	10.96
1983	38	79							18.28	15.10	15.14
1984		89				35			171.17	15.28	15.61
Totals	104	1530			110	796					

Flood Protection

Maximum Sept. 1 stage: 16.94 feet NGVD
Mean Sept. 1 stage: 14.77 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	91	79	67	54	35	15	3

Demands Not Met

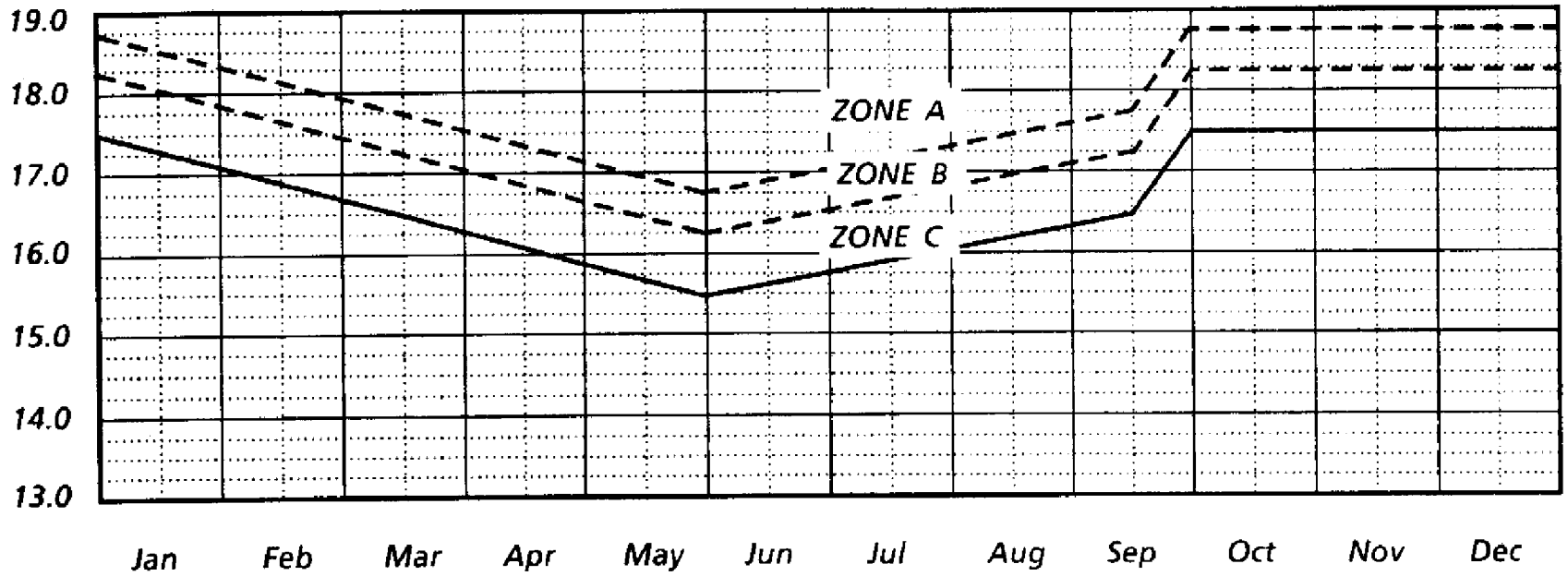
Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	513800	5.6	1133700	1.2
1971	117400	22.2	40900	2.7
1974	91700	30.8	294803	19.6
1981	33000	12.6	139881	9.3
1982	1700	0.7	363992	24.2

*Total study period

Regulation Schedule: RUN 7

Description: Divide the present zone B discharges into zone B and zone C discharges with 3500 cfs releases at S-80 and maximum releases at S-77 being made for the new zone B. Zone A discharges start at a stage of a quarter of a foot higher than present schedule.

Comment: This schedule decreases maximum releases to the St. Lucie Estuary but substantially increases them to the Calooshatchee Estuary.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Maximum capacity at S-77	Maximum capacity at S-80
B	Maximum practicable to WCA's	Maximum capacity at S-77	3500 cfs
C	Maximum practicable to WCA's	4500 cfs	2500 cfs

Run 7 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			47				19		18.07	15.12	15.36
1953			100		20	23	54		19.16	14.92	14.94
1954	11	30	139				98		18.19	15.51	15.52
1955			39				18		17.45	15.15	15.17
1956									15.87	11.25	12.36
1957							67		17.69	13.75	15.06
1958		50	123				30		18.16	15.62	15.94
1959			92			36	116		18.68	15.51	15.52
1960		38	175		44	12	79		18.76	15.50	15.53
1961	1	21	108						17.53	13.46	15.21
1962									15.95	11.35	11.68
1963									15.36	11.77	13.05
1964									15.46	12.16	12.37
1965									14.64	11.34	11.67
1966							81		17.58	14.39	15.08
1967									16.88	13.27	13.45
1968						7	34		17.32	12.09	12.63
1969			90		2	19	22		18.83	15.26	15.46
1970	26	37	121				4		18.40	14.88	15.68
1971									18.40	10.90	11.08
1972									14.88	12.15	12.60
1973									13.65	11.27	11.34
1974							13		14.31	9.99	9.98
1975									16.62	11.99	12.14
1976									15.92	11.60	12.22
1977									14.28	11.69	12.06
1978							10		16.81	13.90	14.06
1979			56				27		17.99	14.32	15.49
1980			109				5		17.49	14.13	15.51
1981									14.15	9.81	10.48
1982							11		17.64	10.18	10.94
1983	36	30	45						18.21	14.83	14.86
1984			75				34		17.01	15.28	15.60
Totals	74	206	1319		62	97	717				

Flood Protection

Maximum Sept. 1 stage: 16.73 feet NGVD
Mean Sept. 1 stage: 14.75 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg.	10	11	12	13	14	15	16	17	18
%	99	97	91	79	67	54	34	14	3

Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	541200	5.9	1128600	1.2
1971	117000	22.2	44200	2.9
1974	97300	32.6	294803	19.6
1981	40000	15.3	136873	9.1
1982	1700	0.7	363992	24.2

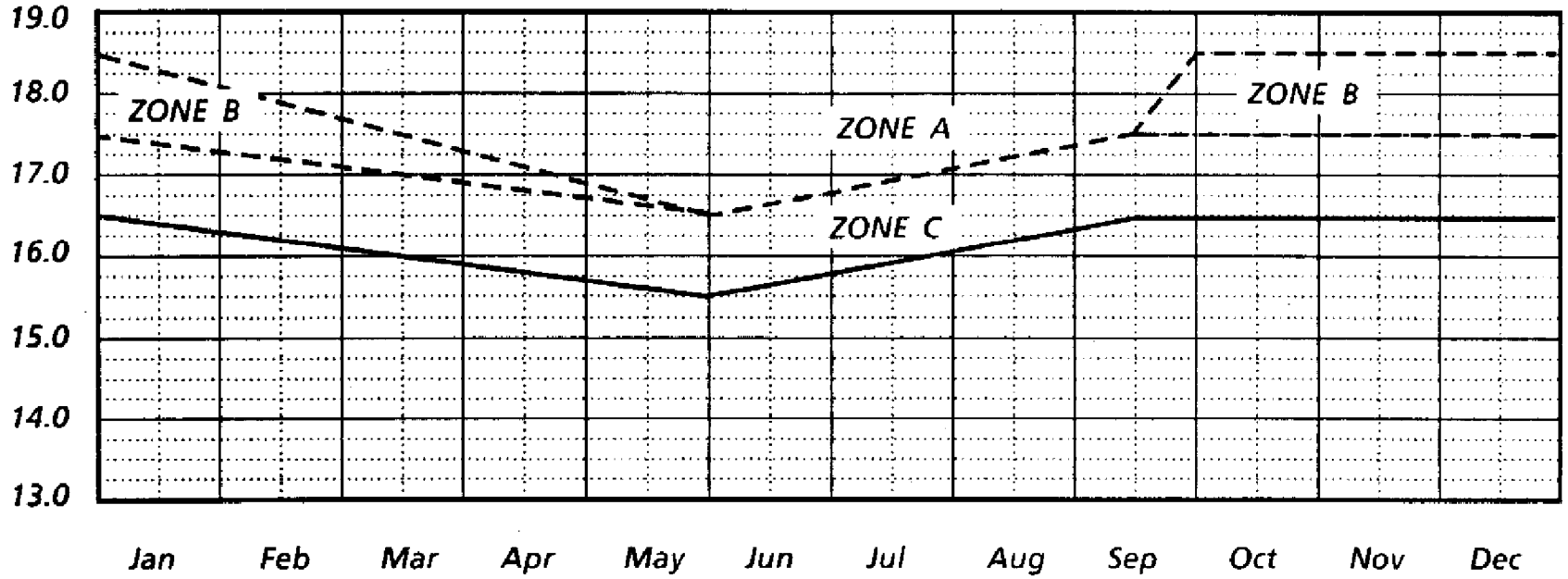
*Total study period

Run 8 Summary Sheet 1 of 2

Regulation Schedule: RUN 8

Description: This schedule begins regulatory releases at lower stages during the period September 15 through May 31 and introduces a new zone of higher releases in an effort to reduce maximum discharges to the St. Lucie Estuary during the late winter and early spring months.

Comment: This schedule has the advantage of decreasing zone A discharges to the St. Lucie Estuary. However, it has the disadvantage of increasing the number of days of maximum discharges made to the Calooshahatchee Estuary..



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum Practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum Practicable to WCA's	Up to maximum capacity at S-77	3500 cfs
C	Maximum Practicable to WCA's	4500 cfs	2500 cfs

Run 8 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			51				26		17.45	14.63	14.88
1953					23	23	38		19.03	14.58	14.60
1954	15	50	92				132		17.52	15.50	15.51
1955			26						16.45	14.44	14.47
1956									15.98	10.92	12.02
1957							76		17.20	13.49	14.84
1958		8	175				59		17.39	15.55	15.68
1959			96		3	10	110		18.44	15.50	15.51
1960		53	145		54	0	81		18.53	15.50	15.51
1961	2	31	76						16.69	13.07	15.11
1962									15.73	11.08	11.10
1963									15.25	11.55	12.81
1964			4				104		14.37	11.99	12.24
1965									14.60	13.25	13.57
1966									16.92	14.36	15.02
1967									15.95	12.35	12.52
1968							53		16.75	11.47	12.05
1969			72			25	27		18.45	15.20	15.40
1970	24	39	118						18.05	14.77	15.44
1971									14.78	10.82	11.00
1972									13.61	12.11	12.56
1973									14.31	11.26	11.34
1974							18		16.50	9.96	9.99
1975									15.80	11.88	12.04
1976									14.24	11.54	12.17
1977									14.21	11.65	12.03
1978							14		16.57	13.88	14.04
1979			72				37		17.42	13.79	14.97
1980			93						16.49	13.92	15.27
1981									13.94	9.71	10.35
1982							33		17.15	10.12	10.88
1983	15	42	55						17.65	14.67	14.70
1984			97				22		16.51	14.99	15.31
Totals	56	223	1172		80	88	825				

Flood Protection

Maximum Sept. 1 stage: 16.97 feet NGVD
Mean Sept. 1 stage: 14.62 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg.	10	11	12	13	14	15	16	17	18
%	99	96	90	77	64	49	29	6	2

Demands Not Met

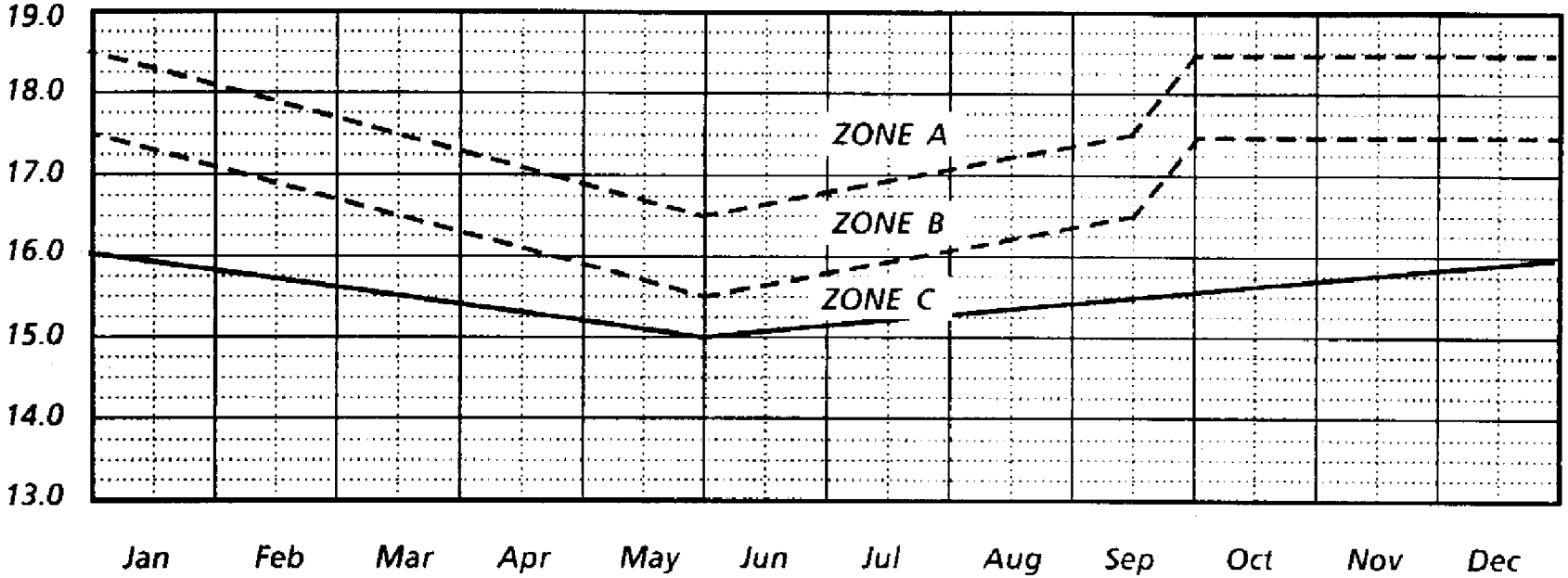
Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	556000	6.0	1283600	1.4
1971	118800	22.5	50600	3.4
1974	97300	32.6	299315	19.9
1981	43600	16.7	168459	11.3
1982	1700	0.7	363992	24.2

*Total study period

Regulation Schedule: RUN 9

Description: This schedule begins regulatory releases at lower stages throughout the year. A new zone of higher releases is introduced at stages where Zone B existed under the present operational policies.

Comment: This schedule reduced maximum Zone A releases by 40 per cent while only slightly decreasing the water requirements met during cruicial years.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6000 cfs	3500 cfs
C	Maximum practicable to WCA's	Maximum non-harmful discharges to Estuary	Maximum non-harmful discharges to Estuary

Run 9 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		10	104			7	74		17.62	14.81	14.92
1953		8	171		23	45	5448		19.00	14.46	14.48
1954	14	112	96			68	9885		17.79	15.47	15.49
1955			135				1819		16.85	14.19	14.22
1956									15.03	10.49	11.54
1957						32	64		17.58	13.17	14.55
1958		140	72			1	152		17.90	15.42	15.49
1959		17	112		1	129	23		18.45	15.49	15.50
1960	1	124	88		43	69	41		18.54	15.46	15.47
1961	2	53	134				9		17.31	14.03	15.68
1962							2		15.73	11.09	11.11
1963									15.21	11.56	12.83
1964									14.38	12.04	12.30
1965									14.60	11.27	11.60
1966			35			40	92		17.49	14.36	14.66
1967			58						15.95	12.39	12.55
1968						27	95		16.61	11.49	12.07
1969		9	145		2	30	117		18.61	15.16	15.37
1970	27	127	41				60		18.06	14.50	15.39
1971									14.51	10.55	10.72
1972									13.47	11.99	12.44
1973									14.29	11.23	11.31
1974						6	79		16.41	9.95	9.99
1975									15.27	11.42	11.60
1976									14.11	11.34	11.99
1977									14.09	11.53	11.89
1978						3	88		16.33	13.78	13.96
1979		14	110			8	36		17.61	13.84	15.00
1980		23	190				5		17.10	13.84	15.21
1981									13.86	9.68	10.32
1982							85		17.42	10.12	10.87
1983	26	53	119				50		17.91	14.65	14.69
1984		14	150			10	106		16.43	15.02	15.31
Totals	70	704	1760		69	475	1330				

Flood Protection

Maximum Sept. 1 stage: 16.35 feet NGVD
Mean Sept. 1 stage: 14.46 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg.	10	11	12	13	14	15	16	17	18
%	99	96	88	76	63	47	24	10	2

Demands Not Met

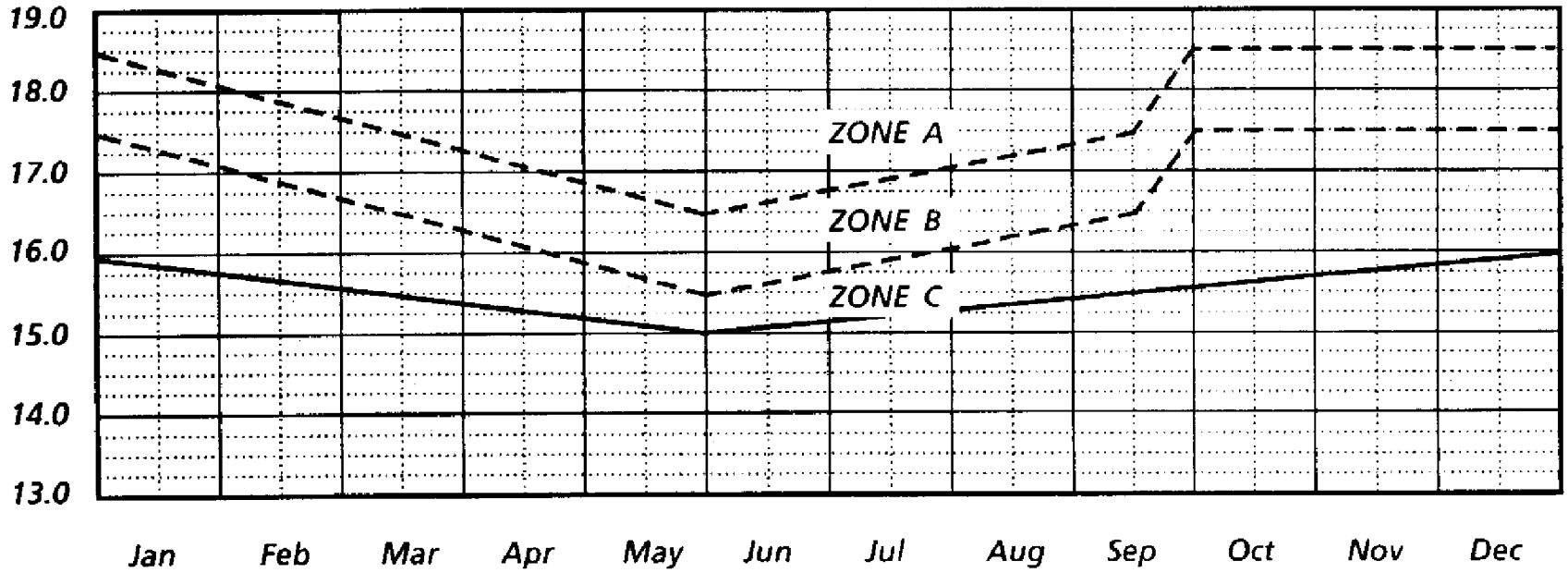
Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	516400	5.6	1422400	1.5
1971	117800	22.3	74500	4.9
1974	92300	30.1	303828	20.2
1981	35900	13.7	186508	12.4
1982	1800	0.8	363992	24.2

*Total study period

Regulation Schedule: RUN 10

Description: Same as Run 9 except Zone C discharges through S-80 structure discontinued during declining stages in Lake Okeechobee.

Comment: Substantial reductions in zone A discharges with favorable changes in the stage frequency curve. Water use requirements satisfied are not substantially reduced.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6000 cfs	3500 cfs
C	Maximum practicable to WCA's	Maximum non-harmful discharges to Estuary	Maximum non-harmful discharges to Estuary when stage is rising

Run 10 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		8	102			7	69		17.61	14.74	14.86
1953		7	165		23	42	46		18.98	14.25	14.27
1954	13	98	101			68	85		17.8	15.48	15.50
1955			125				14		16.75	14.09	14.12
1956									15.03	10.47	11.52
1957						31	65		17.60	14.15	14.54
1958		138	74			1	152		17.88	15.31	15.50
1959		15	104		1	129	23		18.44	15.47	15.47
1960		121	92		14	67	42		18.53	15.48	15.49
1961	2	53	123				3		17.37	13.98	15.03
1962									15.72	11.06	11.08
1963									15.24	11.55	12.81
1964									14.37	12.03	12.29
1965									14.60	11.27	11.59
1966			33			38	94		17.48	14.35	14.63
1967			55						15.89	12.33	12.48
1968						26	96		16.56	11.45	12.04
1969		6	138		2	29	113		18.6	15.13	15.37
1970	27	126	42				55		18.07	14.49	15.38
1971									14.49	10.54	10.71
1972									13.97	11.98	12.43
1973									14.29	11.23	11.30
1974						6	78		16.40	9.95	9.99
1975									15.25	11.41	11.59
1976									14.11	11.34	12.00
1977									14.09	11.53	11.89
1978						3	88		16.32	13.78	13.96
1979		12	107			8	36		17.59	13.82	14.98
1980		16	197				2		17.01	13.80	15.14
1981									13.81	9.66	10.30
1982							85		1741	10.11	10.86
1983	24	55	112				50		17.85	14.64	14.67
1984		10	149			8	99		16.37	14.96	15.25
Totals	66	665	1719		70	463	1295				

Flood Protection

Maximum Sept. 1 stage: 16.38 feet NGVD
Mean Sept. 1 stage: 14.45 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	99	96	88	76	62	46	46	23	9

Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	530900	5.8	1450200	1.6
1971	123100	23.3	74900	5.0
1974	92300	31.0	303828	20.2
1981	35900	13.7	195553	13.0
1982	1700	.7	363992	24.2

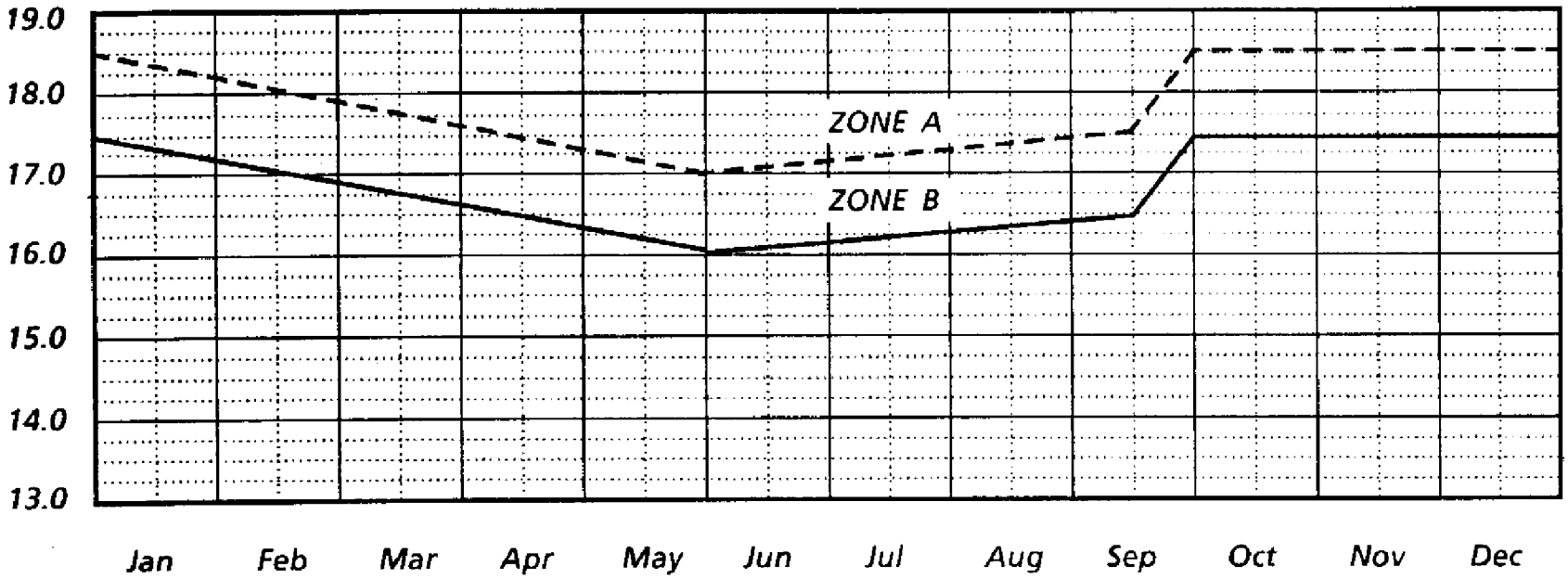
*Total study period

Run 11 Summary Sheet 1 of 2

Regulation Schedule: RUN 11

Description: The regulation schedule varies only 1.5 feet. The low point of the schedule is modified to be at 16 feet instead of 15.5 feet.

Comment: This schedule reduces Zone A releases slightly in the spring. However, the overall annual number of days of zone A releases remained about the same. Mean stages during the hurricane season are about.2 feet higher.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	4500 cfs	2500 cfs

Run 11 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		44				22			18.20	15.36	15.60
1953		90			35	67			19.07	15.28	15.30
1954	16	152				112			18.34	16.00	16.01
1955		34				17			17.45	15.32	15.34
1956									16.01	11.42	12.53
1957						74			17.68	13.89	15.17
1958	6	167				58			18.18	16.07	16.47
1959		81			27	126			18.49	16.00	16.01
1960	6	206			55	87			18.68	16.00	16.01
1961	4	109							17.53	14.83	15.88
1962									16.27	11.75	11.78
1963									15.78	12.00	13.35
1964									14.60	12.44	12.63
1965									14.70	11.48	11.83
1966						83			17.59	14.45	15.15
1967									16.88	13.25	13.43
1968						40			17.48	12.08	12.61
1969		81			13	38			18.75	15.71	15.93
1970	32	150				5			18.71	15.24	16.03
1971									15.24	11.13	11.32
1972									13.80	12.30	12.74
1973									14.33	11.30	11.38
1974						12			16.70	9.97	10.01
1975									15.99	12.07	12.21
1976									14.31	11.63	12.26
1977									14.27	11.71	12.08
1978						31			16.87	13.92	14.07
1979		54				34			18.04	14.49	15.67
1980		98							17.49	14.52	15.93
1981									14.53	10.01	10.71
1982						12			17.69	10.27	11.02
1983	39	72							18.22	15.27	15.30
1984		84				41			17.27	15.68	16.00
Totals	103	1422			130	839					

Flood Protection

Maximum Sept. 1 stage: 17.20 feet NGVD
Mean Sept. 1 stage: 14.93 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	93	81	69	55	41	17	4

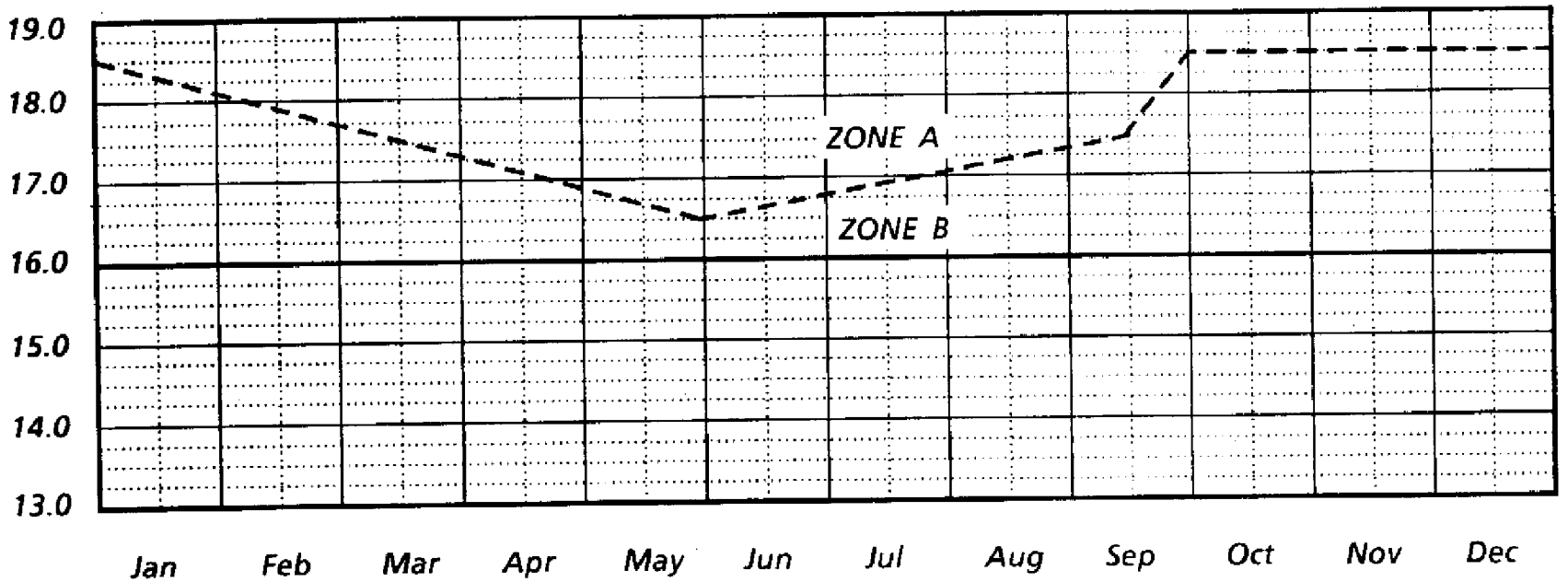
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	500600	5.4	951600	1.0
1971	112600	21.3	227700	15.1
1974	91500	30.7	293299	19.5
1981	29100	11.1	72196	04.8
1982	1708	0.7	341430	22.7

*Total study period.

Description: Zone B releases are started whenever the Lake Okeechobee stage rises above 16 feet, Zone A releases begin when the lake stage rises into Zone A as defined by the present regulation schedule.

Comment: This schedule eleminates the buildup of storage during the autumn months which decreases the chances of Zone A discharges in the spring months. Zone A discharges were decreased by 50 days during the dry season with this schedule while water use requirements satisfied remained about the same as the base run. Mean stages during hurricane season were lower.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	4500 cfs	2500 cfs

Run 12 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		51				30			17.45	14.51	14.76
1953		66			25	59			19.04	14.37	14.40
1954	16	142			3	150			18.32	15.78	16.00
1955		18							15.99	14.07	14.10
1956									15.22	10.56	11.62
1957						75			17.11	13.21	14.60
1958		181				118			16.99	15.89	16.00
1959		60			27	126			18.48	15.69	16.00
1960	6	175			52	91			18.56	15.87	15.87
1961	2	112							17.26	13.95	14.99
1962									15.69	11.02	11.35
1963									15.21	11.53	12.78
1964									14.36	12.31	12.28
1965									14.61	11.26	11.58
1966						120			16.67	14.36	15.06
1967									15.49	11.88	12.03
1968						69			16.33	11.22	11.81
1969		35				75			18.53	15.53	15.82
1970	34	147				3			18.47	15.02	15.78
1971									15.03	10.94	11.12
1972									13.68	12.18	12.62
1973									14.33	11.29	11.36
1974						28			16.17	9.97	10.00
1975									15.33	11.43	11.62
1976									14.11	11.34	12.00
1977									14.09	11.53	11.89
1978						30			16.10	13.79	13.96
1979		65				40			17.28	13.74	14.89
1980		68							16.09	14.08	15.45
1981									14.09	9.79	10.45
1982						58			16.73	10.19	10.94
1983	17	95				23			17.65	14.93	14.96
1984		95				47			16.30	15.17	15.49
Totals	75	1310			107	1142					

Flood Protection

Maximum Sept. 1 stage: 16.96 feet NGVD
Mean Sept. 1 stage: 14.51 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	96	88	76	63	47	22	6	3

Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	526800	5.7	1333000	1.4
1971	115200	21.8	31700	2.1
1974	91600	30.7	294803	19.6
1981	33300	12.7	147401	09.8
1982	1800	0.8	363992	24.2

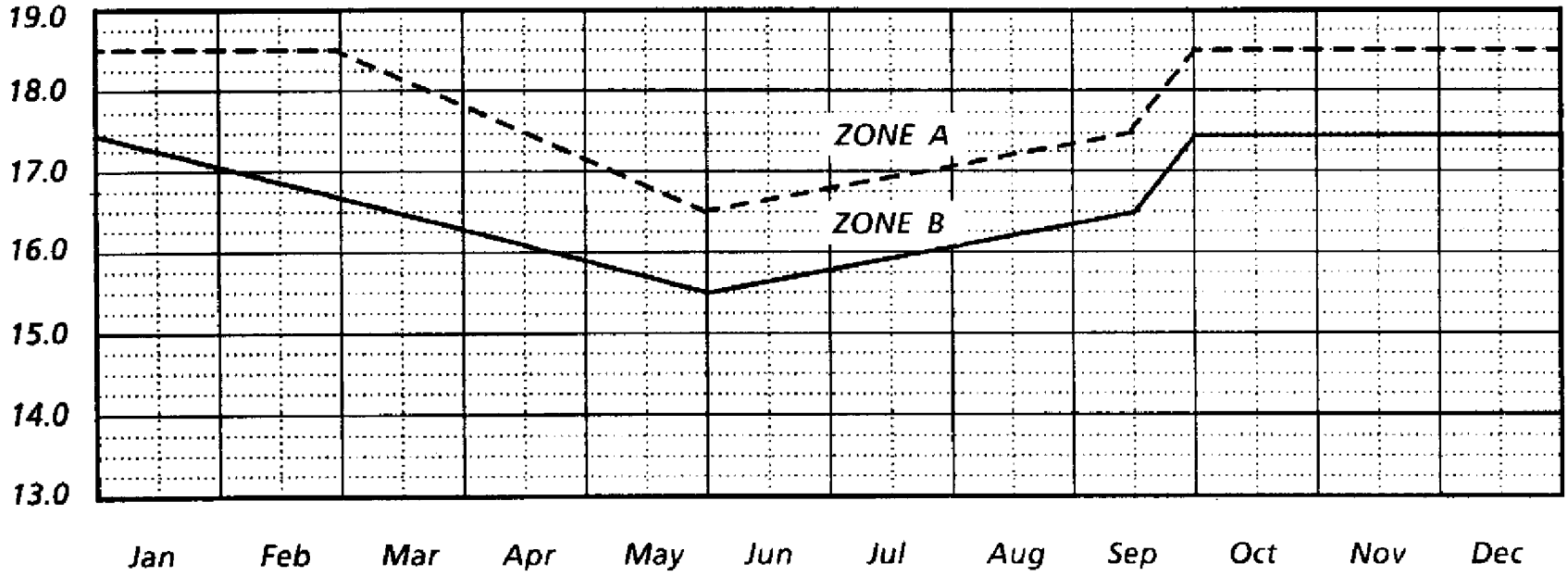
*Total study period

Run 13 Summary Sheet 1 of 2

Regulation Schedule: RUN 13

Description: Similar to schedule 5 this schedule attempts to minimize Zone A releases by raising the upper schedule during the spring months.

Comment: Mean and maximum stages were slightly higher than the base run during peak hurricane season.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	4500 cfs	2500 cfs

Run 13 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		47				19			18.08	15.13	15.38
1953		101			31	66			19.05	14.92	14.94
1954	16	166				96			18.33	15.51	15.57
1955		40				18			17.45	15.15	15.17
1956									15.87	11.27	12.37
1957						71			17.68	13.76	15.07
1958	9	164				44			18.44	15.74	16.40
1959		93			16	137			18.57	15.57	15.51
1960	7	206			53	82			18.57	15.50	15.51
1961	2	129							17.53	14.06	14.11
1962									15.98	11.38	13.07
1963									15.49	11.27	13.07
1964									14.49	12.23	12.36
1965									14.65	11.38	11.71
1966						82			17.59	14.10	15.10
1967									16.88	13.25	13.43
1968						44			17.36	12.08	12.61
1969		92			10	32			18.78	15.25	15.46
1970	32	159				7			18.74	14.91	15.80
1971									14.91	10.86	11.03
1972									13.63	12.13	12.57
1973									14.32	11.28	11.36
1974						13			16.62	9.96	10.00
1975									15.92	11.99	12.13
1976									14.29	11.60	12.23
1977									14.25	11.69	12.06
1978						10			16.81	13.90	14.06
1979		56				28			18.00	14.29	15.46
1980		109							17.49	14.13	15.51
1981									14.14	9.82	10.49
1982						12			17.65	10.20	10.96
1983	36	82							18.70	15.15	15.19
1984		90				35			17.18	15.28	15.61
Totals	102	1534			110	796					

Flood Protection

Maximum Sept. 1 stage: 17.04 feet NGVD
Mean Sept. 1 stage: 14.77 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	91	79	67	54	35	15	4

Demands Not Met

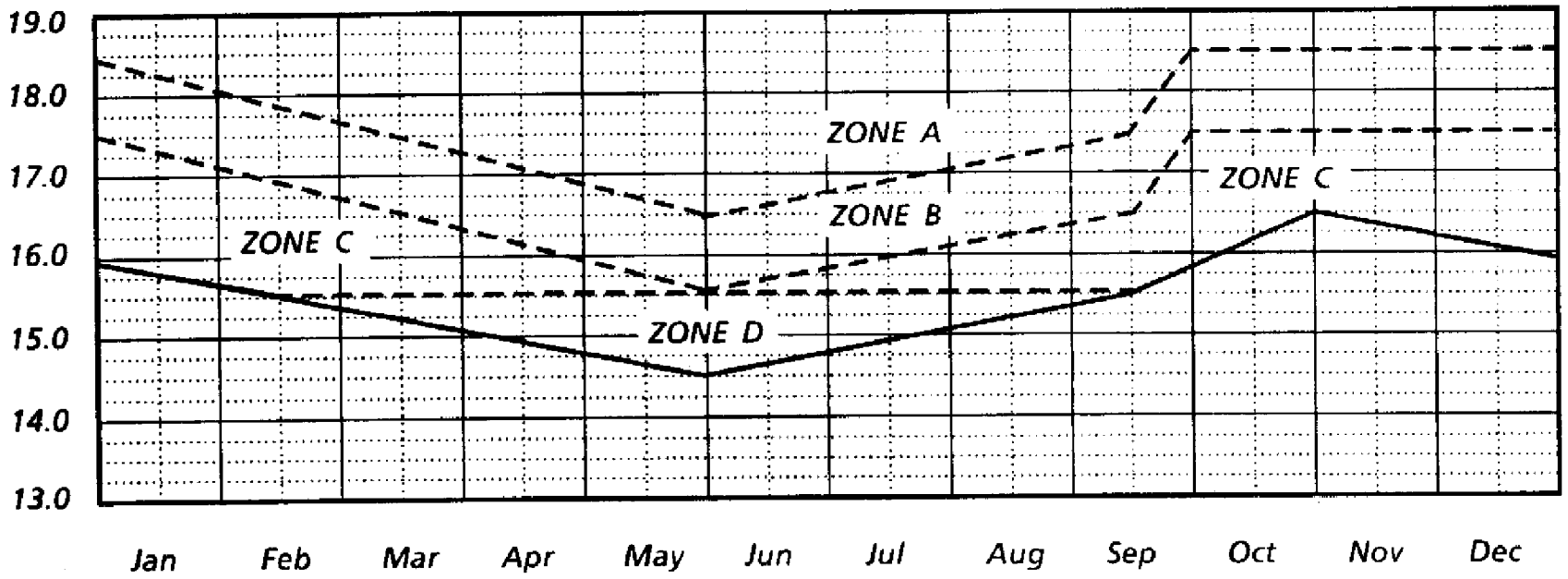
Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	513800	5.6	1133700	1.2
1971	117400	22.2	40900	2.7
1974	91700	30.7	294803	19.6
1981	33000	12.6	139881	09.3
1982	1800	0.8	363992	24.2

*Total study period

Regulation Schedule: RUN 14

Description: This schedule includes four zones. Releases are began at lower stages to reduce zone A discharges to the estuaries and to also keep stages favorable for the lakes littoral zone. The concept of different discharges for rising and falling stages is introduced.

Comment: The number of zone A releases would be substantially decreased. This schedule would also be beneficial for the littoral zone, and for flood protection. Water use requirements satisfied are only slightly reduced. This schedule appears to have many advantages and may be the best of the early schedules proposed.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs at S-77	Up to 4500 cfs at S-80
C	When stage rising - maximum practicable when stage falling - no regulatory discharge	When stage rising - 4500 cfs when stage falling - no regulatory discharge	When stage rising - 2500 cfs when stage falling - no regulatory discharge
D	No regulatory discharge	Maximum non-harmful release to Estuary when stage is rising	No regulatory discharge

Run 14 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		9	116	27			47	93	17.45	14.88	15.17
1953			109	48	11	43	31	28	18.81	14.00	14.02
1954	7	93	111	1		39	113	0	17.57	15.45	15.48
1955				.1				12	15.95	13.76	13.76
1956									14.93	10.34	11.37
1957							83	28	17.04	13.03	14.43
1958		87	123	2			50	55	17.31	15.40	15.48
1959		1	87	57		93	60	0	18.01	15.11	15.50
1960		92	117	4	37	51	65	0	18.54	15.49	15.49
1961	2	39	137	34			2	93	17.28	14.34	15.46
1962									15.92	11.31	11.33
1963									15.43	11.70	13.00
1964									14.45	12.17	12.41
1965									14.64	11.34	11.68
1966			12	60		15	109	29	16.83	14.39	14.67
1967			38	19					15.92	12.26	12.43
1968						19	53	13	16.42	11.42	12.00
1969			132	30		12	85	56	18.10	15.12	15.34
1970	20	106	58	28			5	86	17.97	14.59	15.39
1971									14.55	10.58	10.75
1972									13.47	11.99	12.44
1973									14.29	11.24	11.31
1974							52	4	15.96	9.94	9.98
1975									15.14	11.28	11.47
1976									14.09	11.30	11.96
1977									14.07	11.51	11.87
1978							46	5	15.95	13.77	13.95
1979			99	44			45	17	17.32	13.94	15.10
1980			167	46				15	16.26	13.66	14.97
1981									13.67	9.82	10.25
1982							67	9	16.41	10.08	10.84
1983	5	66	60	21			2	95	17.53	14.67	14.70
1984			140	29			63	38	16.11	15.02	15.35
Totals	34	493	1506	449	48	272	978	676			

Flood Protection

Maximum Sept. 1 stage: 16.31 feet NGVD
Mean Sept. 1 stage: 14.37 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	99	95	89	76	63	47	19	6	1

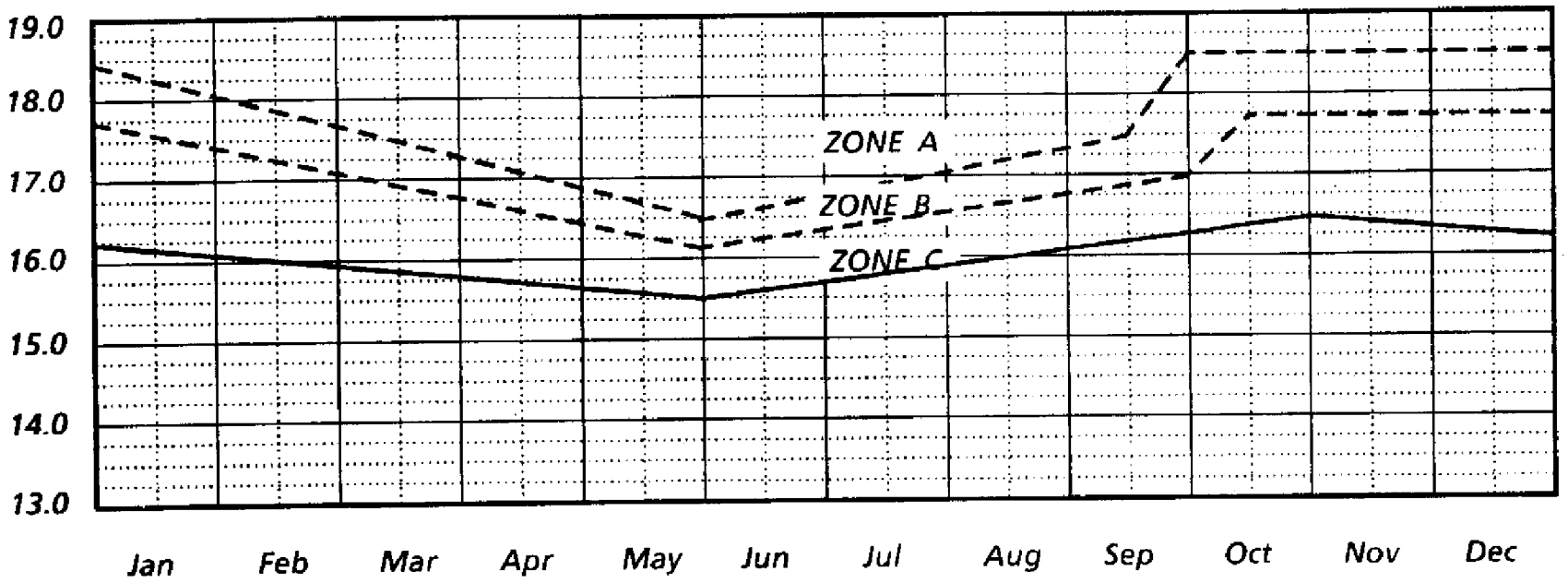
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	553600	6.0	1482600	1.6
1971	118300	22.4	70200	4.7
1974	97300	32.6	299315	19.9
1981	43600	16.7	233135	10.5
1982	1700	0.7	363992	24.2

*Total study period

Description: This schedule begins regulatory releases at lower stages throughout the year, It also introduces a zone of higher discharges in Zone B to aid in reducing the number of days of Zone A releases.

Comment: This schedule substantially reduced Zone A releases without substantially reducing water use requirements satisfied.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs	4500 cfs
C	Rising stage-maximum practicable	Rising stage - 4500 cfs Falling stage - 0 cfs	Falling stage - 2500 cfs Rising stage - 0 cfs

Run 15 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			134				44		17.45	15.23	15.48
1953			114		20	35	31		18.95	14.49	14.51
1954	15	68	132			45	108		17.82	16.05	16.08
1955			87						16.38	14.23	14.26
1956									15.38	10.73	11.81
1957						9	71		17.20	13.34	13.71
1958		76	136				78		17.62	15.66	16.07
1959			125			106	47		18.07	15.63	15.64
1960		78	135		54	42	57		18.52	16.06	16.07
1961	2	28	181						17.30	14.46	15.50
1962									15.95	11.35	11.38
1963									15.47	11.74	13.05
1964									13.47	12.16	12.37
1965									14.63	11.34	11.68
1966			10			9	115		17.19	14.39	14.95
1967			41						16.11	12.53	12.70
1968						5	81		16.68	11.57	12.14
1969			145			24	55		18.37	15.34	15.54
1970	25	94	71				10		18.34	14.82	15.69
1971									14.82	10.85	11.03
1972									13.63	12.13	12.57
1973									14.31	11.26	11.34
1974							25		16.30	9.94	9.98
1975									15.60	11.68	11.85
1976									14.17	11.43	12.08
1977									14.14	11.59	11.96
1978							25		16.43	13.83	14.00
1979			117			13	31		17.53	14.33	15.50
1980			166						16.34	13.93	15.28
1981									13.95	9.71	10.35
1982							56		16.95	10.12	10.88
1983	15	48	77				7		17.67	14.91	14.95
1984			155				57		16.36	15.26	15.55
Totals	54	392	1826		74	288	898				

Flood Protection

Maximum Sept. 1 stage: 16.74 feet NGVD
Mean Sept. 1 stage: 14.66 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	99	96	90	78	65	51	31	8	1

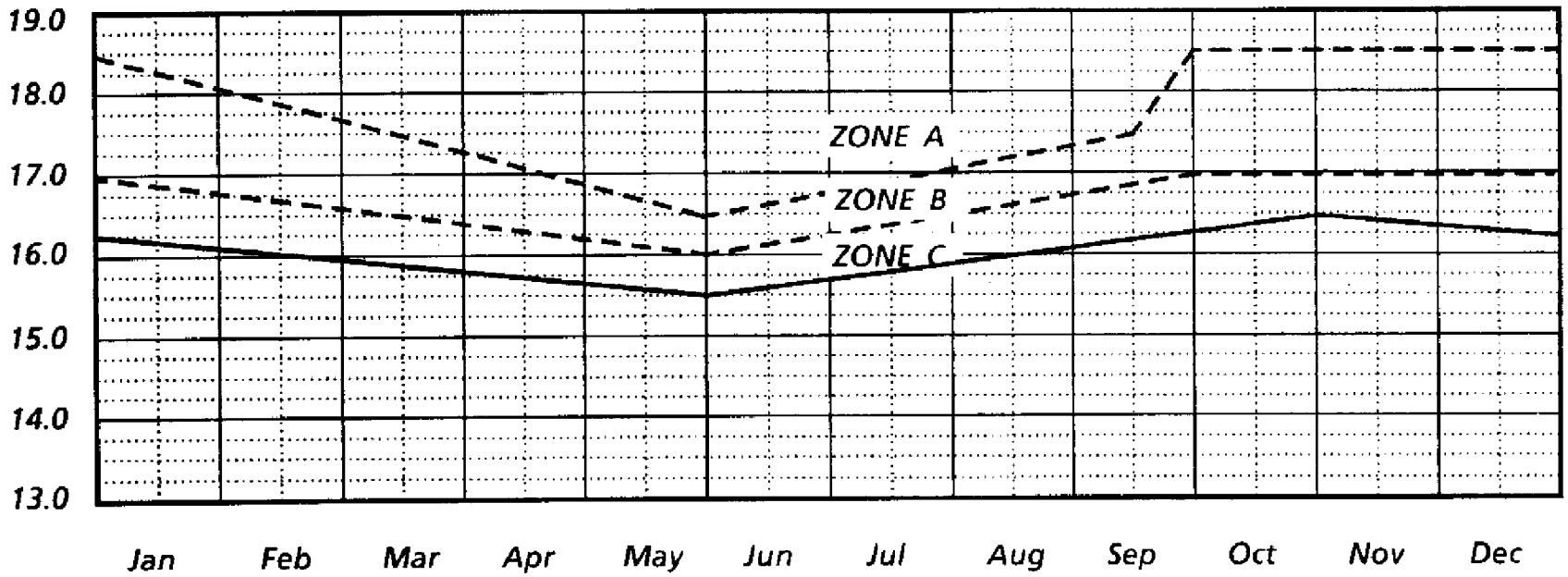
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	553600	6.0	1231400	1.3
1971	118300	22.4	47300	3.1
1974	97300	32.6	294803	19.6
1981	43800	16.8	168459	11.2
1982	1700	0.7	363992	24.2

*Total study period

Description: Similar to schedule 15 except a larger stage range for Zone B. The upper and lower schedule remained the same.

Comment: The effect of the larger Zone B was to reduce the Zone A discharges by 29 days but at the same time reducing water use requirements satisfied slightly more.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Pump maximum practicable to WCA's	6500 cfs	4500 cfs
C	Rising stage - maximum practicable Falling stage - 0 cfs	Rising stage - 4500 cfs Falling stage - 0 cfs	Rising stage - 2500 cfs Falling stage - 0 cfs

Run 16 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		9	102			14	18		17.45	14.93	15.18
1953		6	67		19	36	30		18.94	14.40	14.42
1954	12	68	132			33	120		17.45	15.70	15.70
1955			83						16.33	14.23	14.26
1956									15.38	10.73	11.81
1957						19	61		17.12	13.34	14.71
1958		82	130				71		17.14	15.64	15.95
1959		17	125			118	35		17.89	15.62	15.64
1960		75	138		52	40	61		18.53	15.97	15.97
1961	2	43	114						16.86	14.24	15.28
1962									15.83	11.20	11.22
1963									15.34	11.63	12.02
1964									14.41	12.06	12.29
1965									14.62	11.29	11.61
1966			10			22	102		17.05	14.37	14.95
1967			25						16.08	12.48	12.66
1968						8	73		16.68	11.54	12.12
1969		3	142			28	47		18.28	15.30	15.50
1970	19	108	56				2		17.88	14.60	15.49
1971									14.80	10.85	11.02
1972									13.62	12.12	12.57
1973									14.31	11.26	11.34
1974							25		16.30	9.94	9.98
1975									15.60	11.68	11.85
1976									14.17	11.43	12.08
1977									14.14	11.59	11.96
1978							25		16.43	13.83	14.00
1979		16	81			18	24		17.40	14.11	15.27
1980			145						16.32	13.93	15.28
1981									13.95	9.71	10.35
1982							56		16.95	10.12	10.88
1983	12	60	66				2		17.63	14.77	14.80
1984			148				57		16.35	15.26	15.55
Totals	45	470	1564		71	336	809				

Flood Protection

Maximum Sept. 1 stage: 16.70 feet NGVD
Mean Sept. 1 stage: 14.61 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	99	96	89	77	65	50	29	4	1

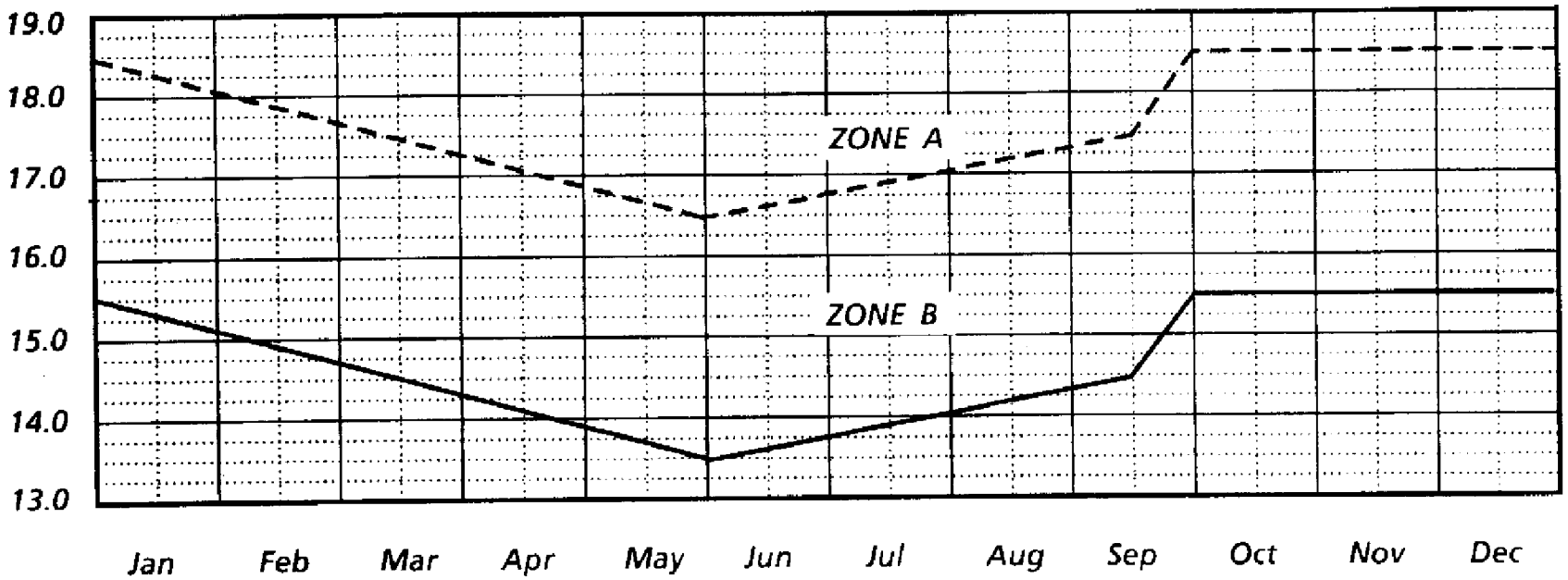
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	557300	6.0	1263900	1.4
1971	118600	22.5	50500	3.3
1974	97300	32.6	294803	19.6
1981	43800	16.8	1168459	11.2
1982	1700	0.7	363992	24.2

*Total study period

Description: Same as Base Run (run 1) except zone B releases are at stages two feet lower.

Comment: Severe droughts would likely be frequent with this schedule. Zone A releases are sharply decreased.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	4500 cfs	2500 cfs

Run 17 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		41			2	20			16.18	13.111	13.26
1953		93				97			18.51	12.85	12.87
1954	5	207				111			18.32	13.98	13.99
1955		36				9			15.45	12.80	12.83
1956									13.90	9.70	10.43
1957		13				121			15.69	12.64	13.57
1958		173				55			16.46	13.77	14.20
1959		89				153			17.59	13.51	13.52
1960		213			13	127			18.49	13.53	13.60
1961		153							17.24	12.53	13.51
1962									15.44	10.12	9.13
1963		7							14.96	10.98	12.10
1964									14.09	11.52	11.75
1965									14.59	10.80	11.11
1966		47				101			15.61	13.14	13.41
1967									14.87	11.07	11.21
1968						73			15.50	10.71	11.33
1969						48			17.47	13.25	13.46
1970	12	196				26			17.74	13.08	14.37
1971									13.71	9.93	10.08
1972									13.36	11.73	12.21
1973									14.45	11.03	11.09
1974		59							15.38	9.87	9.88
1975									14.29	10.48	10.73
1976									14.02	10.95	11.64
1977									13.96	11.22	11.52
1978		17				55			14.97	13.36	13.47
1979		57				37			16.20	12.29	13.47
1980		112							15.49	12.39	13.51
1981									12.42	8.99	9.51
1982						72			15.72	9.58	10.37
1983	4	132				29			17.38	13.62	14.04
1984		102				36			15.36	13.30	13.65
Totals	22	1845			15	1170					

Flood Protection

Maximum Sept. 1 stage: 15.24 feet NGVD
Mean Sept. 1 stage: 13.39 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg.	10	11	12	13	14	15	16	17	18
%	98	92	82	68	42	19	7	3	1

Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	572600	6.2	3438800	3.7
1971	136200	25.8	430100	28.6
1974	83400	28.0	333910	22.2
1981	33700	12.9	585094	38.9
1982	1900	0.8	376025	25.0

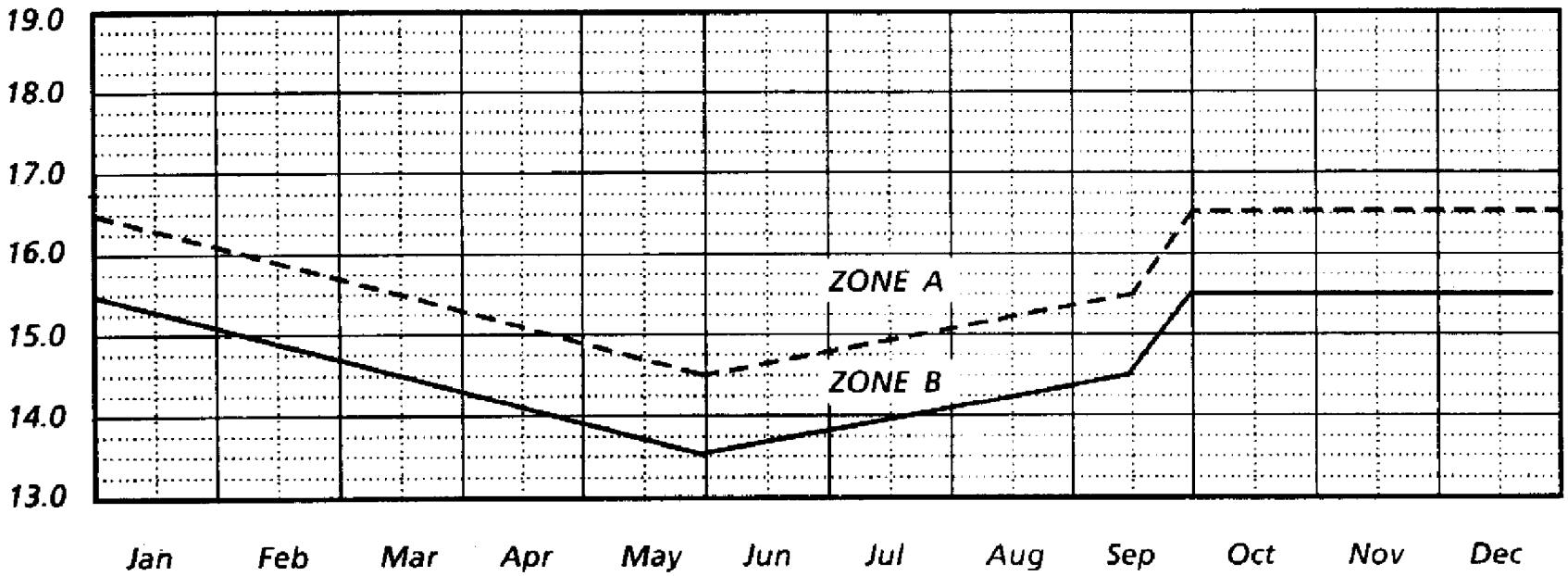
*Total study period

Run 18 Summary Sheet 1 of 2

Regulation Schedule: RUN 18

Description: Base schedule lower two feet.

Comment: Frequent water shortages, more frequent zone A releases due to the lowering of the upper line.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	4500 cfs	2500

Run 18 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		41				20			16.18	13.11	13.26
1953		93			32	67			17.27	12.85	12.87
1954	23	152				97			16.35	13.51	13.52
1955		36				9			15.45	12.79	12.82
1956									13.90	9.70	10.43
1957		13				121			15.69	12.64	12.57
1958	13	160				38			16.19	13.68	14.19
1959		89			19	134			16.57	13.51	13.52
1960	9	203			54	86			16.91	13.50	13.51
1961	9	104							15.52	12.53	13.09
1962									15.44	10.10	10.12
1963		7							14.95	10.98	12.09
1964									14.09	11.52	11.74
1965									14.59	10.80	11.11
1966		47				101			15.61	13.14	13.41
1967									14.87	11.07	11.21
1968					12	50			15.46	10.71	11.33
1969		93			13	35			16.83	13.25	13.46
1970	43	144				9			16.53	13.05	13.78
1971									13.71	9.92	10.07
1972									13.36	11.73	12.21
1973									14.45	11.03	11.09
1974					2	56			15.27	9.86	9.87
1975									14.25	10.46	10.71
1976									24.02	10.94	11.62
1977									13.96	11.22	11.52
1978		17				55			14.97	13.36	13.47
1979		57				37			16.20	12.29	13.47
1980		112							15.49	12.39	13.51
1981									12.42	8.99	9.51
1982						72			15.72	9.58	10.37
1983	55	58							16.26	12.82	12.87
1984		89				36			15.18	13.28	13.64
Totals	152	1515			132	1023					

Flood Protection

Maximum Sept. 1 stage: 15.13 feet NGVD
Mean Sept. 1 stage: 13.37 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	98	92	82	68	41	16	4	0	0

Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	576200	6.2	3451300	3.8
1971	137000	26.0	434800	28.9
1974	83500	28.0	333910	22.2
1981	33700	12.9	585094	38.9
1982	1900	0.8	376025	25.0

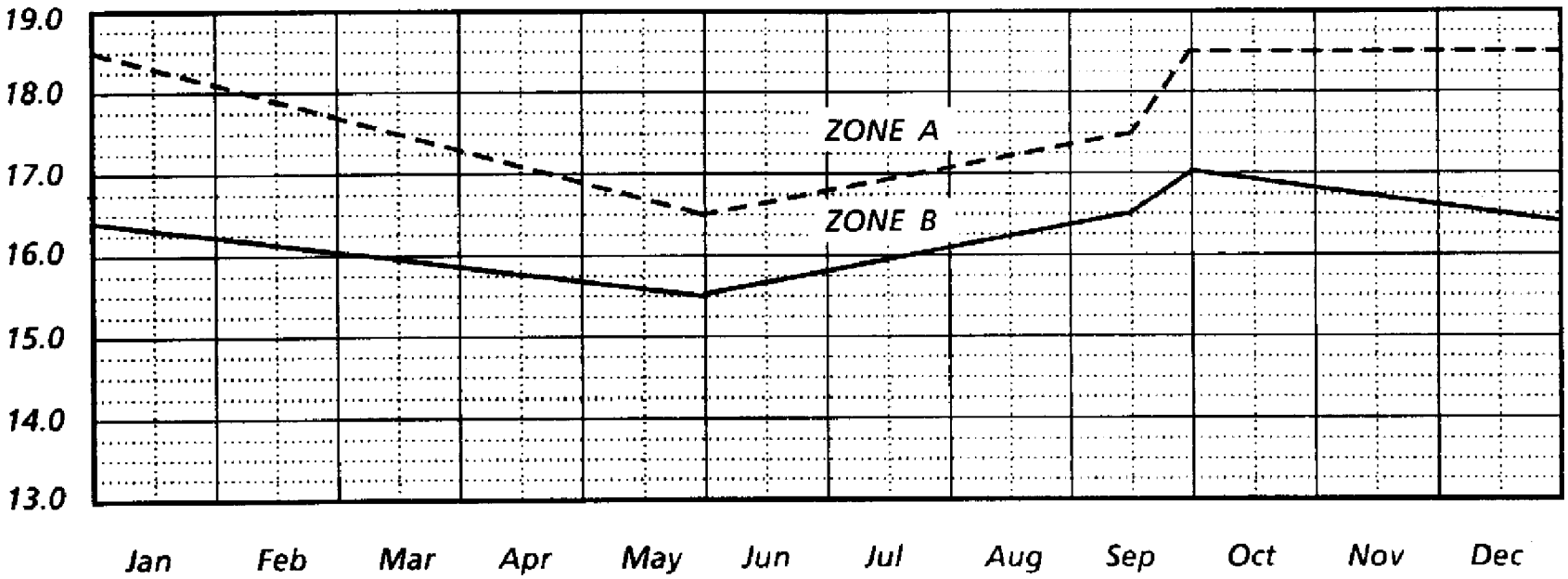
*Total study period

Run 19 Summary Sheet 1 of 2

Regulation Schedule: RUN 19

Description: Start Zone B discharges at a lower stage. Minimize the fluctuation of the lower schedule to 1.5 feet and begin its decline on October 1.

Comment: This schedule helped reduce zone A releases in the dry season from 125 days to 89 days. Wet season Zone A discharges were only decreased by 2 days.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	4500 cfs	2500 cfs

Run 19 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		51				20			17.54	14.60	14.84
1953		73			31	52			19.05	14.52	14.54
1954	16	163				119			18.32	15.50	15.51
1955		45							16.39	14.36	14.39
1956									15.50	10.84	11.93
1957						73			17.37	13.44	14.80
1958		189				25			17.46	15.58	15.81
1959		123			16	137			18.49	15.50	15.51
1960	6	192			53	82			18.57	15.50	15.51
1961	2	115							17.27	14.02	15.06
1962									15.73	11.06	11.09
1963									15.24	11.55	12.81
1964									14.37	12.03	12.30
1965									14.60	11.27	11.59
1966		6				101			17.14	14.25	15.02
1967									16.20	12.58	12.76
1968						46			16.88	11.59	12.16
1969		87			8	37			18.76	15.18	15.40
1970	39	148				2			18.46	14.86	15.61
1971									14.86	10.82	11.00
1972									13.61	12.11	12.55
1973									14.32	11.28	11.35
1974						13			16.62	9.96	10.00
1975									15.92	11.99	12.13
1976									14.29	11.60	12.23
1977									14.25	11.69	12.06
1978						10			16.65	13.90	14.06
1979		73				30			17.50	13.75	14.90
1980		100							16.40	13.88	15.23
1981									13.89	9.69	10.33
1982						27			17.86	10.12	10.88
1983	26	111							17.82	14.81	14.84
1984		106				23			16.54	15.00	15.32
Totals	89	1582			108	797					

Flood Protection

Maximum Sept. 1 stage: 16.97 feet NGVD
Mean Sept. 1 stage: 14.63 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	99	96	90	78	64	48	28	8	3

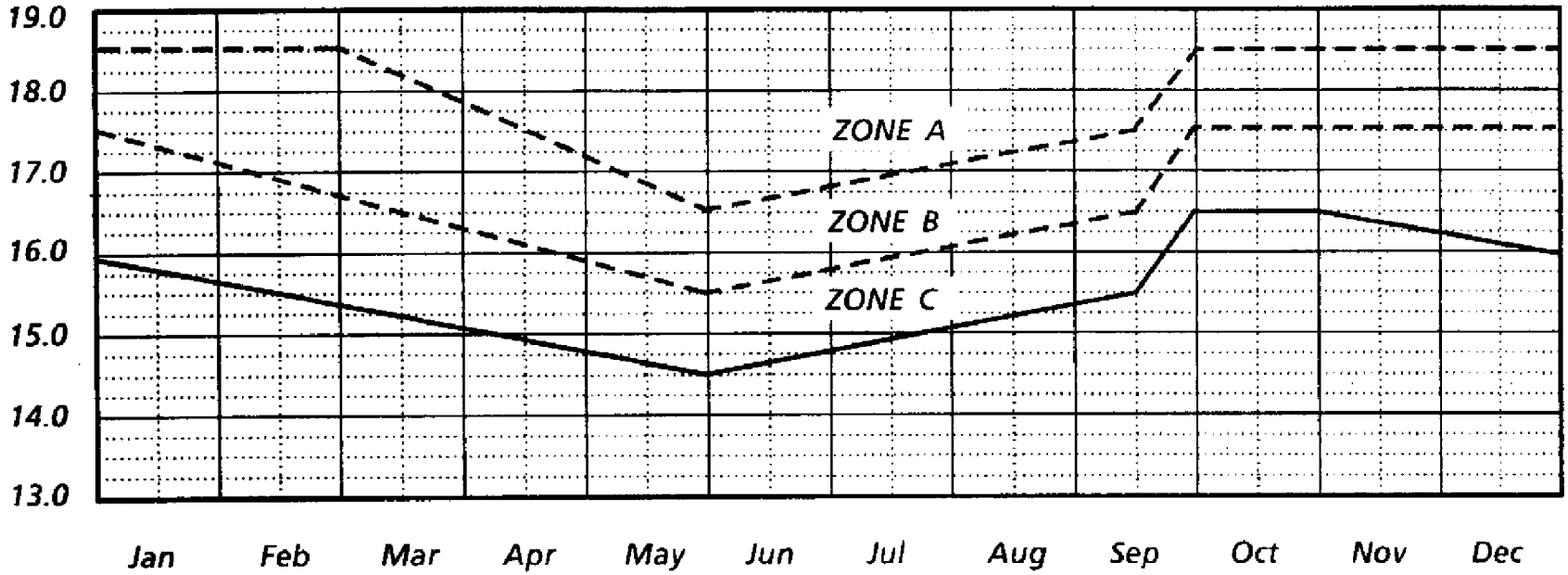
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	520100	5.6	1264000	1.4
1971	117900	22.3	44300	2.9
1974	91800	30.8	294803	19.6
1981	35500	13.6	177483	11.8
1982	1700	0.7	363992	24.2

*Toatl study period

Description: Introduces Zone C discharge which allows for low flow discharges to the estuary at lower stages. Zone A releases are made at higher elevations in the spring.

Comment: Reduced Zone A discharges from 235 in the base run to 181 days with this schedule , and Zone B from 2265 days to 1378 days while only slightly increasing demands not satisfied during the 1981 dry season.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	To maximum capacity at S-77	To maximum capacity at S-80
B	Maximum practicable to WCA's	4500 cfs	2500 cfs
C	Maximum practicable to WCA's	Maximum non-harmful discharges to estuary when stage rising	Maximum non-harmful discharges to estuary when stage rising

Run 20 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952		8	126			7	30		17.71	14.49	14.54
1953		13	164		29	31	55		19.07	14.05	14.07
1954	16	134	62			94	59		18.35	15.52	15.52
1955			132				12		16.72	13.91	13.94
1956									14.87	10.35	11.38
1957						36	92		17.66	13.06	14.15
1958	5	147	60			32	84		18.27	15.58	16.42
1959		11	157		16	137			18.49	15.41	15.51
1960	6	164	43		53	68	32		18.56	15.47	15.51
1961	2	75	132				16		17.46	13.62	14.22
1962									15.58	10.86	10.88
1963									15.09	11.44	12.67
1964									14.31	11.93	12.22
1965									14.59	11.22	11.53
1966			44			46	99		17.54	14.18	14.41
1967			61						15.89	12.23	12.38
1968						32	71		16.77	11.40	11.99
1969			176		4	26	123		18.77	15.08	15.34
1970	32	156	24			2	81		18.73	14.45	15.63
1971									14.45	10.52	10.69
1972									13.46	11.97	12.43
1973									14.29	11.23	11.31
1974						7	50		16.43	9.98	9.99
1975									15.73	11.82	11.98
1976									14.23	11.51	12.15
1977									14.20	11.64	12.01
1978						5	54		16.45	13.86	14.03
1979		29	117			4	43		17.53	13.60	14.78
1980		16	97				15		16.91	13.71	15.14
1981									13.73	9.64	10.27
1982							89		17.38	10.09	10.85
1983	18	72	116				73		18.24	14.95	14.96
1984		16	146			10	97		16.43	14.93	15.20
Totals	79	84	1657		102	537	1175				

Flood Protection

Maximum Sept. 1 stage: 16.97 feet NGVD
Mean Sept. 1 stage: 14.41 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	99	95	89	76	62	44	26	11	3

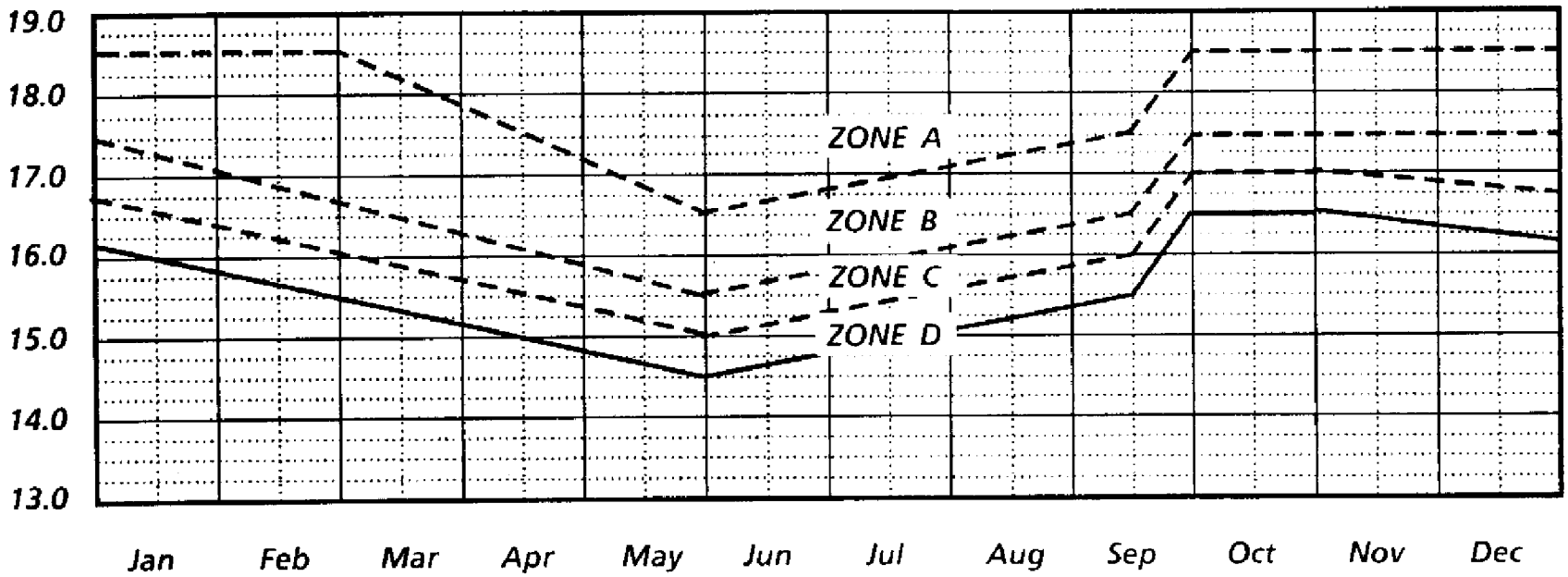
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	527500	5.7	1520600	16
1971	122300	23.2	79900	5.3
1974	92300	31.0	303828	20.2
1981	35900	13.7	219598	14.6
1982	1700	0.7	363992	24.2

*Total study period

Description: Lower schedule varies between 14.5 to 16.5

Comment: The necessity for Zone A discharges was practically eliminated in 1983 with this schedule. Demands met by operation under this schedule were reduced during the 1981 dry season. The demands met during this dry season were still greater than those met in the dry seasons of 1974 and 1982.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs	3500 cfs
C	Maximum practicable to WCA's	4500 cfs	2500 cfs
D	Maximum practicable to WCA's	Maximum non-harmful discharges to estuary when stage is rising	Maximum non-harmful discharges to estuary when stage is rising

Run 21 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			40	78		1	16	20	17.47	14.48	14.54
1953			35	154	14	40	28	46	18.84	14.24	14.27
1954	9	68	77	58		7	84	50	17.70	15.00	15.01
1955				144				38	16.61	14.15	14.18
1956									14.88	10.39	11.42
1957							55	83	17.16	13.09	14.48
1958		67	99	46			9	99	17.43	14.97	15.20
1959			37	88		61	85	7	18.17	14.99	14.99
1960		52	119	44	36	23	62	32	18.55	14.97	15.01
1961	2	33	59	95				19	16.81	13.67	14.73
1962									15.60	10.89	10.92
1963									15.12	11.46	12.70
1964									14.32	11.94	12.23
1965									14.60	11.23	11.54
1966				49			69	82	17.05	14.35	14.60
1967				50					16.15	12.39	12.55
1968						20	20	35	16.62	11.49	12.07
1969			41	128		23	14	61	18.35	14.72	14.92
1970	8	93	87	23			4	56	17.87	14.23	15.18
1971									14.23	10.39	10.56
1972									13.41	11.91	12.37
1973									14.29	11.23	11.30
1974							23	24	16.02	9.95	9.99
1975									15.31	11.43	11.62
1976									14.11	11.34	12.00
1977									14.09	11.53	11.89
1978							21	30	16.17	13.78	13.96
1979			48	56			19	27	17.31	13.50	14.66
1980			48	165				8	16.61	13.49	14.81
1981									13.51	9.57	10.18
1982							13	71	17.06	10.04	10.80
1983	1	84	23	87				31	17.88	14.54	14.55
1984			57	96			17	75	16.27	14.61	14.89
Totals	20	397	780	1361	50	175	539	849			

Flood Protection

Maximum Sept. 1 stage: 16.09 feet NGVD
Mean Sept. 1 stage: 14.23 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	99	95	88	75	61	42	19	6	1

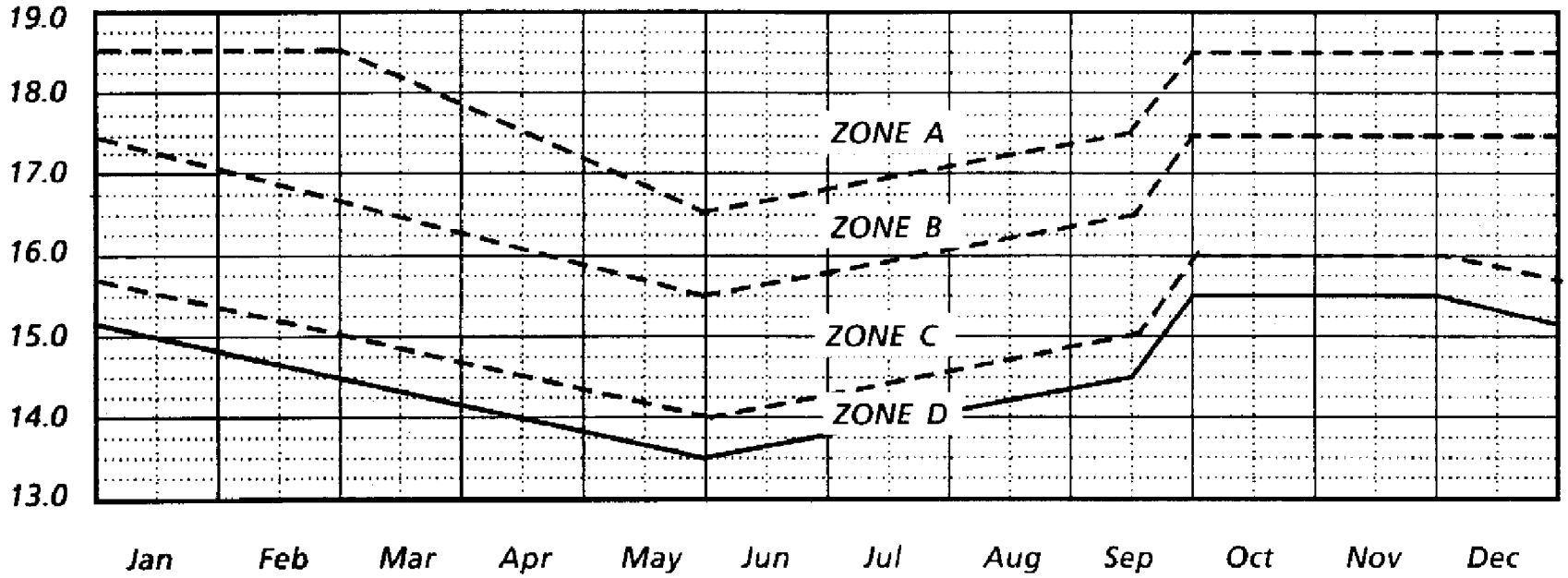
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	540500	5.8	1665100	1.8
1971	125600	23.8	119900	8.0
1974	92300	31.0	303828	20.2
1981	36300	13.9	272242	18.1
1982	1700	0.7	363992	24.2

*Percentage of total demand not met.

Description: Lower schedule varies between 13.5 and 15.5.

Comment: Making regulatory releases at these lower stages will increase drastically demands not met during the critical dry years. It also increased the number of years when water supply becomes critical. Zone A releases were reduced to 28 days for the whole study period.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs	3500 cfs
C	Maximum practicable to WCA's	4500 cfs	2500 cfs
D	Maximum practicable to WCA's	Maximum non-harmful discharges to estuary when stage is rising	Maximum non-harmful discharges to estuary when stage is rising

Run 22 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			71	36			16	18	17.45	13.36	13.49
1953			34	142	5	17	57	38	18.58	13.03	13.05
1954	3	72	105	32			94	47	17.65	14.00	14.01
1955				134				18	15.61	12.85	12.88
1956									13.90	9.71	10.43
1957				13			62	91	16.17	12.65	13.79
1958			166	46			35	74	16.75	14.12	14.99
1959			45	93		6	147	0	17.70	14.00	14.01
1960		35	158	20	14	34	75	30	18.46	13.98	13.99
1961	1	33	89	54				13	16.76	12.69	13.65
1962									15.47	10.22	10.24
1963				75					13.96	10.34	12.05
1964									14.08	11.49	11.73
1965									14.54	10.80	11.11
1966			17	61			73	79	16.05	13.45	13.63
1967				46					15.15	11.24	11.37
1968							56	53	15.75	10.79	11.40
1969			40	149		2	36	65	17.70	13.70	13.91
1970	5	53	153	1			11	52	17.82	13.35	14.49
1971									13.78	10.05	10.20
1972									13.42	11.77	12.25
1973									14.46	11.05	11.11
1974							46	19	15.57	9.86	9.88
1975									14.56	10.63	10.88
1976									13.92	11.05	11.72
1977									13.90	11.18	11.48
1978				46			32	41	15.28	13.37	13.51
1979			51	46			24	25	16.46	12.42	13.60
1980			46	167				8	15.62	12.65	13.85
1981									12.67	9.06	9.59
1982							38	81	16.12	9.61	10.40
1983		58	57	84				69	17.07	13.72	13.74
1984			56	97			19	73	15.31	13.63	13.94
Totals	9	251	1088	1292	19	59	821	894			

Flood Protection

Maximum Sept. 1 stage: 15.55 feet NGVD
Mean Sept. 1 stage: 13.58 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	98	93	83	69	47	23	8	3	1

Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	589500	6.4	3218900	3.5
1971	137700	26.1	364600	24.2
1974	97700	32.8	327894	21.8
1981	45100	17.3	520418	34.6
1982	1900	.8	371513	24.7

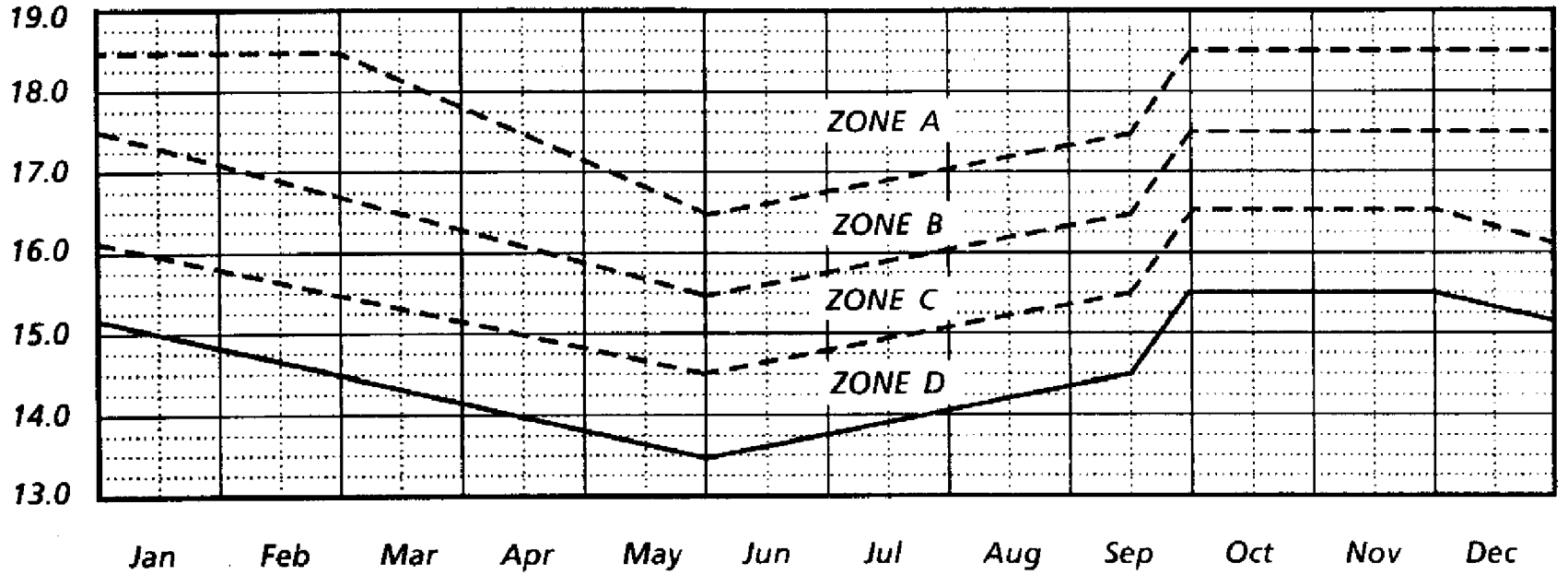
*Total study period

Run 23 Summary Sheet 1 of 2

Regulation Schedule: RUN 23

Description: This schedule is similar to 22 in concept, but the decline of the lower line begins on October 1.

Conclusion: Although this schedule may have several advantages it severely increases water shortages during the critical year of 1981. It also creates large shortage during other years that were not a problem with the higher schedules in effect.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump Maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs	3500 cfs
C	Maximum practicable to WCA's	4500 cfs	2500 cfs
D	Maximum practicable to WCA's	Maximum non-harmful discharges to estuary when stage is rising	Maximum non-harmful discharges to estuary when stage is rising

Run 23 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			61	91			8	63	17.45	13.65	13.76
1953			29	183	9	22	45	77	18.82	13.56	13.59
1954	9	67	96	40			95	58	17.68	14.49	14.5
1955				178				74	16.03	13.33	13.36
1956									13.99	9.77	10.73
1957				20			44	109	16.67	12.57	13.96
1958		30	137	45			26	89	17.21	14.59	15.20
1959			35	128		22	131	0	18.00	14.50	14.51
1960		47	137	29	23	31	68	31	18.51	14.48	14.48
1961	1	34	77	100				40	16.81	13.03	14.07
1962									15.49	10.81	10.83
1963				31					14.92	11.16	12.34
1964									14.16	11.61	11.96
1965									14.52	11.07	11.38
1966			2	103			63	90	16.54	13.74	13.88
1967				91					15.21	11.40	11.54
1968							48	76	16.01	11.01	11.60
1969			28	183		6	30	117	17.99	14.22	14.41
1970	8	66	124	14			7	87	17.87	13.57	14.81
1971									13.57	10.16	10.32
1972									13.36	11.84	12.31
1973									14.27	11.19	11.26
1974							30	45	15.74	9.93	9.97
1975									14.84	11.06	11.27
1976									14.01	11.20	11.86
1977									14.00	11.45	11.81
1978				62			21	57	15.45	13.37	13.53
1979			45	83			14	40	16.71	12.75	13.96
1980			50	163				20	16.10	12.98	14.30
1981									13.00	9.31	9.89
1982							21	100	16.56	9.86	10.62
1983		71	35	106				98	17.40	14.08	14.10
1984			42	116			18	88	15.56	14.07	14.35
Totals	18	315	898	1766	32	81	669	1359			

Flood Protection

Maximum Sept. 1 stage: 15.99 feet NGVD
Mean Sept. 1 stage: 13.81 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg.	10	11	12	13	14	15	16	17	18
%	99	94	85	71	52	30	12	4	1

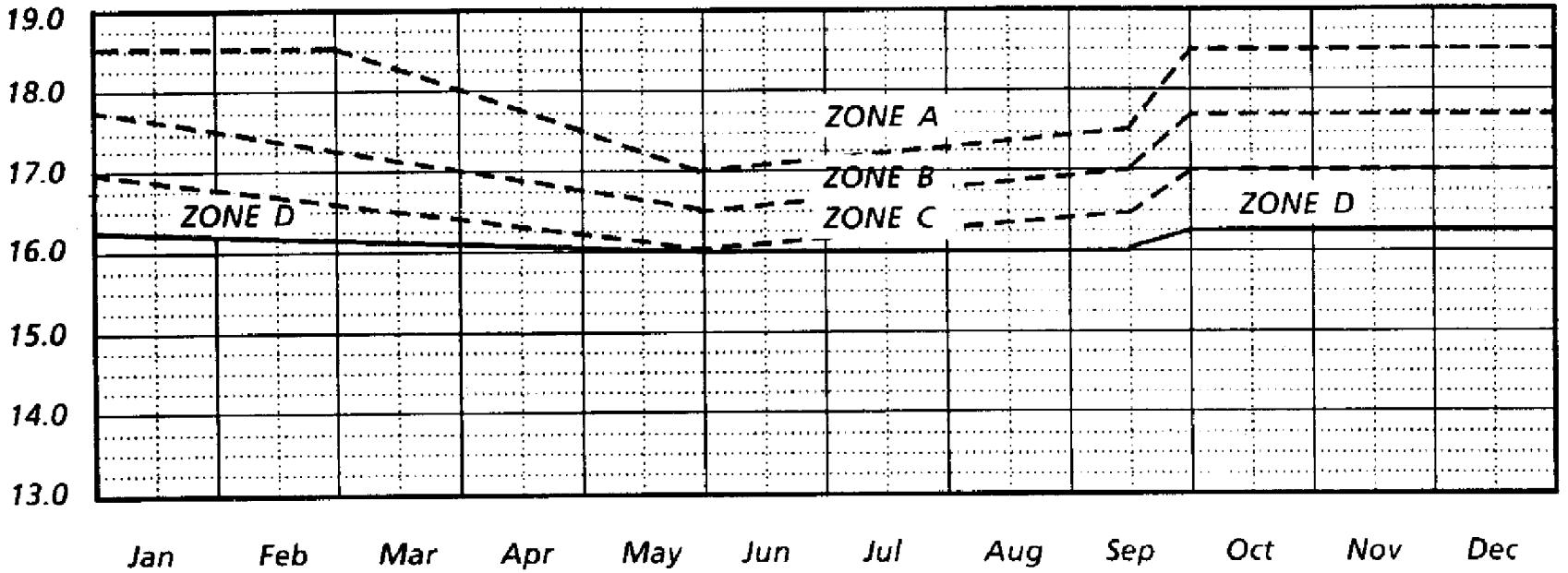
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	545100	5.9	2333800	2.5
1971	129200	24.5	221500	14.7
1974	83400	28.0	311400	20.7
1981	32100	12.3	447100	29.7
1982	1900	0.8	365900	24.3

*Total study period

Description: Lower schedule varies between 16 feet and 16.25 feet. Spring decline of upper schedules does not begin until March 1.

Comment: This schedule increases the water use requirements satisfied. It reduces Zone A discharges by almost 50% overall and by 66% during the dry season and by not allowing the winter buildup of storage to occur it would be helpful to the literal zone.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs	3500 cfs
C	Maximum practicable to WCA's	4500 cfs	2500 cfs
D	Maximum practicable to WCA's	Maximum non-harmful discharges to estuary when stage is rising	Maximum non-harmful discharges to estuary when stage is rising

Run 24 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			25	64		1	21	31	17.72	15.07	15.21
1953			37	78	24	30	29	6	19.04	14.71	14.74
1954	15	46	61	90		19	98	36	17.80	16.00	16.00
1955			8	91					16.55	14.38	[illegible]
1956									15.52	10.90	[illegible]
1957							69	13	17.46	13.48	[illegible]
1958		10	159	42			11	137	17.63	15.96	16.00
1959			27	123	[illegible]	93	59	0	18.47	[illegible]	[illegible]
1960	1	52	93	65	54	6	74	19	18.62	16.00	[illegible]
1961	3		46	68					16.98	[illegible]	[illegible]
1962									15.94	[illegible]	[illegible]
1963									15.45	11.72	[illegible]
1964									14.47	12.19	12.43
1965									14.64	11.35	[illegible]
1966						4	84	35	17.12	[illegible]	[illegible]
1967				30					16.02	12.43	[illegible]
1968							30	75	16.92	11.51	[illegible]
1969			27	109	2	23	28	49	18.71	15.68	[illegible]
1970	18	60	102	1				19	18.24	15.08	[illegible]
1971									15.09	11.00	[illegible]
1972									13.71	12.21	[illegible]
1973									14.33	11.29	[illegible]
1974							6	62	16.53	9.97	10.01
1975									15.64	11.75	11.91
1976									14.20	11.47	12.12
1977									14.17	11.61	11.98
1978							3	79	16.45	13.85	14.01
1979			39	57			35	9	17.70	14.12	15.28
1980			23	156					16.76	14.30	15.70
1981									14.31	9.89	10.57
1982							19	56	17.30	10.24	10.99
1983	4	67	23	70				54	18.18	15.22	15.25
1984			35	130			25	36	16.74	15.48	15.80
Totals	41	264	705	1174	81	176	591	716			

Flood Protection

Maximum Sept. 1 stage: 16.78 feet NGVD
Mean Sept. 1 stage: 14.72 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	90	78	65	52	34	7	2

Demands Not Met

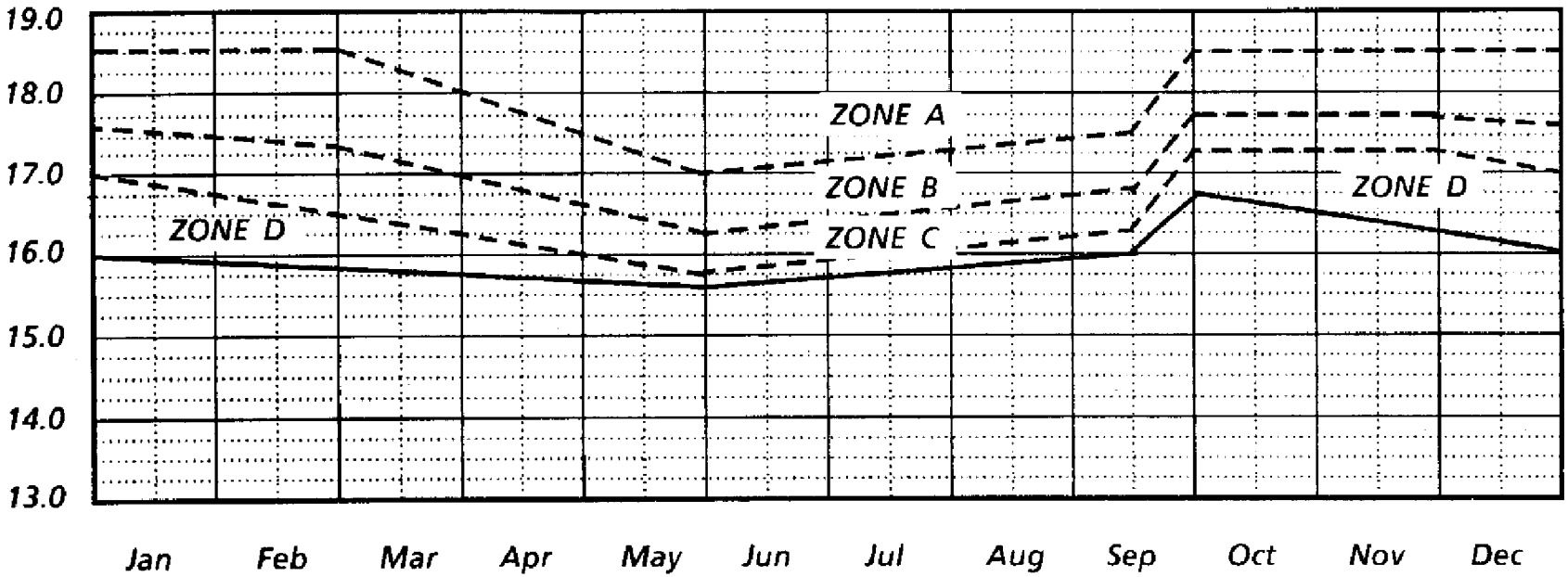
Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	508300	5.5	1123300	1.2
1971	114700	21.7	31500	2.1
1974	91500	30.7	294803	19.6
1981	30900	11.8	102278	6.8
1982	1700	0.7	359479	23.9

*Total study period

Regulation Schedule: RUN 25

Description: Similar to schedule 21, with slightly more variation in the lower schedules during the year including earler decline during the dry season.

Comment: This schedule reduces Zone A discharges substantially and apparently does not reduce the ability of the system to meet flood protection criteria or meet water use requirements.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs	3500 cfs
C	Maximum practicable to WCA's	4500 cfs	2500 cfs
D	Maximum practicable to WCA's	Maximum non-harmful discharges to estuary when stage rising	Maximum non-harmful discharges to estuary when stage rising

Run 25 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			27	71		5	14	15	17.77	14.96	15.08
1953		1	30	140	21	34	31	15	19.00	14.69	14.71
1954	14	52	66	80		18	82	50	17.72	15.73	15.73
1955				134				4	16.89	14.48	14.51
1956									15.55	10.99	12.07
1957							66	22	17.41	13.53	14.88
1958		32	134	46			15	89	17.67	15.71	15.92
1959			22	164		90	60	3	18.40	15.74	15.74
1960		53	100	60	50	11	70	22	18.53	15.73	15.74
1961	2	29	50	77					17.02	14.24	15.29
1962									15.87	11.24	11.26
1963									15.38	11.67	12.97
1964									14.44	12.14	12.39
1965									14.63	11.32	11.66
1966				8		4	70	50	17.29	14.38	15.01
1967				62					16.01	12.45	12.60
1968						2	34	322	16.97	11.53	12.10
1969			23	160	2	23	24	25	18.67	15.44	15.64
1970	20	55	108	3			3	21	18.27	14.92	15.77
1971									14.92	10.86	11.04
1972									13.63	12.13	12.58
1973									14.32	11.29	11.36
1974							15	16	16.34	9.96	10.00
1975									15.64	11.71	11.88
1976									14.19	11.45	12.09
1977									14.16	11.60	11.97
1978							11	32	16.40	13.84	14.00
1979			43	54				17	17.66	13.96	15.11
1980			40	143					16.88	14.12	15.50
1981									14.13	9.81	10.48
1982							10	62	17.38	10.20	10.95
1983	4	69	24	97				19	18.15	15.14	15.18
1984			38	145			28	27	16.62	15.31	15.63
Totals	40	291	705	1444	73	187	533	521			

Flood Protection

Maximum Sept. 1 stage: 16.55 feet NGVD
Mean Sept. 1 stage: 14.61 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	90	78	65	51	29	9	2

Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	517400	5.6	1193900	1.3
1971	117000	22.2	37700	2.5
1974	91700	30.8	294803	19.6
1981	33200	12.7	139881	9.3
1982	1800	0.8	363992	24.2

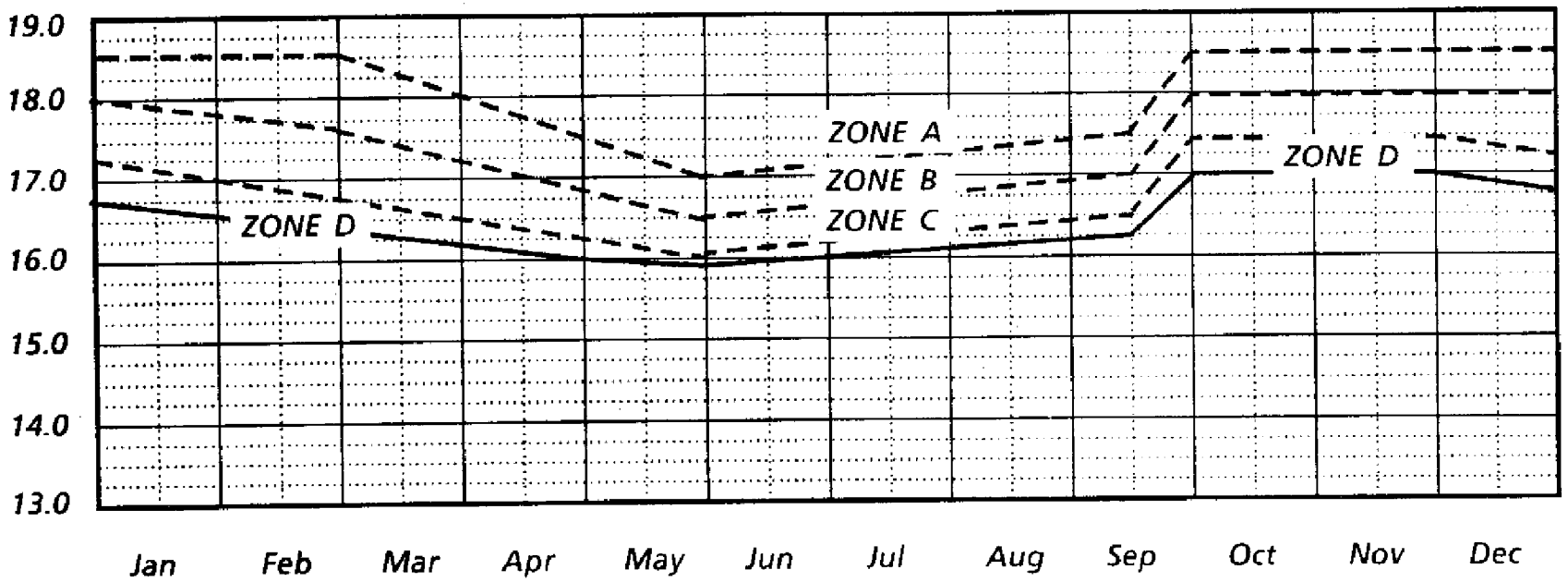
*Total study period

Run 26 Summary Sheet 1 of 2

Regulation Schedule: RUN 26

Description: Similar to 25 but allows a greater buildup of water during the months September through December. Range of stages in which Zone B releases are make is decreased.

Comment: Only increased water use requirements slightly while it increased by 25 the number of days of Zone A discharges forf the model period.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs	3500 cfs
C	Maximum practicable to WCA's	4500 cfs	2500 cfs
D	Maximum practicable to WCA's	Maximum non-harmful discharges to estuary when stage is rising	Maximum non-harmful discharges to estuary when stage is rising

Run 26 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			19	72		5	14	16	18.03	15.24	15.38
1953		1	30	117	27	29	31	19	19.04	15.01	15.04
1954	15	29	89	79		20	80	45	18.00	15.99	16.02
1955				112				10	17.14	14.86	14.89
1956									15.81	11.26	2.35
1957							64	21	17.66	13.75	15.07
1958		30	136	46			15	89	17.99	15.96	16.38
1959			39	92	5	84	61	3	18.47	15.99	15.99
1960	1	44	103	65	50	7	77	21	18.63	15.98	16.00
1961	3	25	49	70					17.29	13.55	15.59
1962									16.84	11.46	1.48
1963									15.55	11.81	13.13
1964									14.52	12.27	12.49
1965									14.67	11.40	11.74
1966						5	63	55	17.50	14.42	15.11
1967				23					16.68	13.02	13.26
1968						4	33	30	17.22	11.93	12.48
1969			36	102	6	19	24	21	18.76	15.68	15.89
1970	25	32	124	5			2	18	18.48	15.15	15.96
1971									15.15	11.05	11.24
1972									13.75	12.25	12.69
1973									14.33	11.30	11.38
1974							7	21	16.59	9.97	10.01
1975									15.89	11.97	12.11
1976									14.28	11.59	12.22
1977									14.24	11.68	12.06
1978							4	35	16.77	13.90	14.06
1979			46	33		1	23	16	17.96	14.28	15.46
1980			38	144					17.12	14.35	15.75
1981									14.36	9.92	10.60
1982							6	43	17.56	10.25	11.00
1983	13	56	33	62					18.37	15.26	15.30
1984			54	77			28	27	16.96	15.57	15.89
Totals	57	217	796	1099	92	174	526	490			

Flood Protection

Maximum Sept. 1 stage: 16.80 feet NGVD
Mean Sept. 1 stage: 14.82 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	91	80	67	54	38	13	2

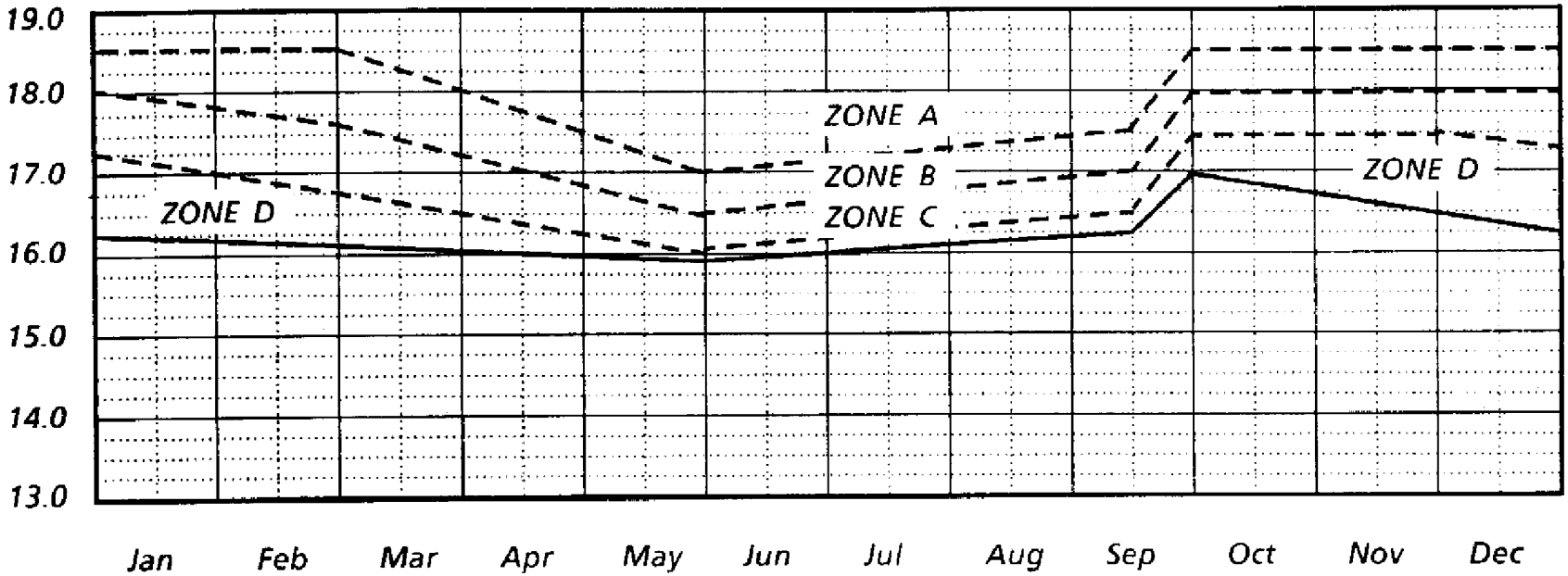
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total *	505500	5.5	1029900	1.1
1971	114100	21.6	30900	2.0
1974	91500	30.7	294803	19.5
1981	30800	11.8	94758	6.3
1982	1700	0.7	354967	23.6

*Total study period

Description: Zone A, B and C are the same as schedule 26. Zone D releases are started at lower stages than schedule 26.

Comment: Results are similar to 26.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs	3500 cfs
C	Maximum practicable to WCA's	4500 cfs	2500 cfs
D	Maximum practicable to WCA's	Maximum non-harmful discharges to estuary when stage is rising	Maximum non-harmful discharges to estuary when stage is rising

Run 27 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			19	79		5	14	16	18.02	15.22	15.33
1953		1	30	140	27	28	31	15	19.04	14.94	14.96
1954	15	29	88	80		19	81	51	18.00	15.99	16.01
1955				134				4	17.13	13.74	13.77
1956									15.80	13.24	13.33
1957							64	20	17.67	13.74	13.75
1958		30	136	46			15	89	17.99	15.96	16.18
1959			24	162	5	84	61	3	18.47	15.99	16.00
1960	1	44	104	64	54	6	73	20	18.67	15.98	16.00
1961	3	25	49	81					17.27	14.16	14.53
1962									16.01	13.42	13.65
1963									15.52	13.79	13.13
1964									14.50	12.25	12.48
1965									14.06	11.39	11.73
1966						5	63	55	17.53	14.47	15.13
1967				61					16.25	12.71	12.87
1968							33	31	17.19	11.67	12.23
1969			22	158	6	19	24	21	18.76	15.68	15.90
1970	25	31	125	6			2	19	18.49	15.15	15.97
1971									15.15	11.06	11.24
1972									13.75	12.25	12.63
1973									14.33	11.30	11.38
1974							7	21	16.59	9.97	10.01
1975									15.89	11.97	12.11
1976									14.28	11.59	12.22
1977									14.24	11.68	12.06
1978							4	35	16.65	13.90	14.06
1979			43	54			22	18	17.88	14.19	15.36
1980			38	145					17.15	14.34	15.75
1981									14.36	9.91	10.60
1982							6	43	17.56	10.25	11.00
1983	11	58	26	97				9	18.34	15.27	15.30
1984			36	148			27	29	16.86	15.58	15.89
Totals	55	218	740	1455	92	166	527	478			

Flood Protection

Maximum Sept. 1 stage: 16.78 feet NGVD
Mean Sept. 1 stage: 14.80 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	91	79	67	54	37	12	2

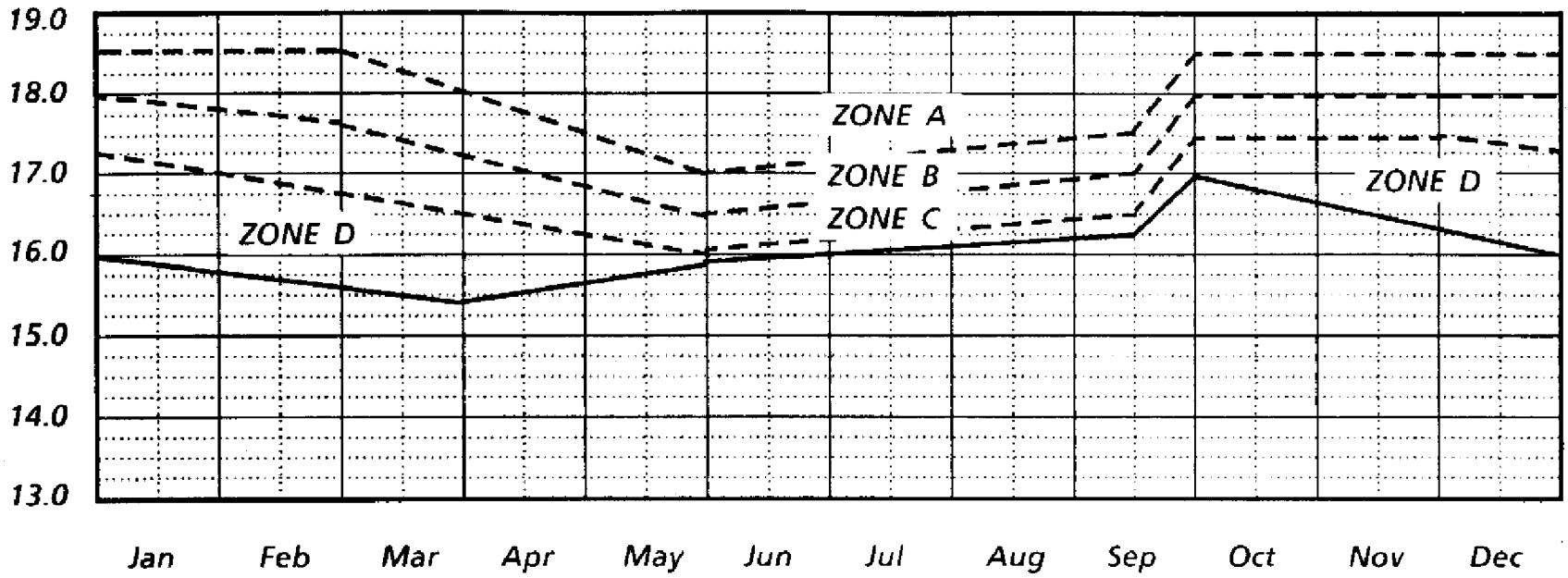
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	503700	5.4	1040400	1.1
1971	114100	21.6	30900	2.0
1974	91500	30.7	294803	19.5
1981	30800	11.8	94758	6.3
1982	1700	0.7	354967	23.6

*Total study period

Description: Zone A, B, and C are the same as schedule 26. The lowest schedule is minimum on April 1.

Comment: Results are similar to schedule 26. The earlier Zone D releases help reduce slightly the number of days of Zone A, B, and C releases when compared to schedule 26.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs	3500 cfs
C	Maximum practicable to WCA's	4500 cfs	2500 cfs
D	Maximum practicable to WCA's	Maximum non-harmful discharges to estuary when stage is rising	Maximum non-harmful discharges to estuary when stage is rising

Run 28 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			19	94		5	14	15	18.01	15.13	15.25
1953		1	29	150	26	24	31	13	19.05	14.97	14.93
1954	15	29	89	79		20	80	51	18.01	15.99	16.02
1955				159					17.14	14.60	14.63
1956									15.74	11.19	12.28
1957							63	19	17.67	13.70	15.02
1958		31	135	46			15	92	17.98	15.96	16.18
1959			20	192	5	83	62	3	18.47	15.36	15.60
1960	1	44	103	65	54	6	73	20	18.67	15.98	16.00
1961	3	25	49	95					17.27	14.33	15.15
1962									15.96	11.35	11.78
1963									15.47	11.74	13.05
1964									14.48	12.21	12.44
1965									14.65	11.37	11.70
1966				33		5	52	57	17.54	14.40	14.79
1967				88					16.24	12.53	12.68
1968							30	33	17.16	11.56	12.14
1969			17	193	6	19	24	21	18.76	15.65	15.88
1970	25	32	124	10			2	18	18.49	15.15	15.96
1971									15.15	11.05	11.24
1972									13.75	12.25	12.69
1973									14.33	11.30	11.38
1974							7	21	16.59	9.97	10.01
1975									15.89	11.97	12.11
1976									14.28	11.59	12.22
1977									14.24	11.68	12.06
1978							4	35	16.58	13.90	14.06
1979			37	95			20	18	17.85	14.08	15.24
1980			38	156					17.14	14.32	15.72
1981									14.33	9.90	10.58
1982							6	42	17.56	10.24	10.99
1983	11	58	26	101				9	18.34	15.24	15.28
1984			36	159			25	28	16.86	15.48	15.79
Totals	55	220	741	1715	91	167	498	495			

Flood Protection

Maximum Sept. 1 stage: 16.78 feet NGVD
Mean Sept. 1 stage: 14.78 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	91	79	66	53	36	12	2

Demands Not Met

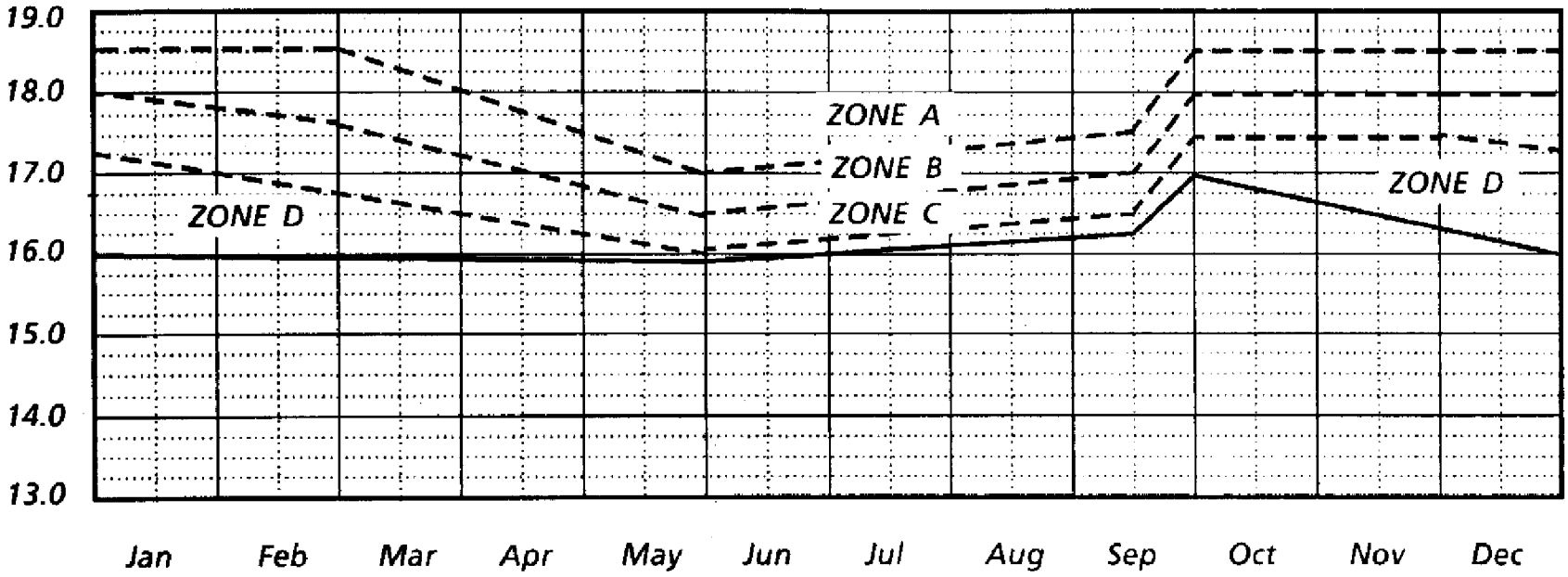
Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	502500	5.4	1066500	1.2
1971	114100	21.6	30900	2.0
1974	91500	30.7	293299	19.5
1981	30900	11.8	99270	6.6
1982	1700	0.7	356171	23.7

*Total study period

Regulation Schedule: RUN 29

Description: Again Zone A, B and C are the same as schedule 26. Zone D releases are started earlier than schedule 26.

Comment: Results are similar to 26. The early Zone D releases appear almost insignificant in reducing Zone A discharges.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs	3500 cfs
C	Maximum practicable to WCA's	4500 cfs	2500 cfs
D	Maximum practicable to WCA's	Maximum non-harmful discharges to estuary when stage is rising	Maximum non-harmful discharges to estuary when stage is rising

Run 29 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			19	83		5	14	16	18.02	15.20	15.31
1953		1	29	142	26	29	31	15	19.05	14.93	14.95
1954	15	29	89	79		20	80	51	18.02	16.00	16.02
1955				139				3	17.14	14.70	14.73
1956									15.80	11.24	12.31
1957							64	20	17.67	13.74	15.05
1958		30	136	46			15	92	17.98	15.96	16.18
1959			20	191	5	83	62	3	18.47	15.96	16.00
1960	1	44	104	64	54	6	73	20	18.62	15.98	16.00
1961	3	25	49	84					17.27	13.48	13.52
1962									16.00	11.47	11.83
1963									15.52	11.78	13.09
1964									14.50	12.24	12.47
1965									14.66	11.39	11.72
1966				1		4	64	55	17.53	14.41	15.10
1967				72					16.24	12.63	12.78
1968							32	32	17.17	11.62	12.19
1969			18	182	6	21	24	27	18.77	15.70	15.90
1970	25	33	123	6			2	19	18.49	15.15	15.97
1971									15.15	11.06	11.24
1972									13.75	12.25	12.69
1973									14.33	11.30	11.38
1974							7	21	16.59	9.97	10.01
1975									15.89	11.97	12.11
1976									14.28	11.59	12.22
1977									14.24	11.68	12.06
1978							4	35	16.58	13.90	14.06
1979			37	85			22	18	17.88	14.16	15.32
1980			39	149					17.15	14.34	15.74
1981									14.35	9.91	10.59
1982							6	42	17.56	10.25	11.00
1983	11	58	26	98				11	18.34	15.26	15.30
1984			36	152			27	27	16.86	15.54	15.86
Totals	55	220	725	1573	91	168	527	507			

Flood Protection

Maximum Sept. 1 stage: 16.78 feet NGVD
Mean Sept. 1 stage: 14.79 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg,	10	11	12	13	14	15	16	17	18
%	100	97	91	79	66	53	37	12	2

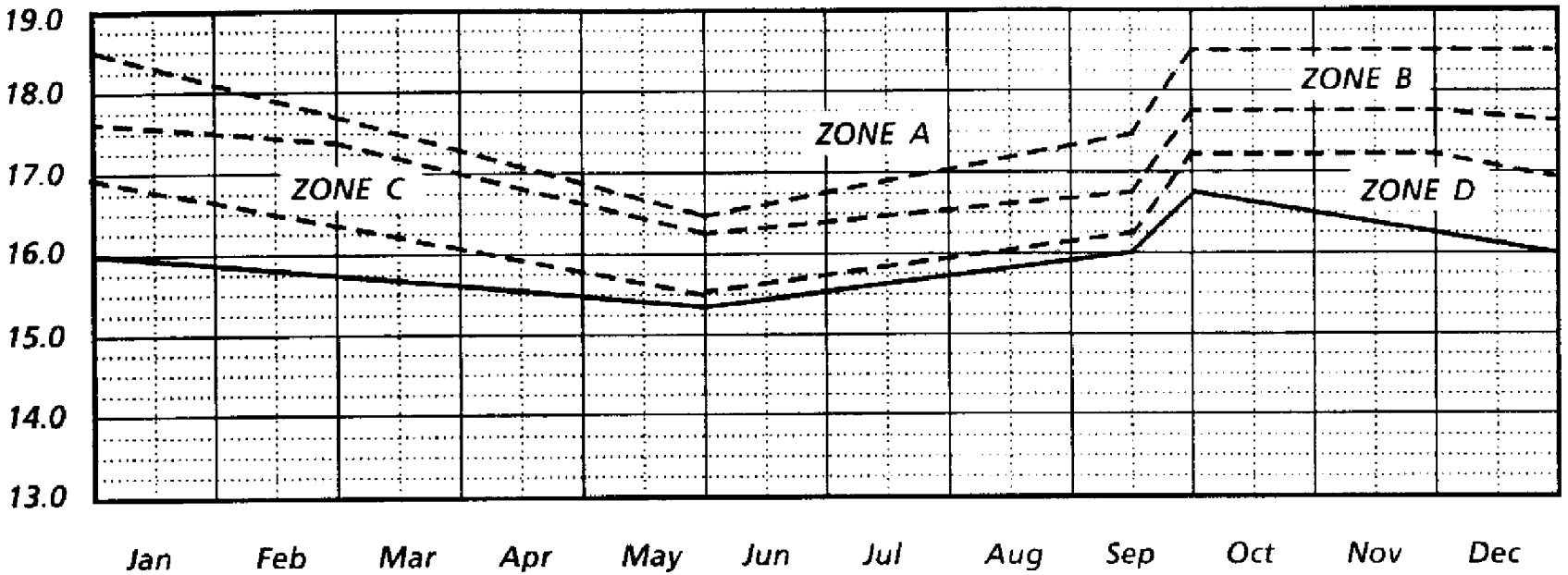
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	502900	5.4	1046100	1.1
1971	114100	21.6	30900	2.0
1974	91500	30.7	293299	19.5
1981	30700	11.8	94758	6.3
1982	1700	0.7	356471	23.7

*Total study period

Description: Similar to schedule 25, with slightly more variation in the lower schedules during the year including earler decline during the dry season.

Conclusion: This schedule reduces Zone A discharges substantially and apparently does not reduce the ability of the system to meet flood protection criteria or meet water use requirements.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump Maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs	3500 cfs
C	Maximum practicable to WCA's	4500 cfs	2500 cfs
D	Maximum practicable to WCA's	Maximum non-harmful discharges to estuary when stage rising	Maximum non-harmful discharges to estuary when stage rising

Run 30 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			28	76		4	14	13	17.73	14.89	15.00
1953			28	147	20	34	32	22	18.95	14.62	13.65
1954	12	57	63	80		21	80	46	17.72	15.75	15.76
1955				138				4	16.84	14.40	11.43
1956									15.47	10.90	11.98
1957							57	35	17.42	13.47	14.83
1958		34	132	46			20	76	17.69	15.51	15.91
1959			19	152		91	59	3	18.47	15.73	15.75
1960		54	98	61	48	11	76	18	18.51	15.65	15.75
1961		30	53	79					16.99	14.16	13.70
1962									15.80	11.16	11.18
1963									15.31	11.61	12.90
1964									14.40	12.04	12.28
1965									14.61	11.27	11.60
1966				24			70	54	17.28	14.36	14.86
1967				61					16.00	12.46	12.62
1968						1	37	29	16.92	11.53	12.11
1969			19	176	2	22	28	32	18.58	15.27	15.64
1970	19	51	111	13			8	18	18.26	14.77	15.71
1971									14.78	10.82	11.00
1972									13.61	12.11	12.55
1973									14.31	11.26	11.34
1974							16	11	16.29	9.96	9.99
1975									15.59	11.68	11.85
1976									14.17	11.43	12.08
1977									14.14	11.59	11.96
1978							12	29	16.34	13.83	14.00
1979			41	54			21	19	17.63	13.91	15.06
1980			35	178					16.89	14.03	15.38
1981									14.05	9.76	10.42
1982							7	60	17.32	10.15	10.91
1983	4	68	25	103				20	18.14	15.05	15.08
1984			35	162			29	28	16.58	15.18	15.49
Totals	36	294	687	1550	70	184	566	448			

Flood Protection

Maximum Sept. 1 stage: 16.49 feet NGVD
Mean Sept. 1 stage: 14.55 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg.	10	11	12	13	14	15	16	17	18
%	99	96	89	77	64	49	27	08	02

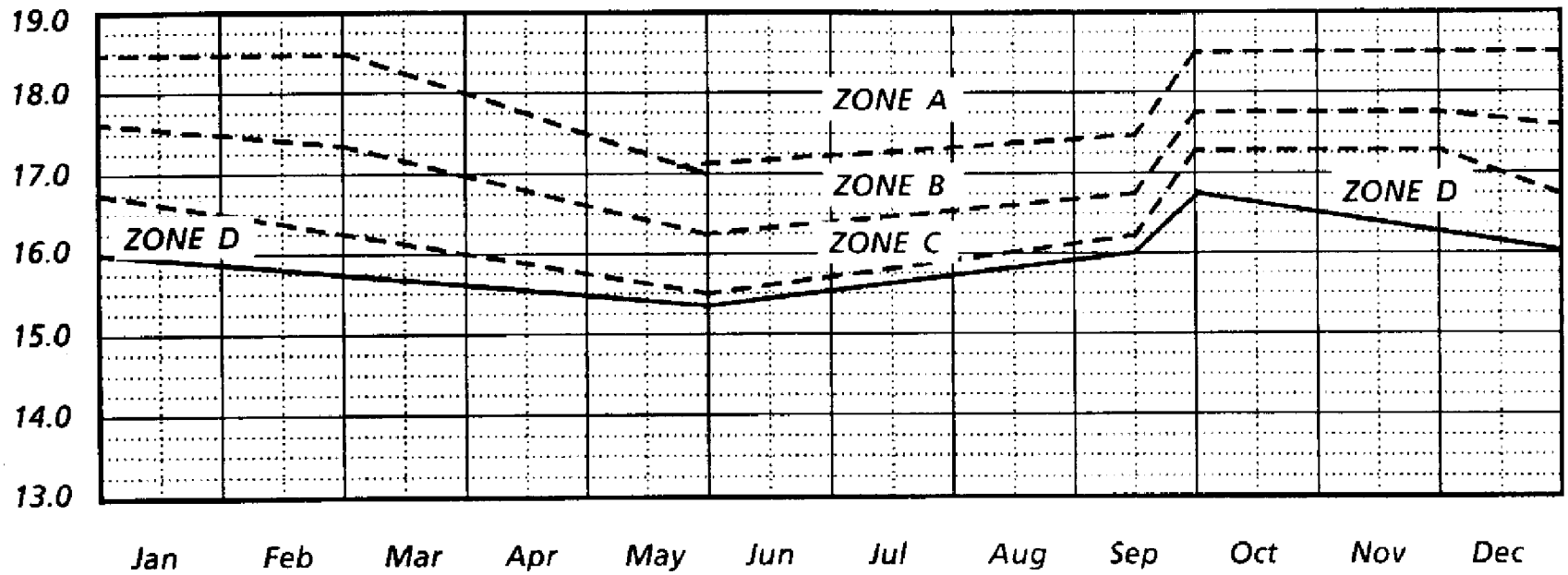
Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	552700	5.9	1259300	1.4
1971	118700	0.7	42200	2.8
1974	97300	16.0	299600	19.9
1981	41800	32.6	165000	11.0
1982	1700	22.5	363500	24.2

*Total study period

Description: Same as Schedule 25 except Zone C and Zone D releases began at lower levels.

Conclusion: This schedule helped the literal zone while it decreases demands satisfied compared to scedule 25.



Releases Through Outlets

ZONE	Agricultural Canals	Caloosahatchee River	St. Lucie Canal
A	Pump Maximum practicable to WCA's	Up to maximum capacity at S-77	Up to maximum capacity at S-80
B	Maximum practicable to WCA's	6500 cfs	3500 cfs
C	Maximum practicable to WCA's	4500 cfs	2500 cfs
D	Maximum practicable to WCA's	Maximum non-harmful discharges to estuary when stage is rising	Maximum non-harmful discharges to estuary when stage is rising

Run 31 Summary Sheet 2 of 2

Year	Dry Season Regulation Discharges (# of days)				Wet Season Regulation Discharges (# of days)				Stages Feet NGVD		May 31 Stage Feet NGVD
	Zone A	Zone B	Zone C	Zone D	Zone A	Zone B	Zone C	Zone D	Max	Min	
1952			37	58			16	9	17.69	14.71	14.83
1953			34	129	19	34	32	8	18.94	14.47	14.49
1954	12	56	72	72		6	94	44	17.72	15.49	15.52
1955			7	123					16.72	14.30	14.33
1956									15.44	10.85	11.94
1957							56	35	17.40	13.44	14.80
1958		27	143	42			20	76	17.66	15.51	15.91
1959			30	141		74	75	4	18.41	15.49	15.50
1960		54	107	52	47	12	69	25	18.54	15.48	15.49
1961	2	29	59	65					16.85	14.01	15.05
1962									15.71	11.04	11.07
1963									15.22	11.53	12.80
1964									14.36	11.97	12.22
1965									14.60	11.24	11.56
1966				23			70	54	17.28	14.35	14.86
1967				61					16.00	12.46	12.62
1968						1	37	29	16.92	11.53	12.11
1969			30	161	2	22	19	26	18.59	15.19	15.38
1970	19	52	115	4			3	22	18.26	14.78	15.60
1971									14.79	10.83	11.01
1972									13.61	12.11	12.56
1973									14.31	11.26	11.33
1974							16	11	16.29	9.96	9.99
1975									15.59	11.68	11.85
1976									14.17	11.43	12.08
1977									14.14	11.59	11.96
1978							12	29	16.34	13.83	14.00
1979			49	40			18	20	17.56	13.78	14.94
1980			46	137					16.75	13.90	15.25
1981									13.92	9.69	10.33
1982							6	60	17.32	10.11	10.87
1983	1	69	35	94				12	18.04	14.99	15.02
1984			47	133			24	28	16.37	15.04	15.35
Totals	34	287	811	1335	68	149	567	492			

Flood Protection

Maximum Sept. 1 stage: 16.45 feet NGVD
Mean Sept. 1 stage: 14.52 feet NGVD

Stage Frequency

Percent of time at or above given stage (period of record).

Stg.	10	11	12	13	14	15	16	17	18
%	99	96	89	77	64	48	26	8	2

Demands Not Met

Year	Lower East Coast		Lake Okeechobee	
	Acre-feet	Percent	Acre-feet	Percent
Total*	554500	6.0	1308600	1.4
1971	118700	22.5	50600	3.4
1974	97300	32.6	2996	19.9
1981	42500	16.3	1732	11.5
1982	1700	0.7	3635	24.2

*Total study period

APPENDIX B

Water Use Requirements

I. Lake Okeechobee Service Area Water Use Requirements

Agricultural water use is the primary type of water use for the Lake Okeechobee service area. There are nearly 700,000 acres of farm land that is supplied with with water directly from the lake during dry periods when rainfall is not sufficient to meet the water use requirements for the agricultural regions within this service area. Agricultural water use requirements are estimated in this study by the following relationship:

$$AWUR = \Sigma_{i=1}^{NC} PET * K_i * SA_i$$

where

AWUR = Agricultural Water Use Requirements (Acre-Feet)

K_i = crop coefficient which is a function of crop density and type

PET = evapotranspiration as represented by pan evaporation (feet)

SA_i = is cultivated area of each crop type (acres)

NC = number of different crop types

In addition to the agricultural water use requirements in the lake service area, there are municipal water use requirements of the service area that must be considered to obtain the total water use requirement of the area. Therefore, the total water use requirements can be represented by

$$TWUR = AWUR + MWUR$$

where

TWUR = the Total Water Use Requirement (acre feet)

AWUR = the agricultural water use requirement

MWUR = municipal water use requirement

A portion of the demand may be met by direct rainfall or from rainfall that occurred during previous periods and was kept in local storage. Therefore, the portion of the water required from the lake or the supplemental demand may be defined as

$$SD = (PET * K - RF) * SA - LSA$$

where the additional terms are defined as

SD - is the supplemental demand on Lake Okeechobee (acres)

RF - is the rainfall (feet), and

LSA - water taken from local storage when available

These values are estimated on a daily basis. When SD is computed to be less than zero then it is set equal to zero.

In previous studies, demand not met was often represented as a percentage of the supplemental demand not met divided by the supplemental demand. This value, however, does not adequately represent the stress put on the water user since this percentage may be very large when supplemental water use requirements are small, while, in reality, the majority of the demands were satisfied by rainfall or local storage that is available. Therefore, in this report the percentage of water use requirements were represented by the ratio of demands not met to the total water use requirement. Since long term daily average PET values were used for the estimation of agricultural demand, and the municipal demands are assumed to be constant with time, the total annual water use requirements for the lake service areas are constant from year to year. The water use requirements for the Lake Okeechobee service area for the dry season is approximately 1,500,000 acre feet, while for the wet season it is approximately 1,281,000 acre feet.

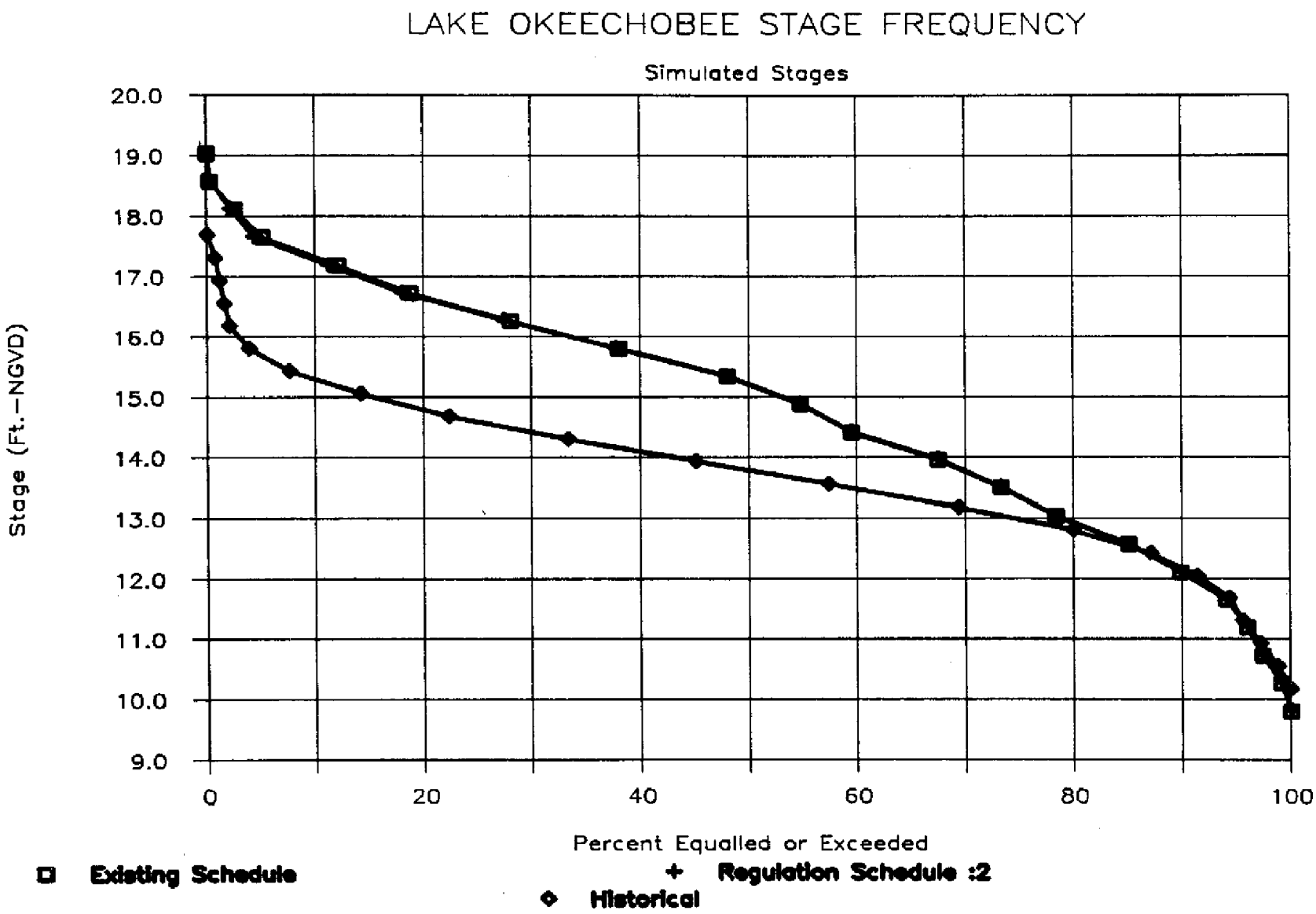
II. Lower East Coast Service Area Water Use Requirements

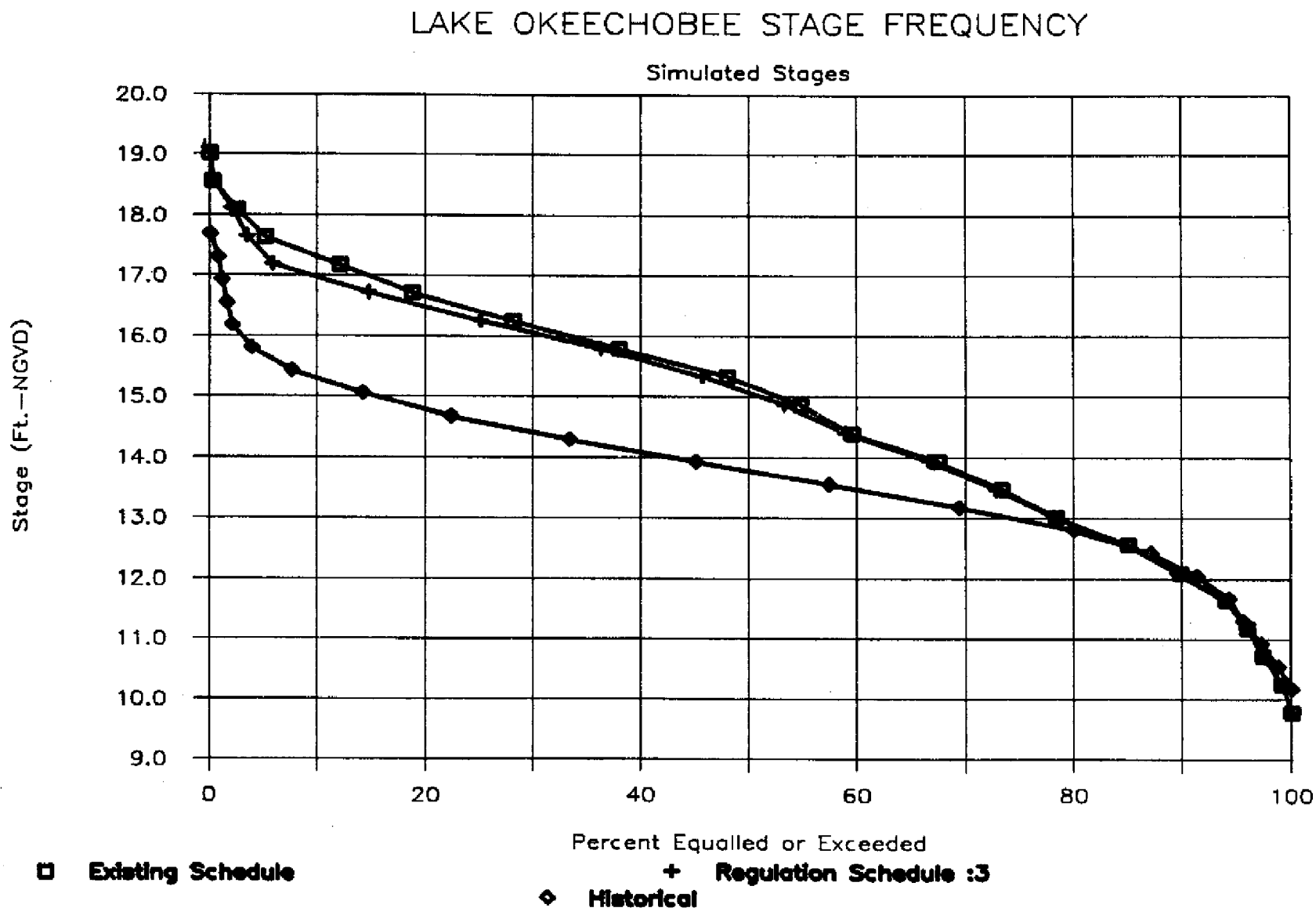
The Lower East Coast service area demands are more complex to estimate due to the large transmissivity of the aquifer, the threat of saltwater intrusion in the region of coastal wellfields, and the large variety of water use requirements in the region. The aquifer in this region is deep and porous creating a tremendous source of fresh water; however, due to the threat of saltwater intrusion, fresh water levels must be maintained higher than the saltwater levels near the interface of the two water types. Therefore, the Lower East Coast water use requirement on the regional hydrologic system is defined as the surface water deliveries required from outside the service area necessary to maintain the canals at specific levels during dry periods in an effort to prevent saltwater intrusion. No attempt is made to estimate actual allowable pumpage rates at individual wellfields since these may be limited due to local conditions.

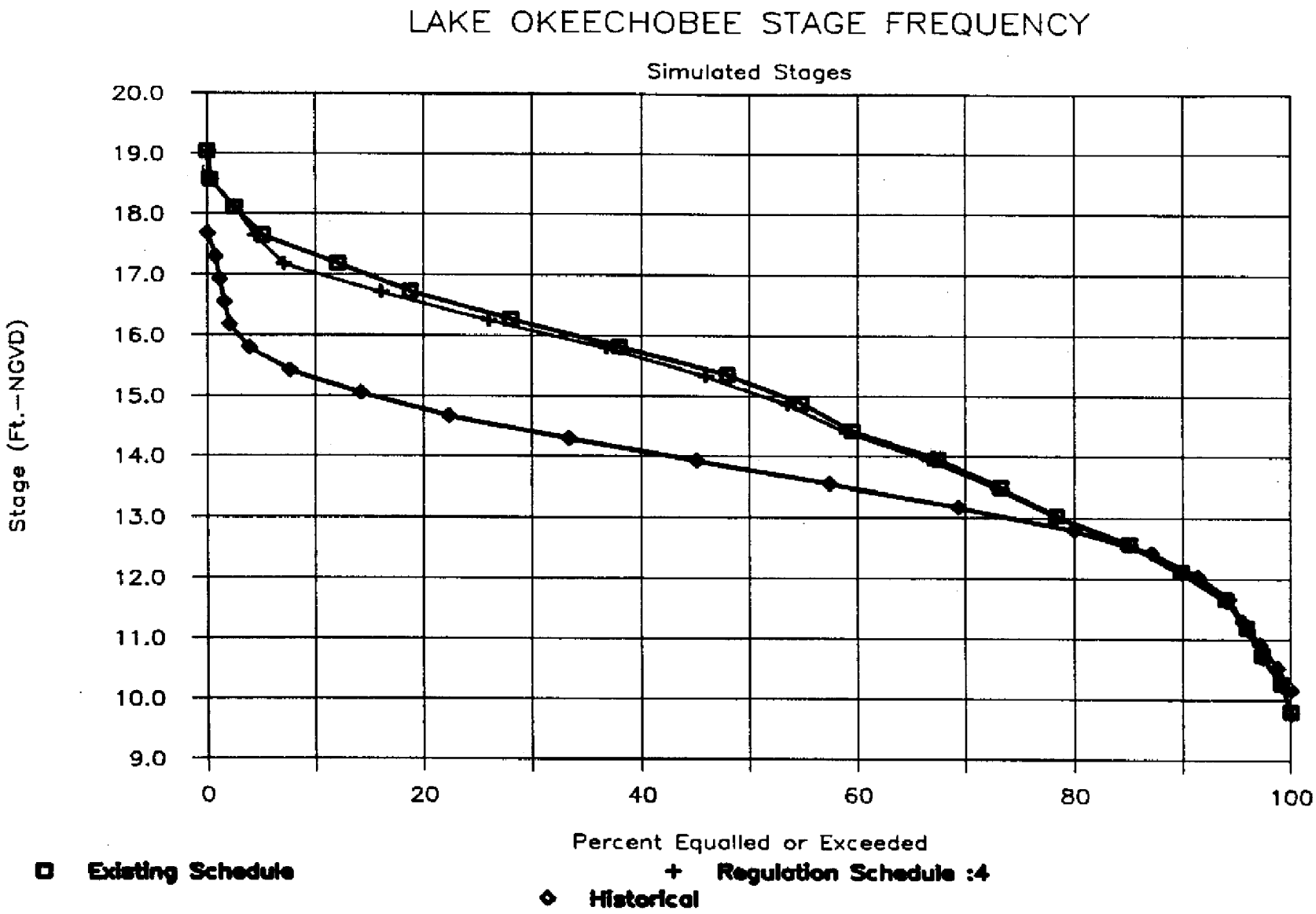
A regional integrated channel groundwater model with a daily time step is used to calculate the Lower East Coast water use requirements. For the critical drought years of 1974, 1981, and 1982, the water use requirements for the Lower East Coast service areas for the dry season were 298,200, 261,200, and 232,600 acre feet respectively.

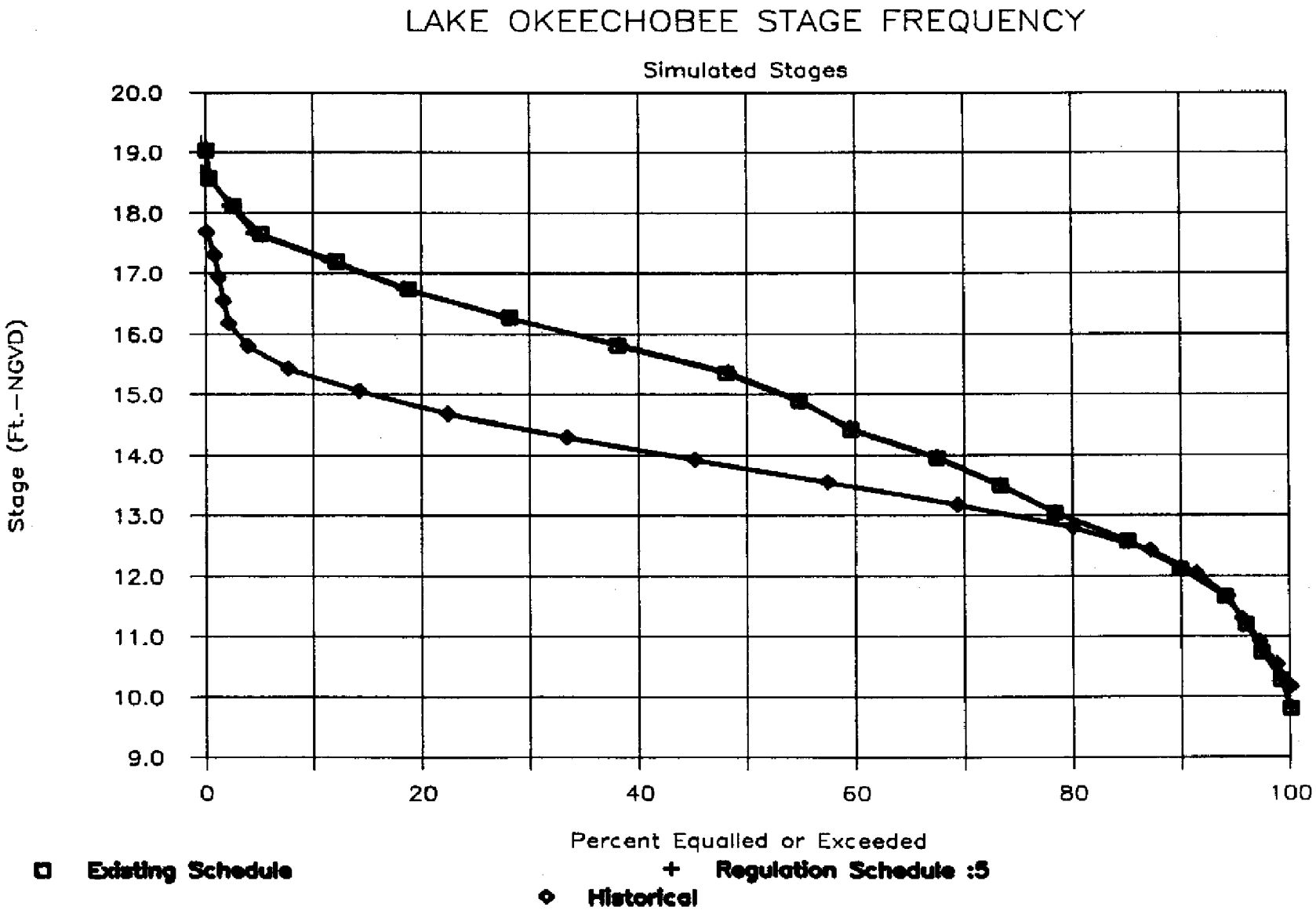
APPENDIX C

Stage Exceedence Curves for all Schedules

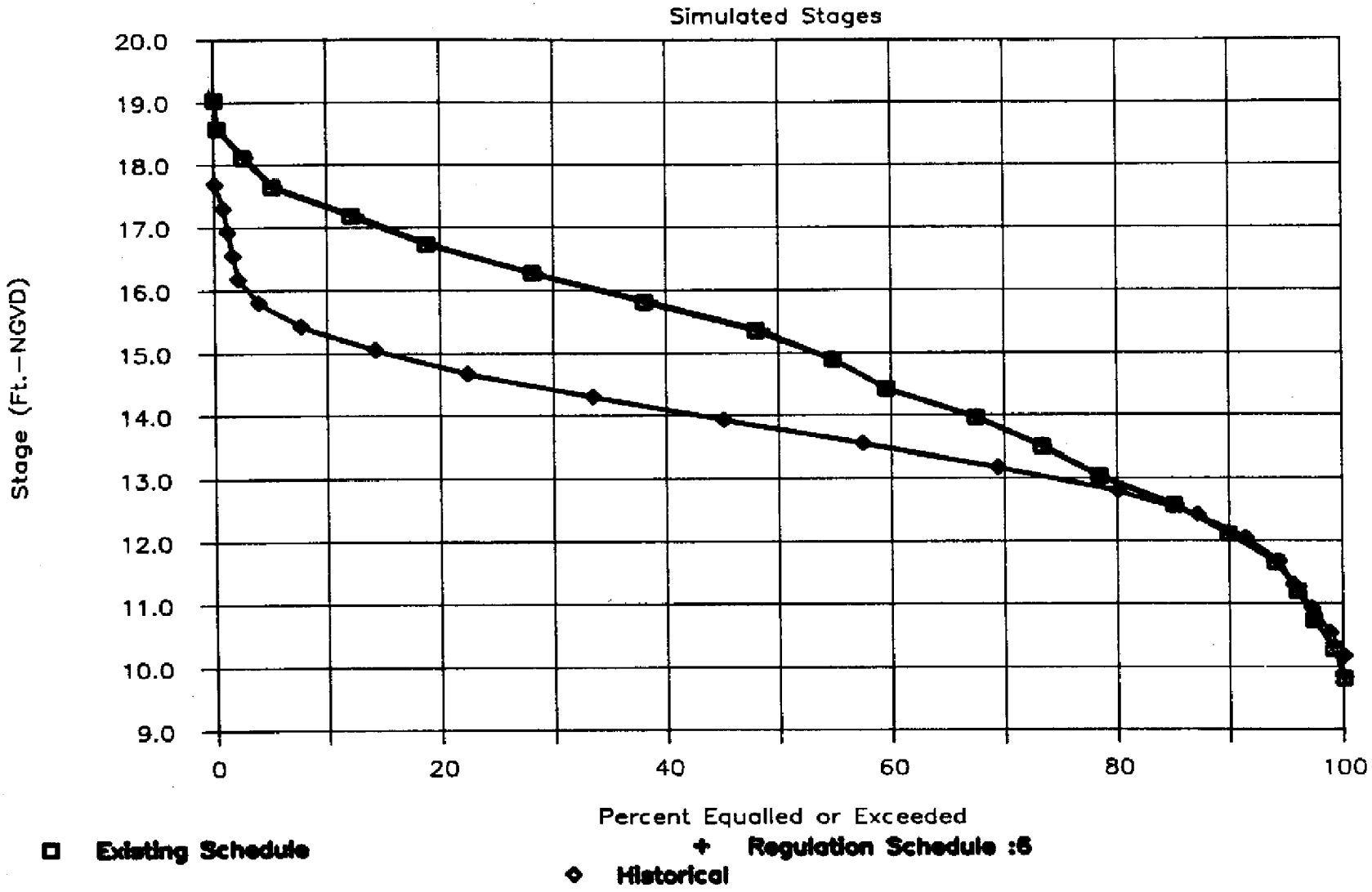

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.-NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :2
Historical


LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.–NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :3
Historical

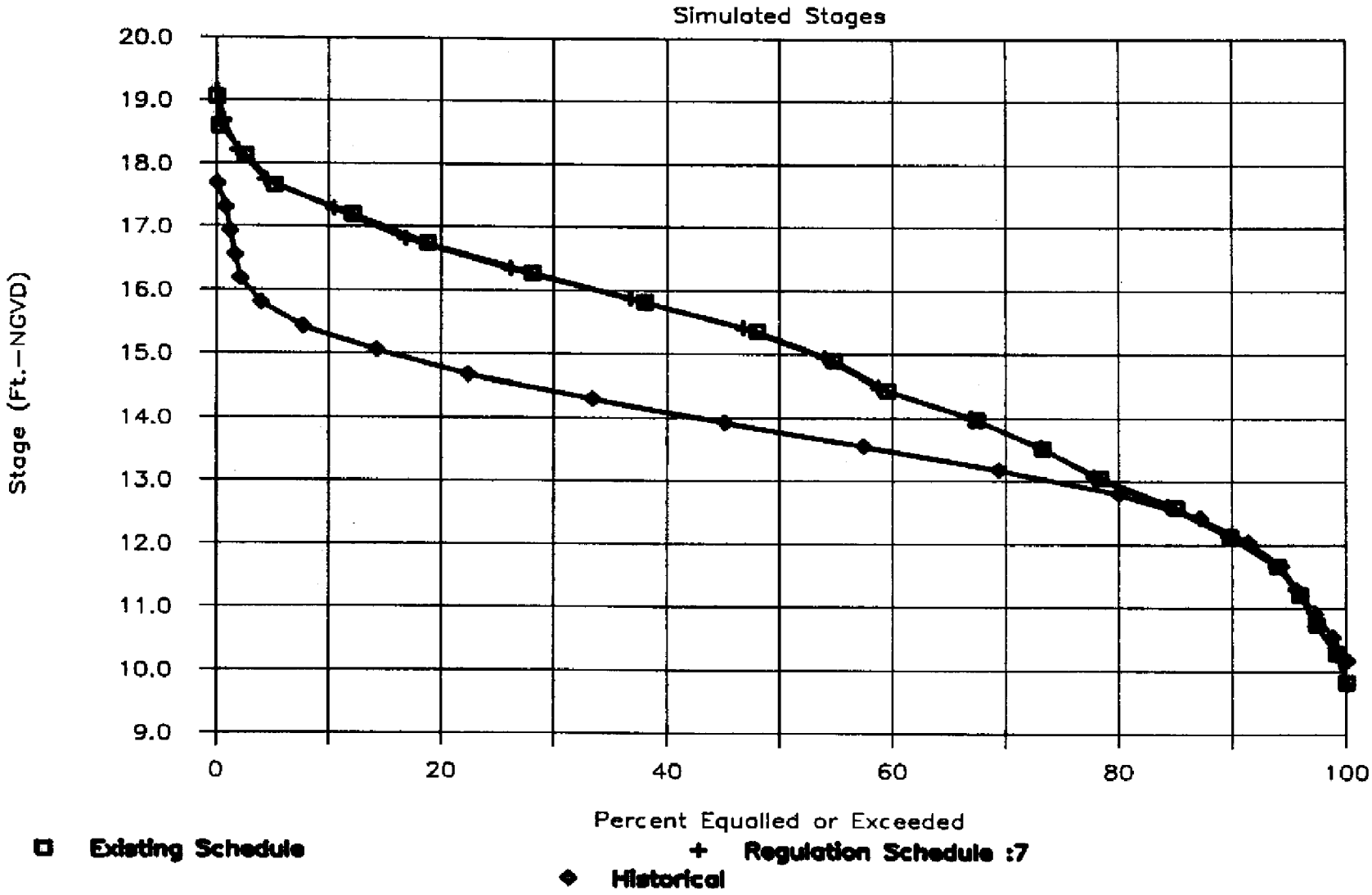

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.—NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :4
Historical

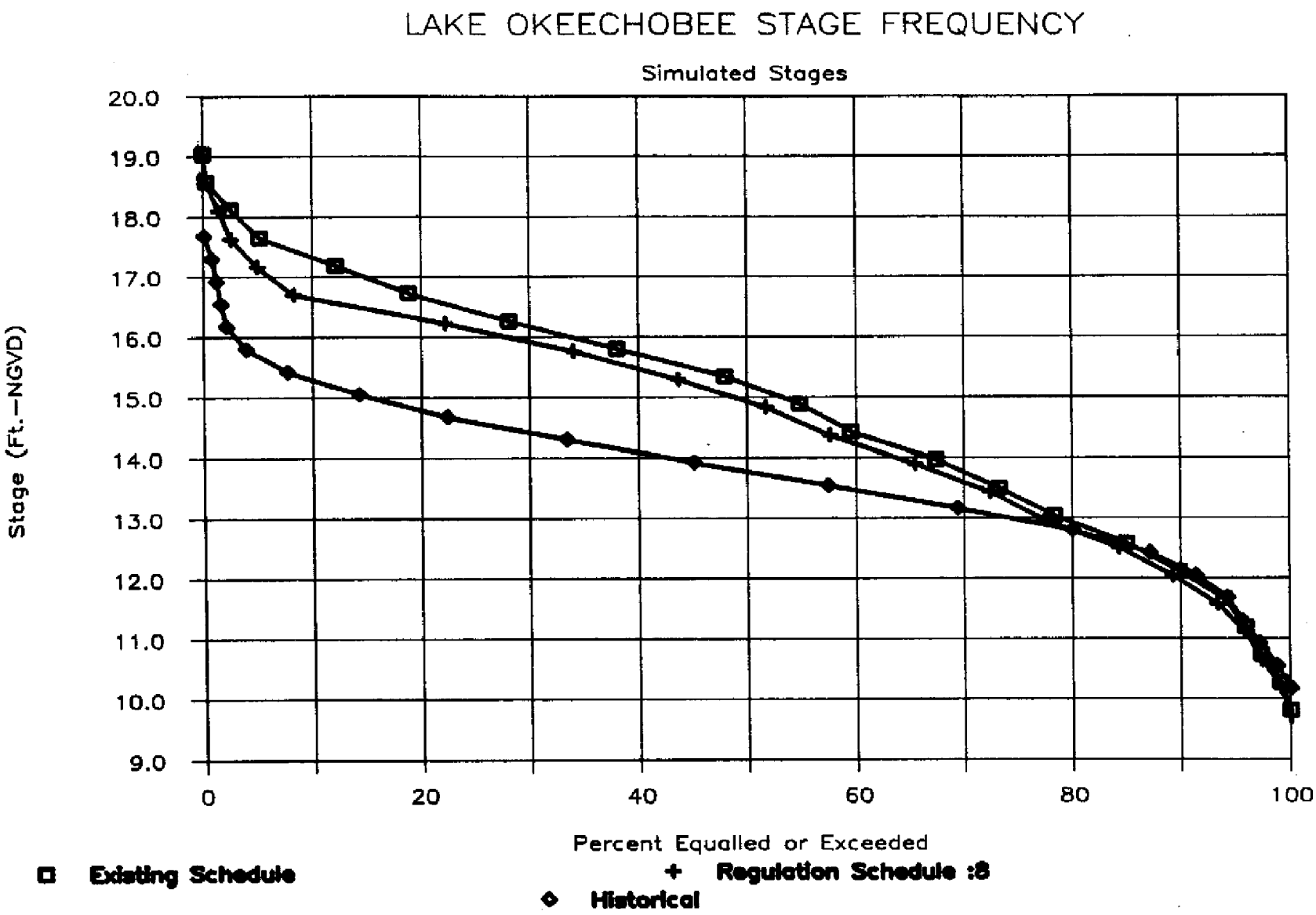

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.—NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :5
Historical

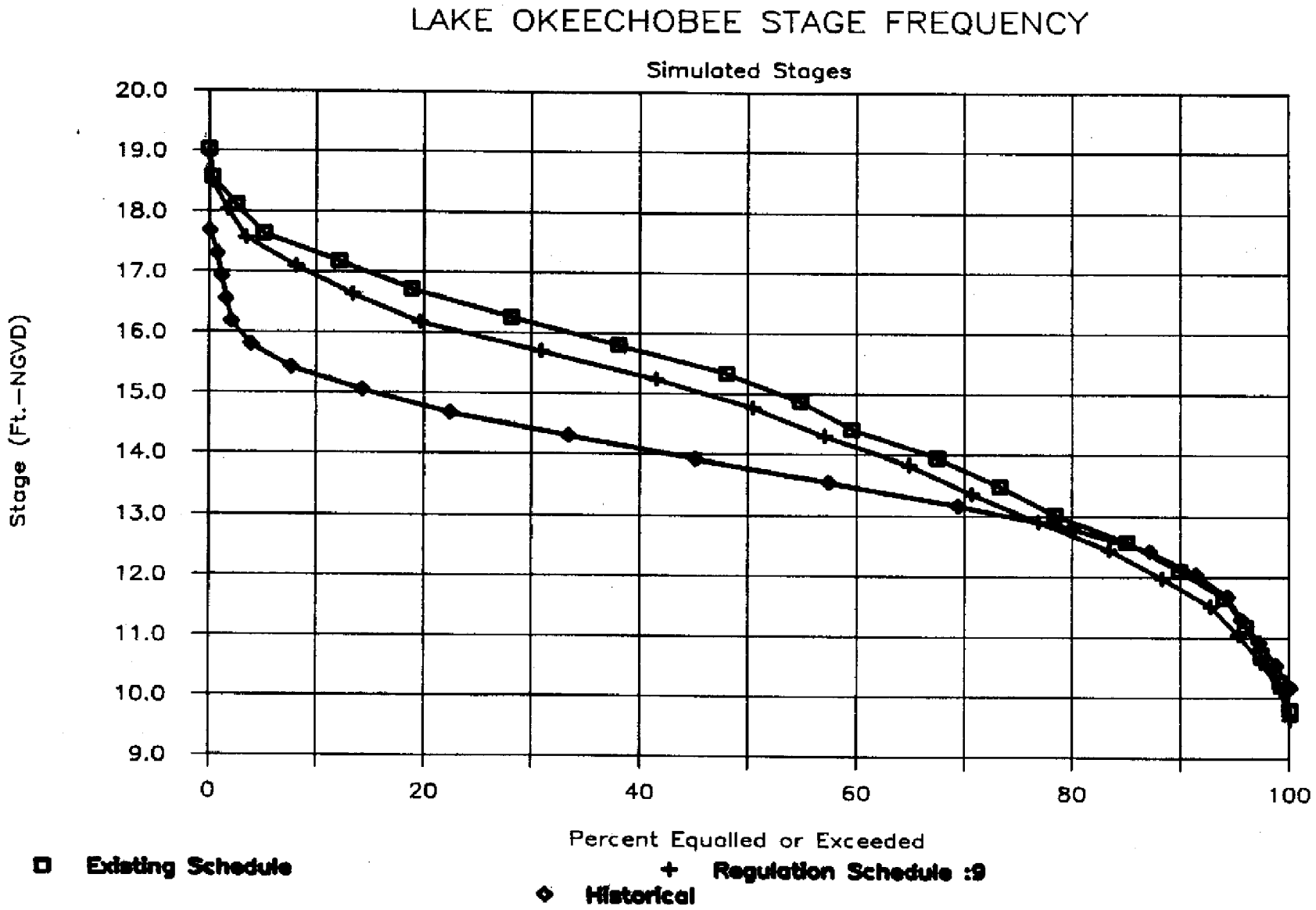
LAKE OKEECHOBEE STAGE FREQUENCY



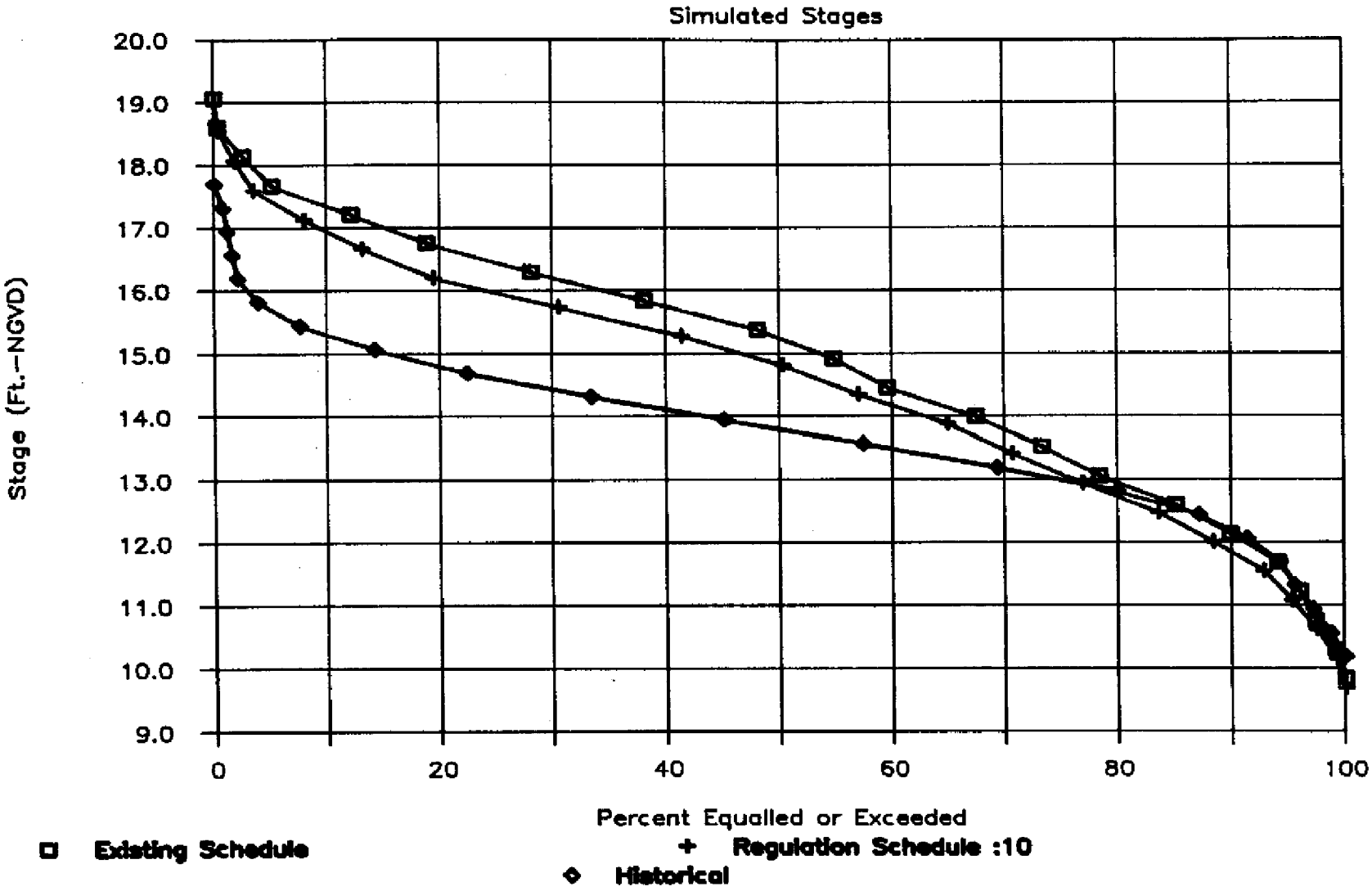
LAKE OKEECHOBEE STAGE FREQUENCY

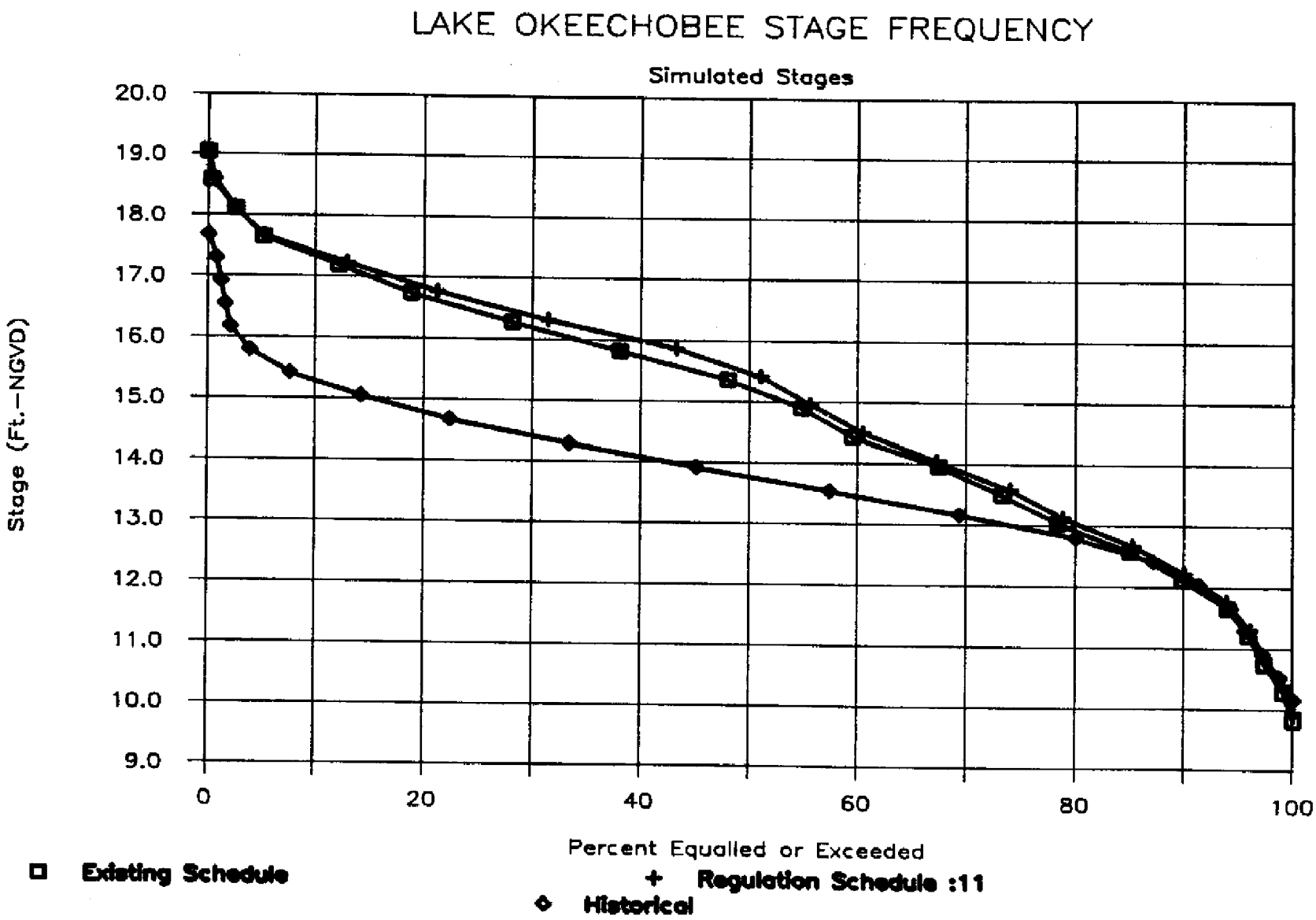


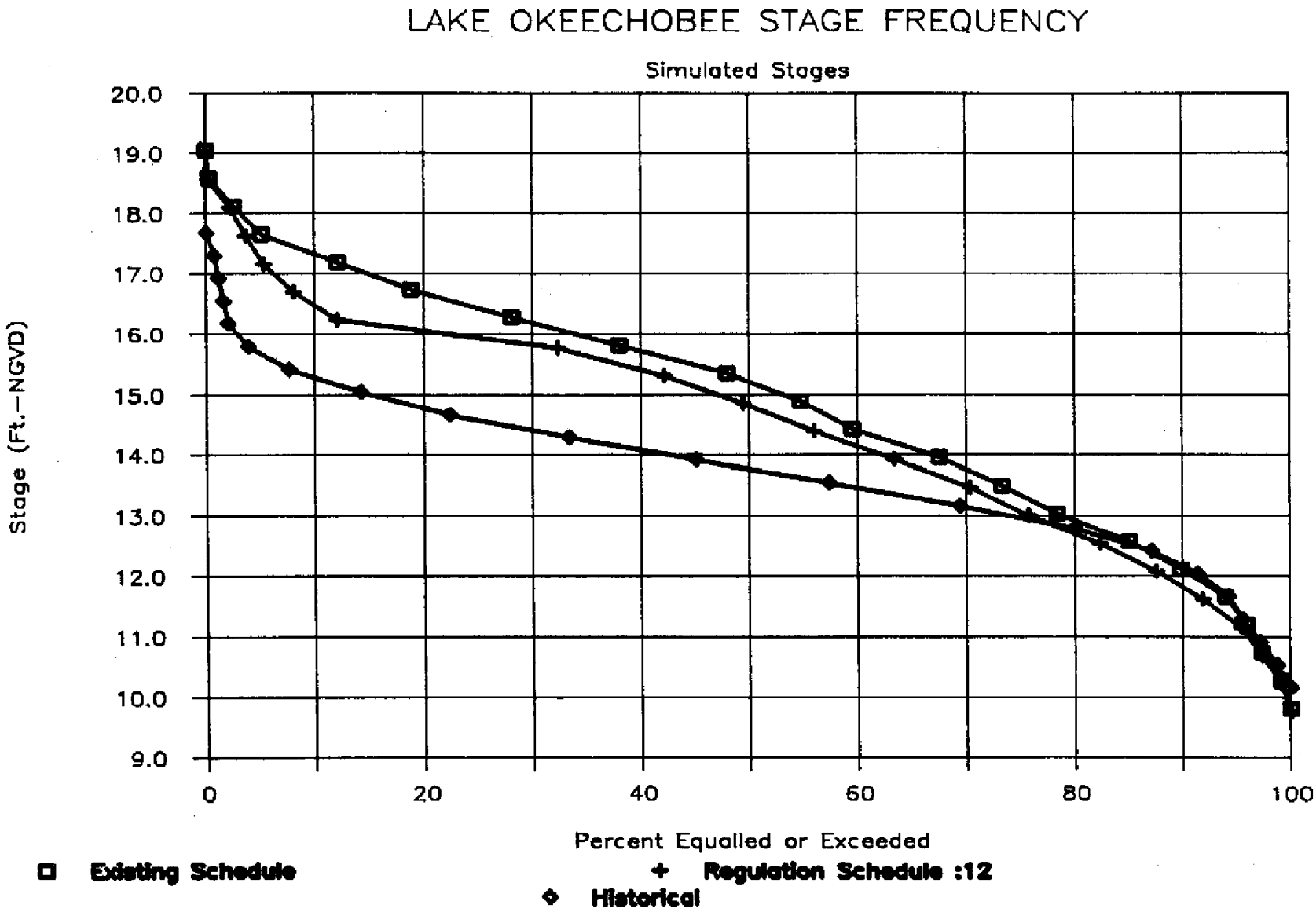

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.—NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :8
Historical


LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.–NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :9
Historical

LAKE OKEECHOBEE STAGE FREQUENCY




LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.–NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :11
Historical


LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.—NGVD)
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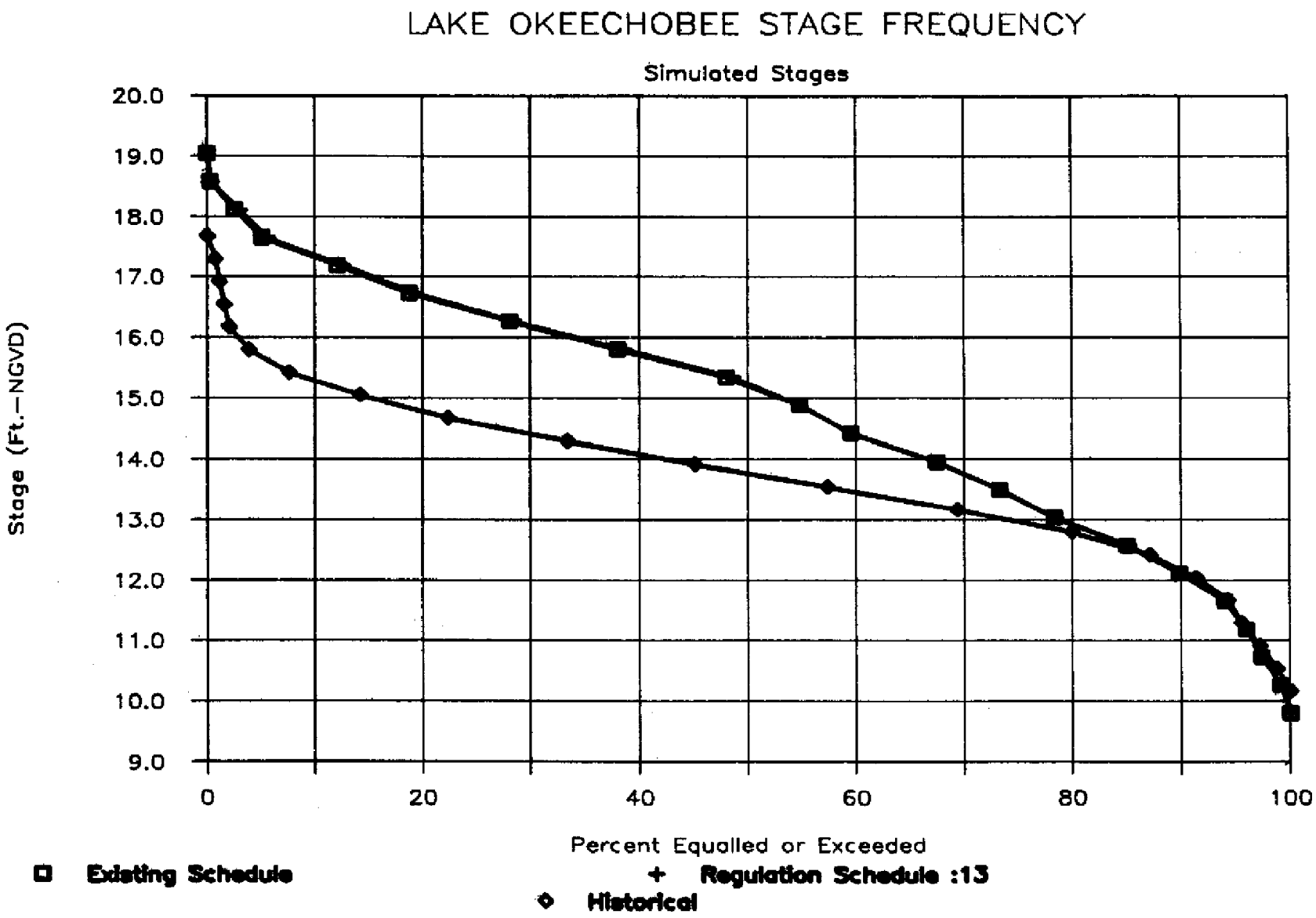
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :12
Historical


LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.–NGVD)
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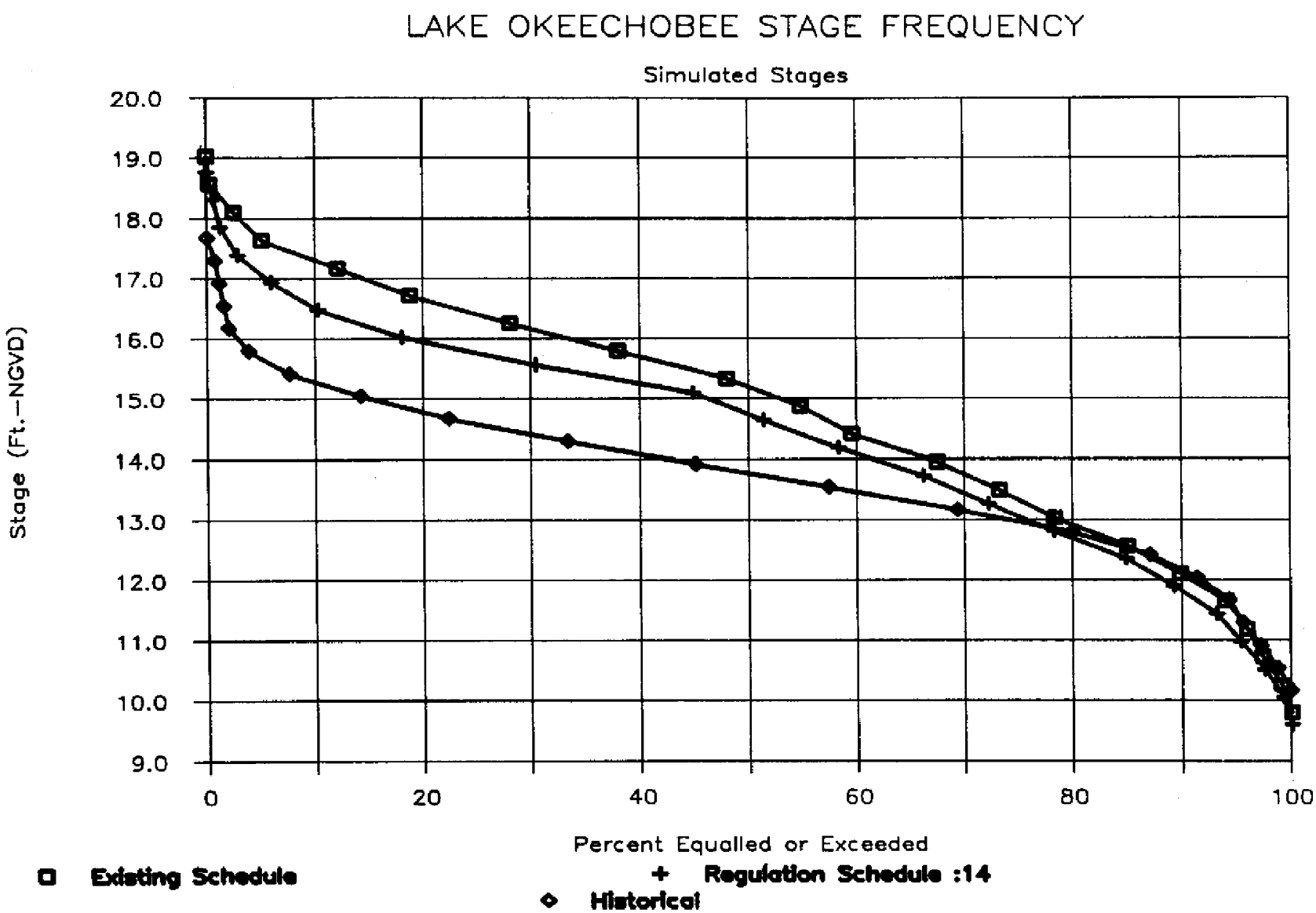
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :13
Historical


LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.–NGVD)
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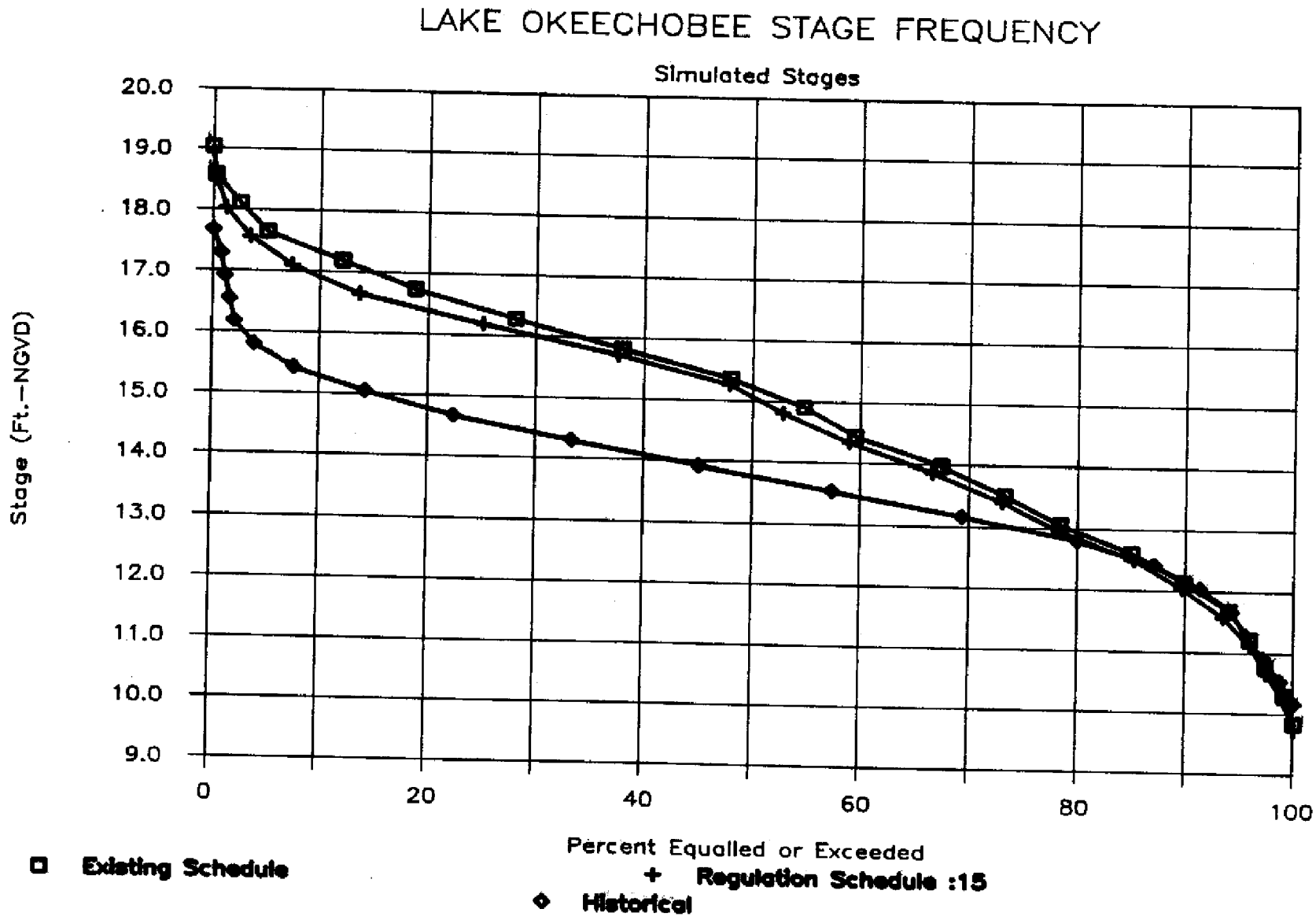
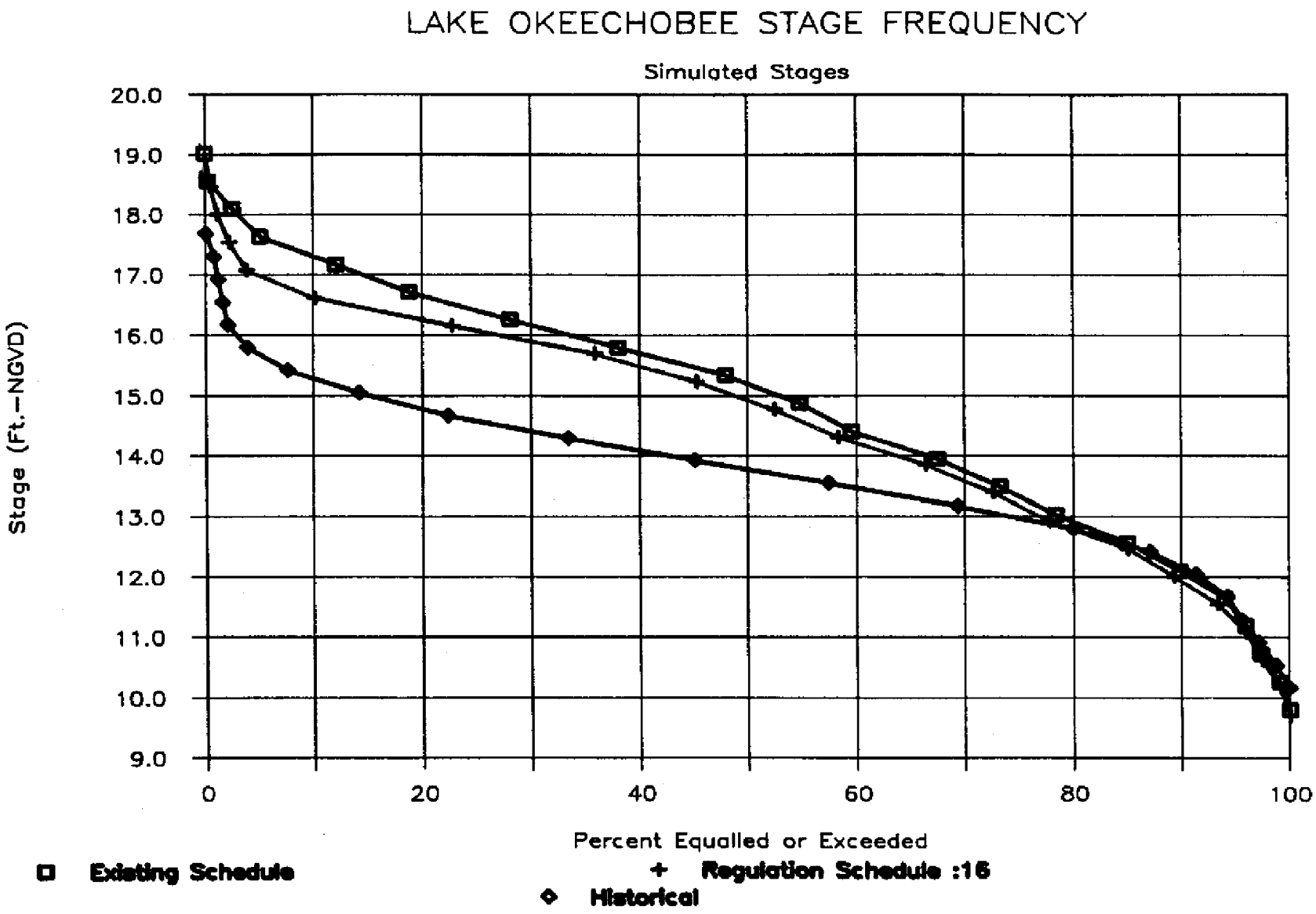
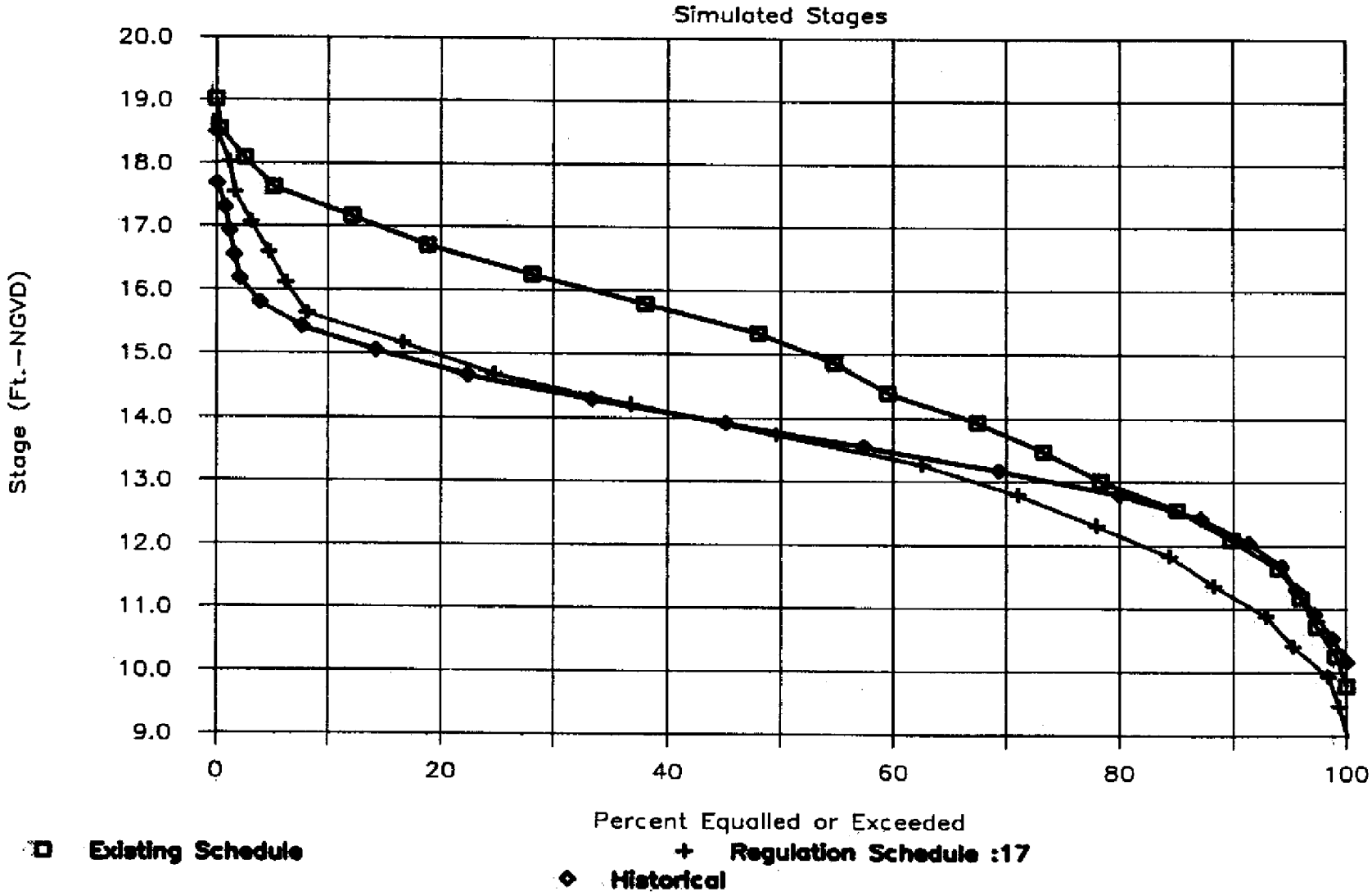
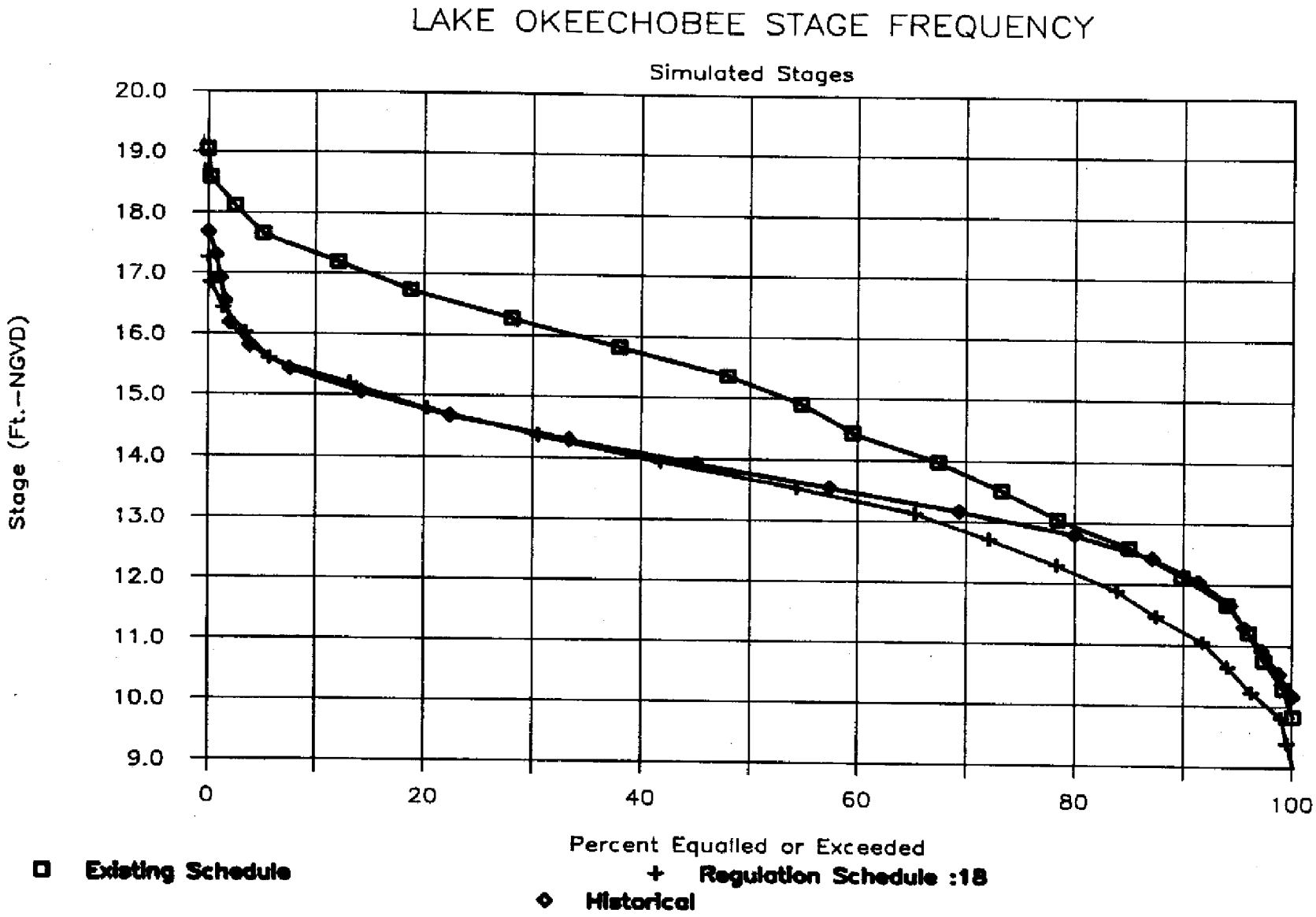
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :14
Historical

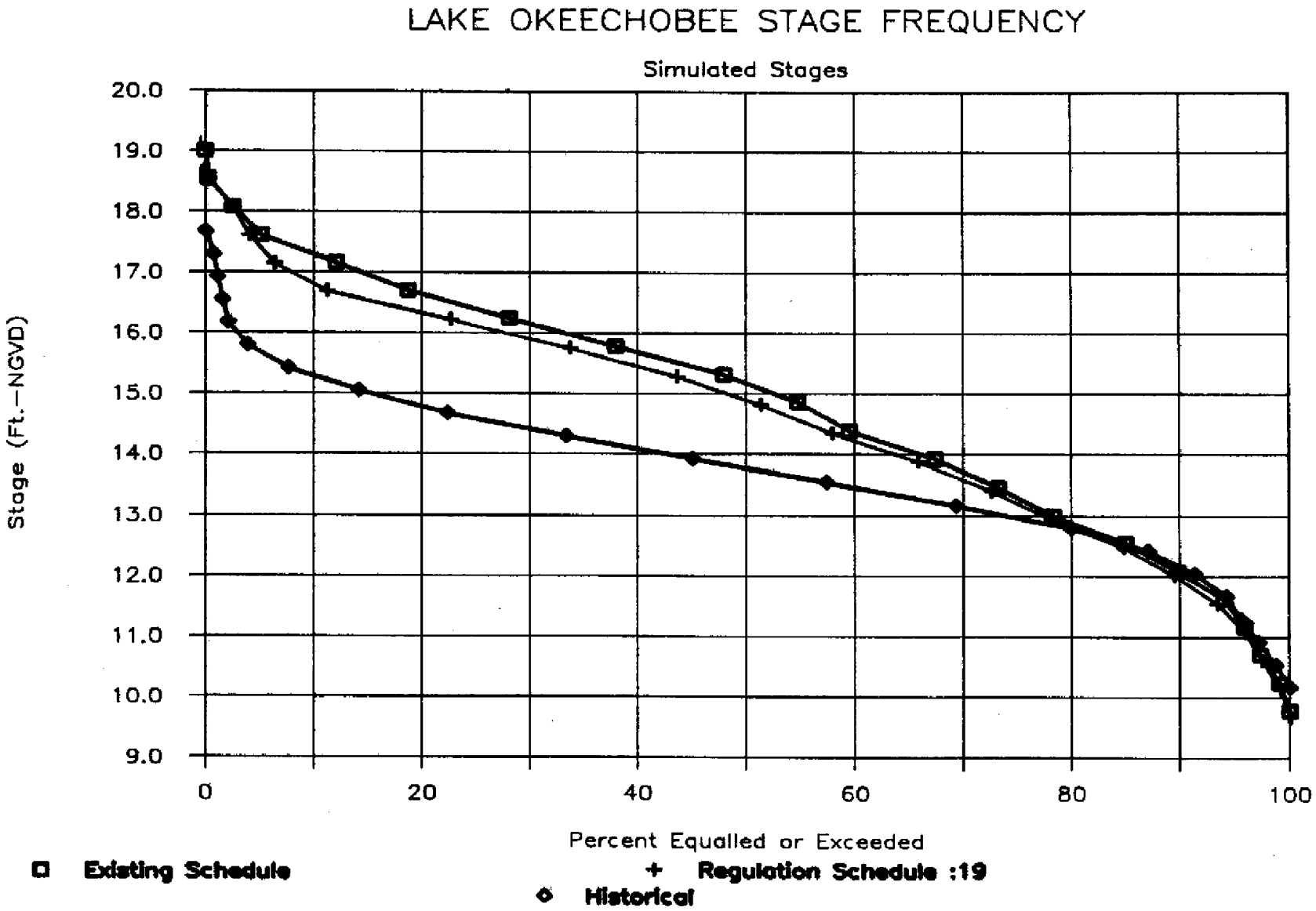

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.–NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :15
Historical

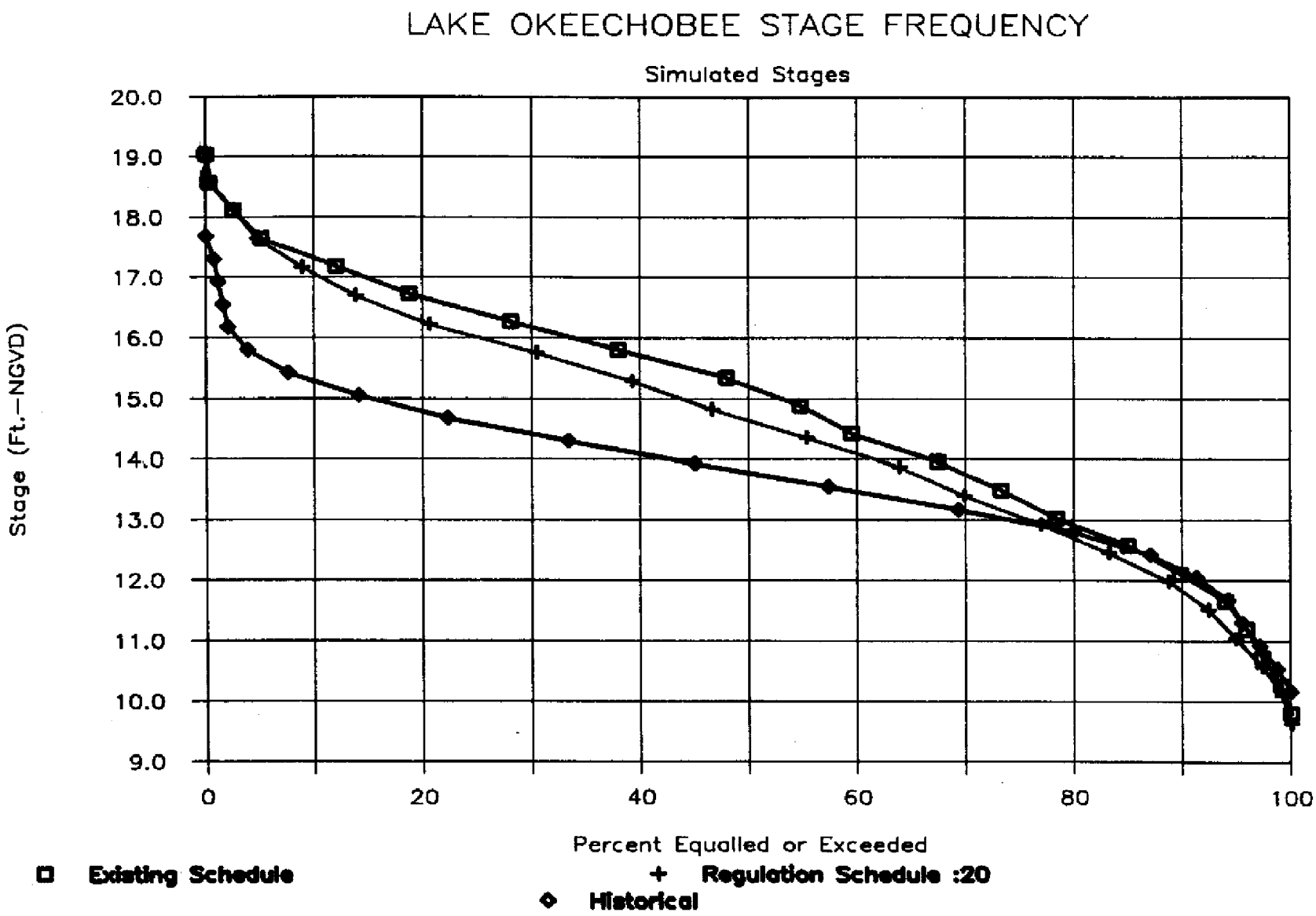

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.-NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :16
Historical

LAKE OKEECHOBEE STAGE FREQUENCY

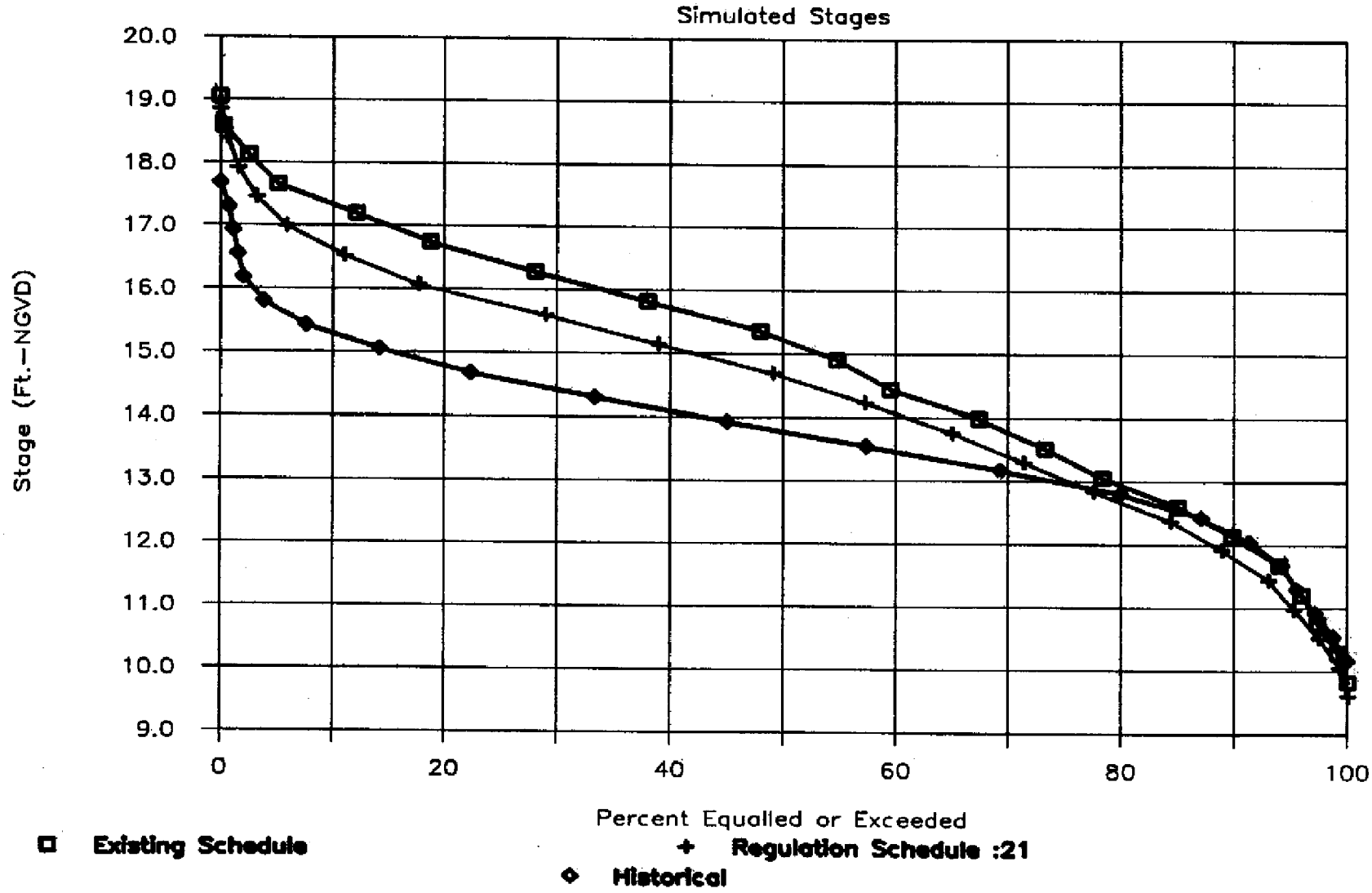


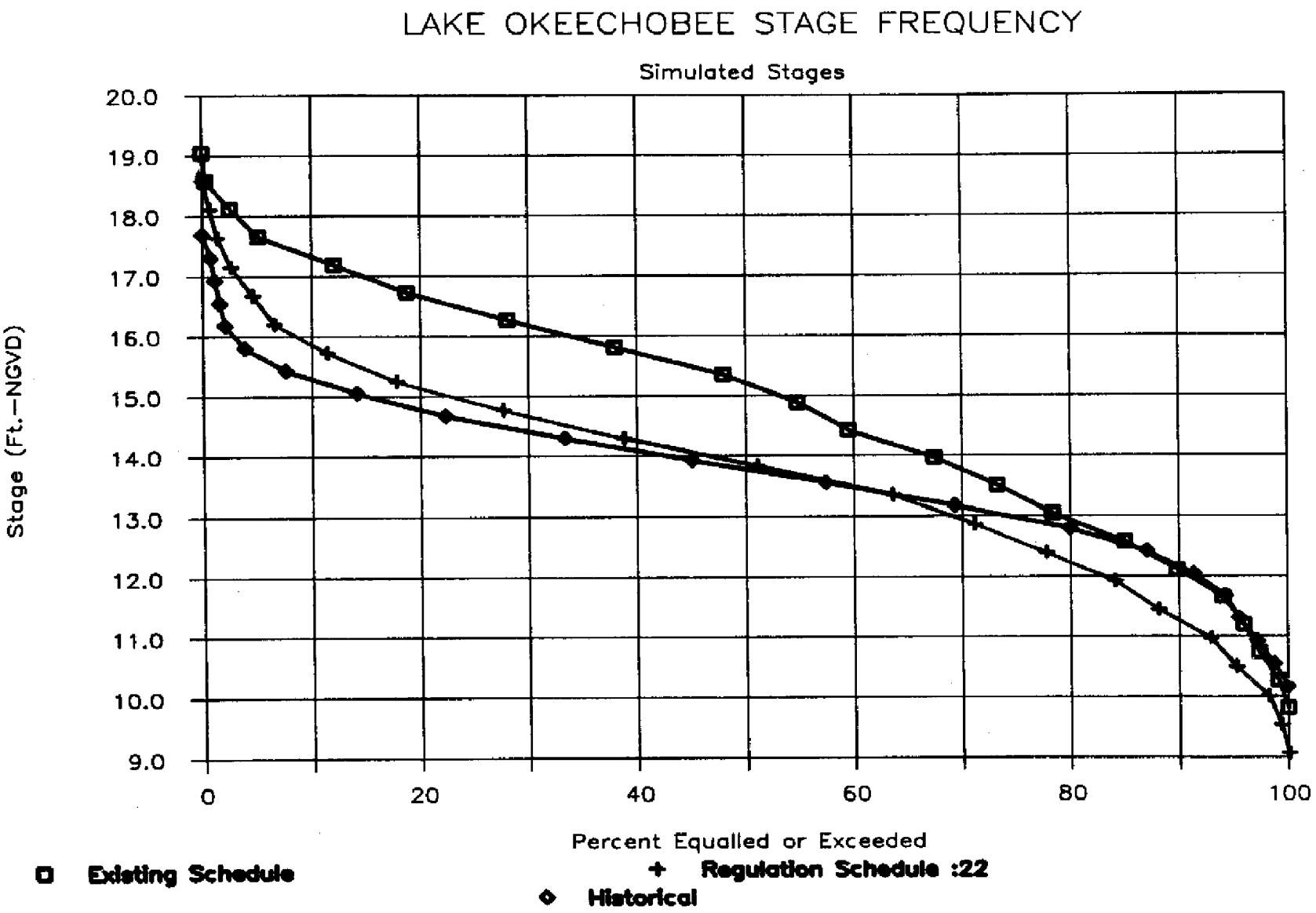

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.–NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :18
Historical

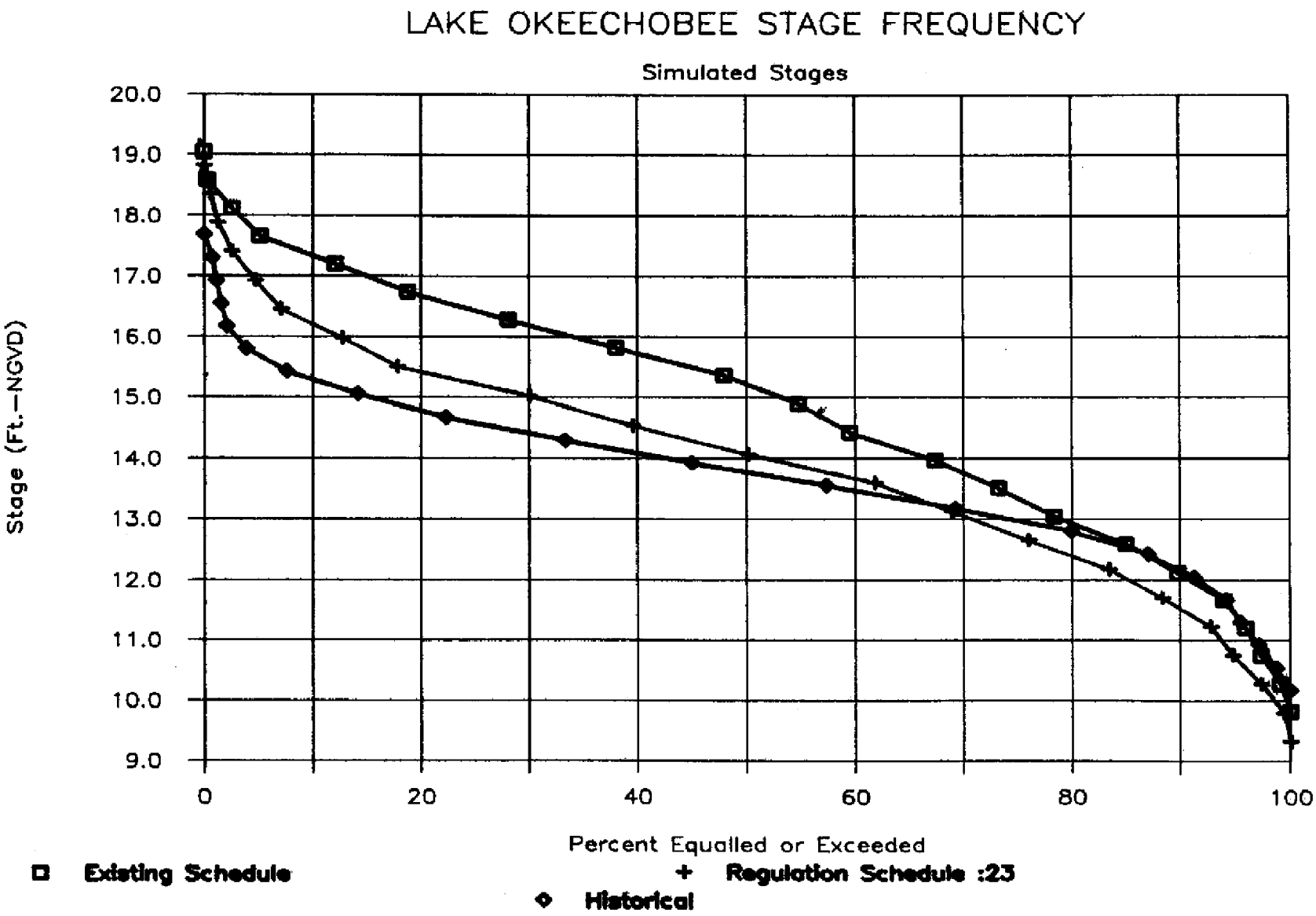

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.—NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :19
Historical

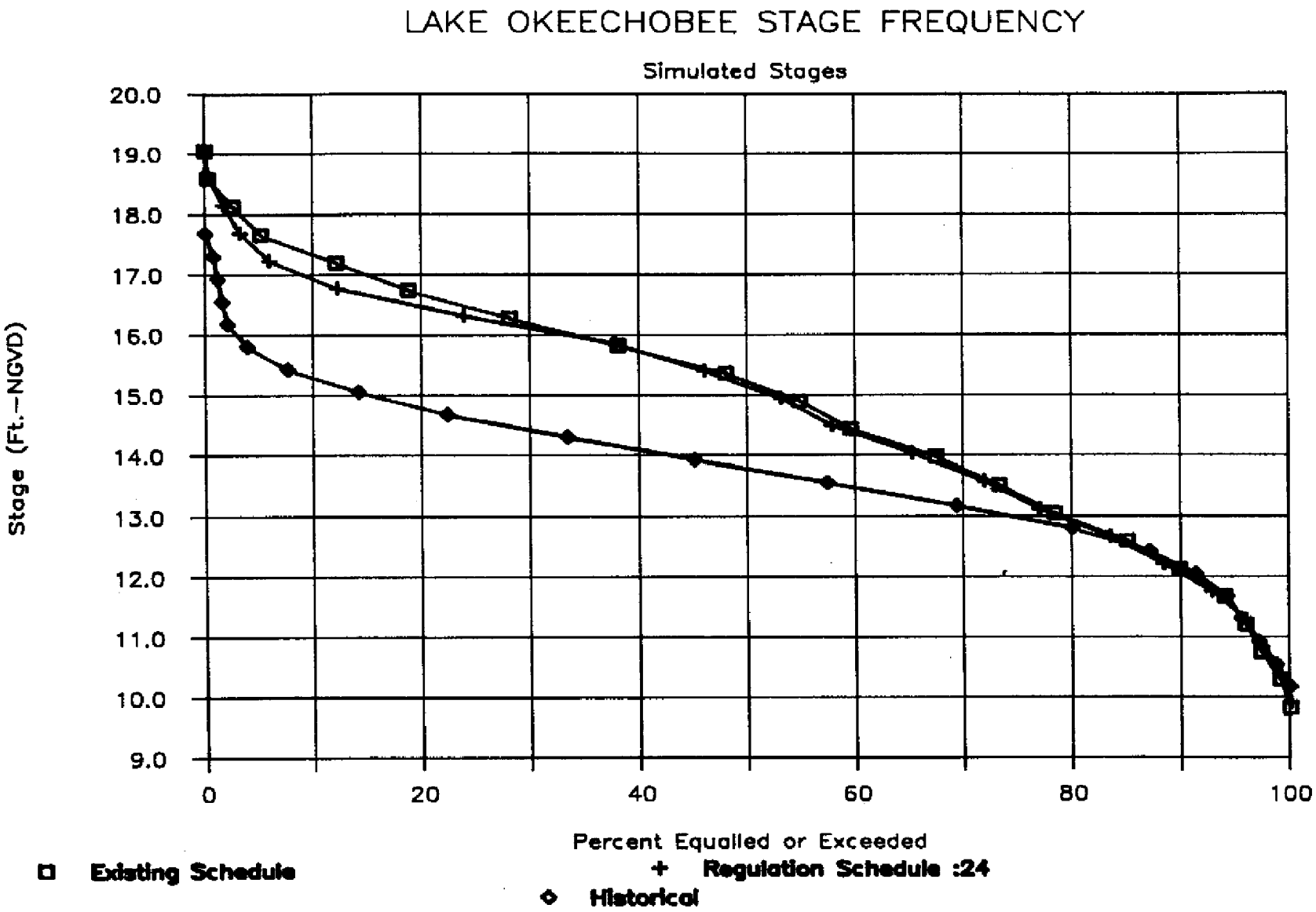

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.–NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :20
Historical

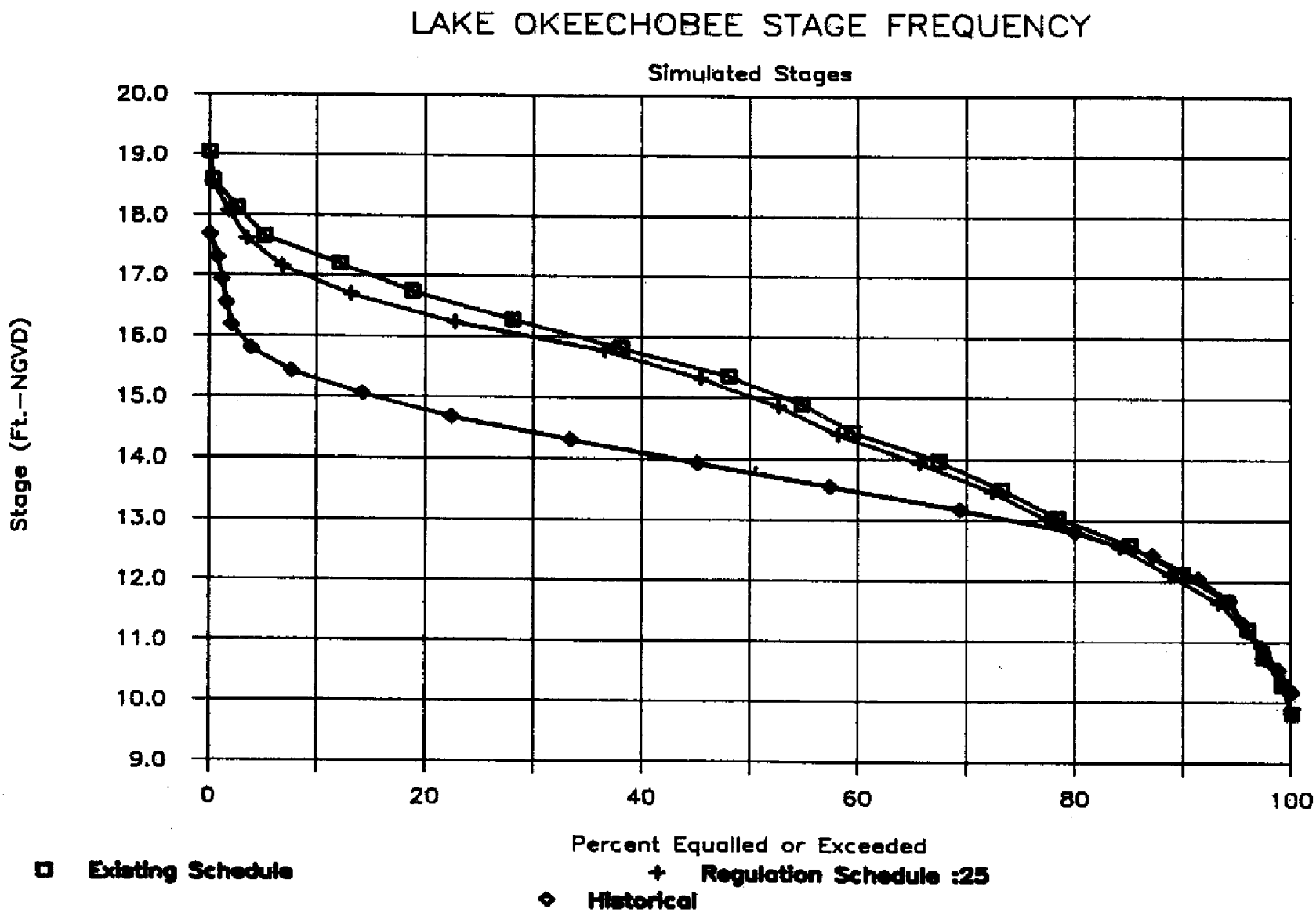
LAKE OKEECHOBEE STAGE FREQUENCY



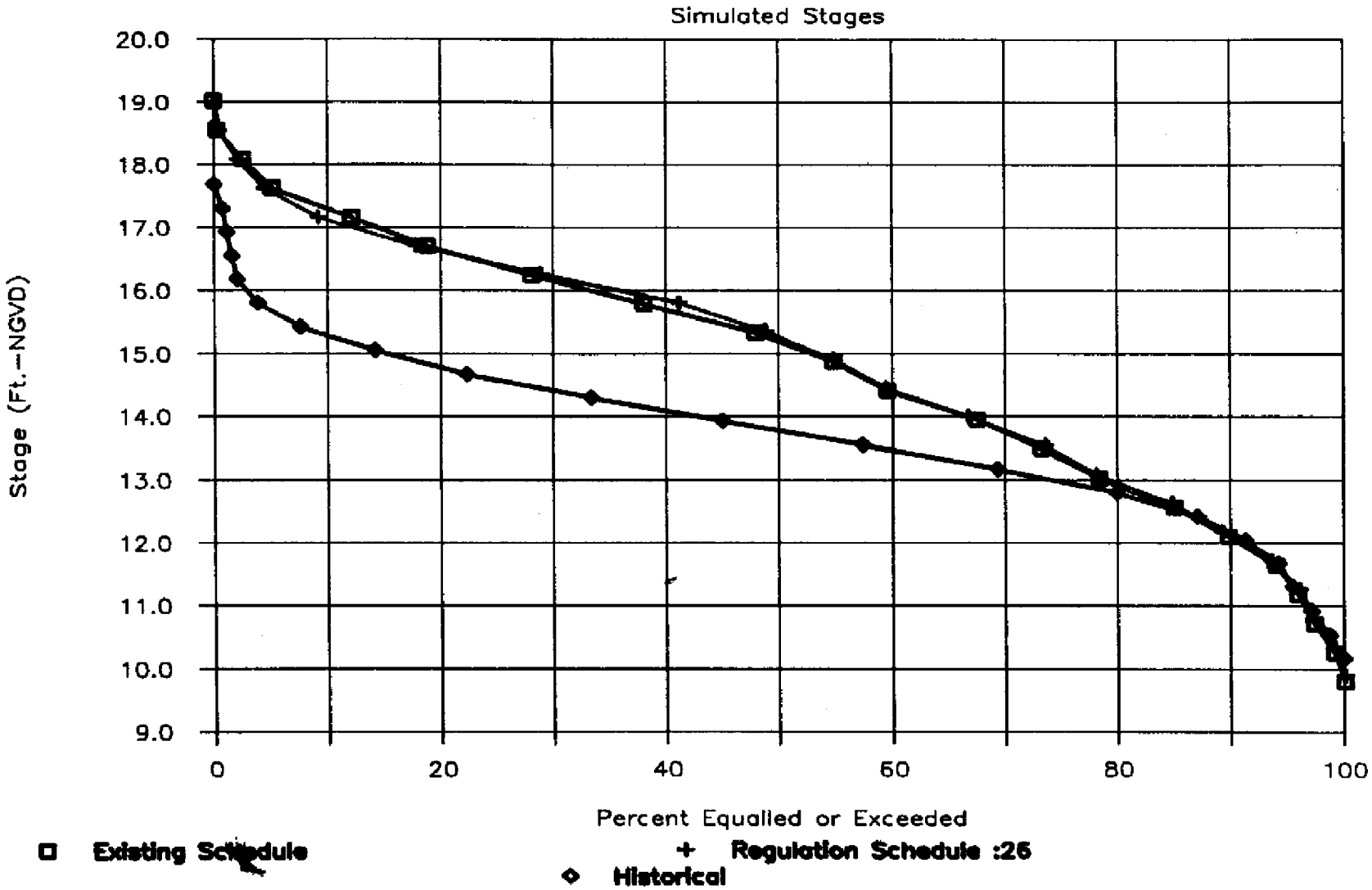

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.–NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :22
Historical

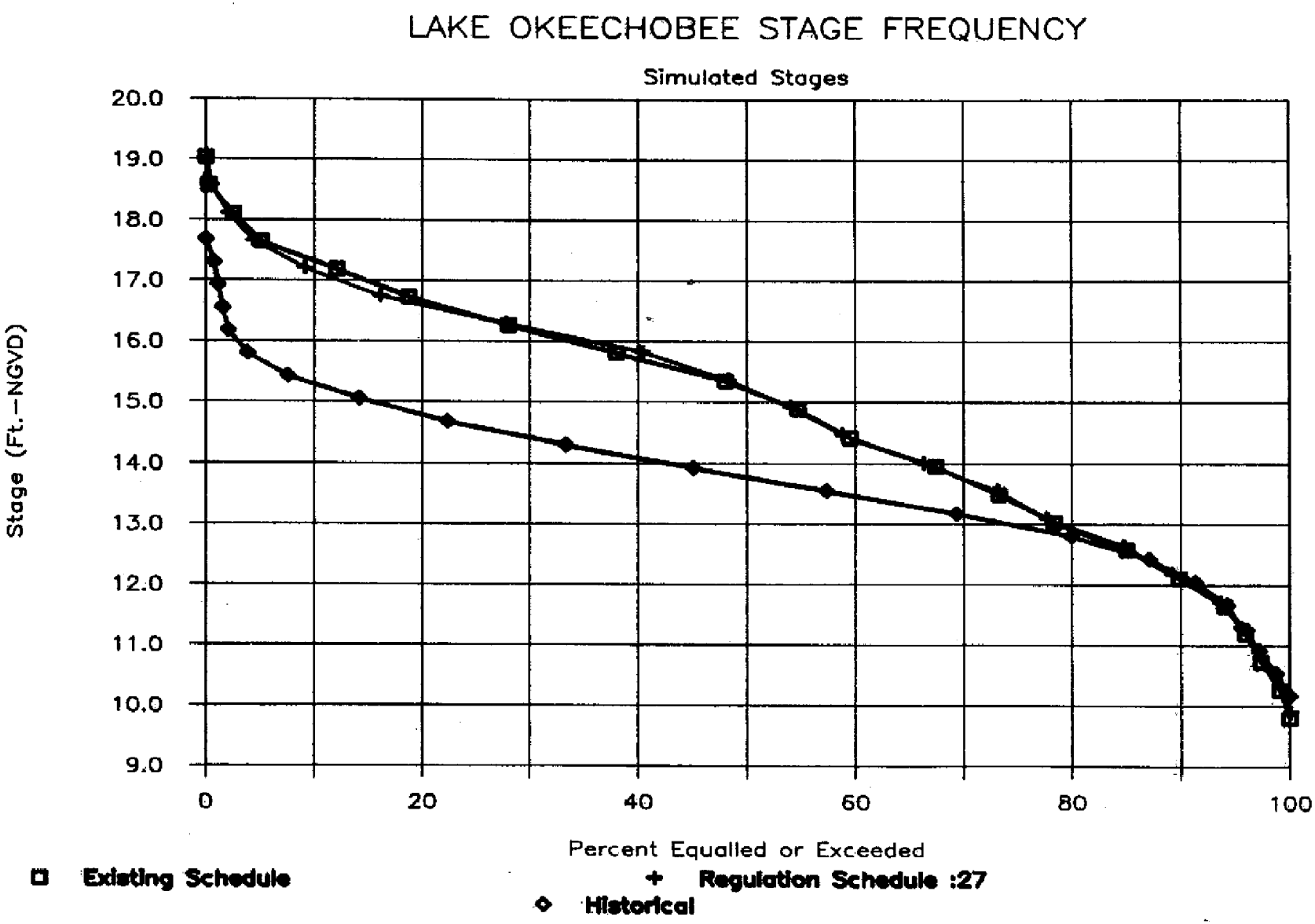

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.—NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :23
Historical

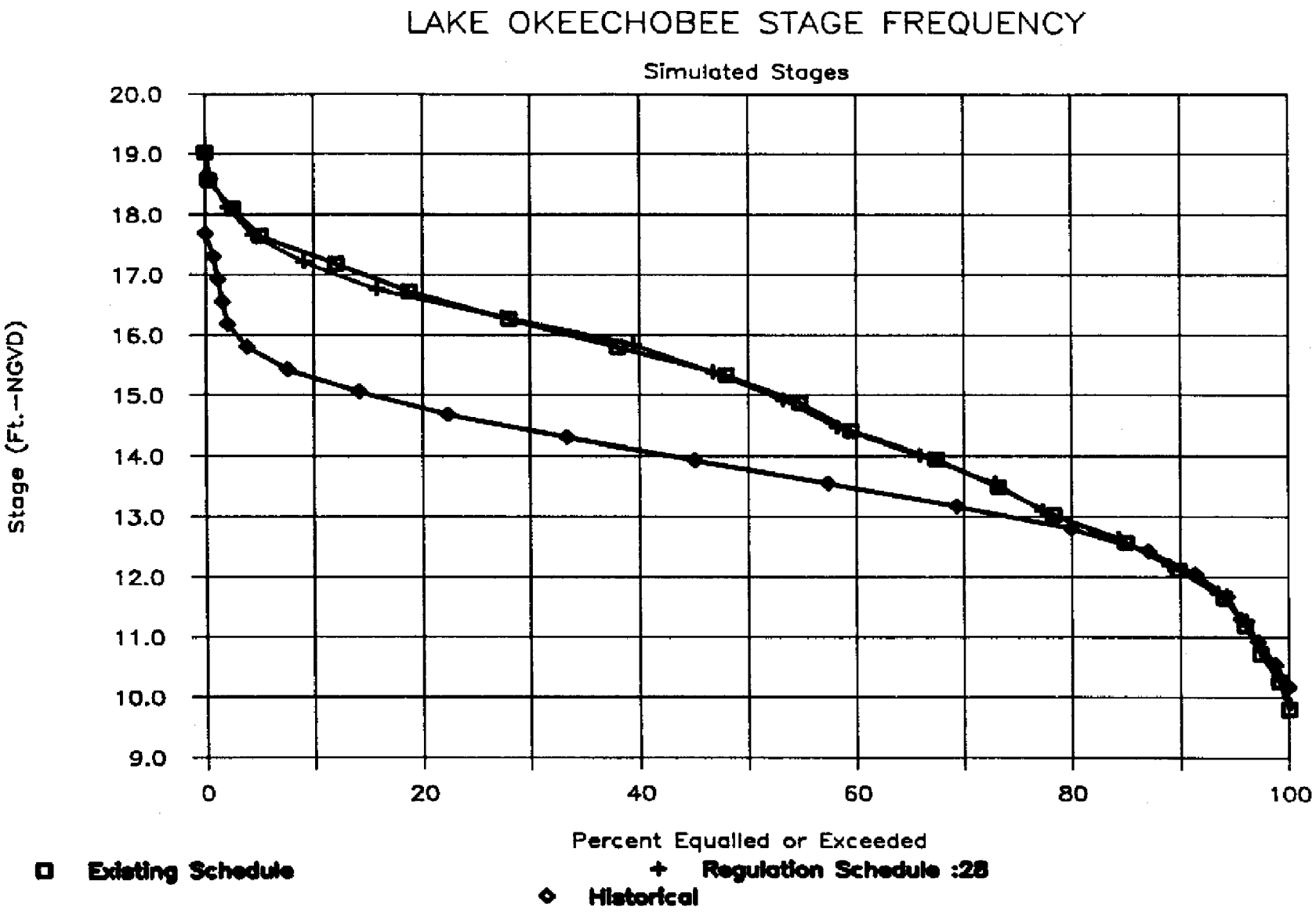

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.–NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :24
Historical

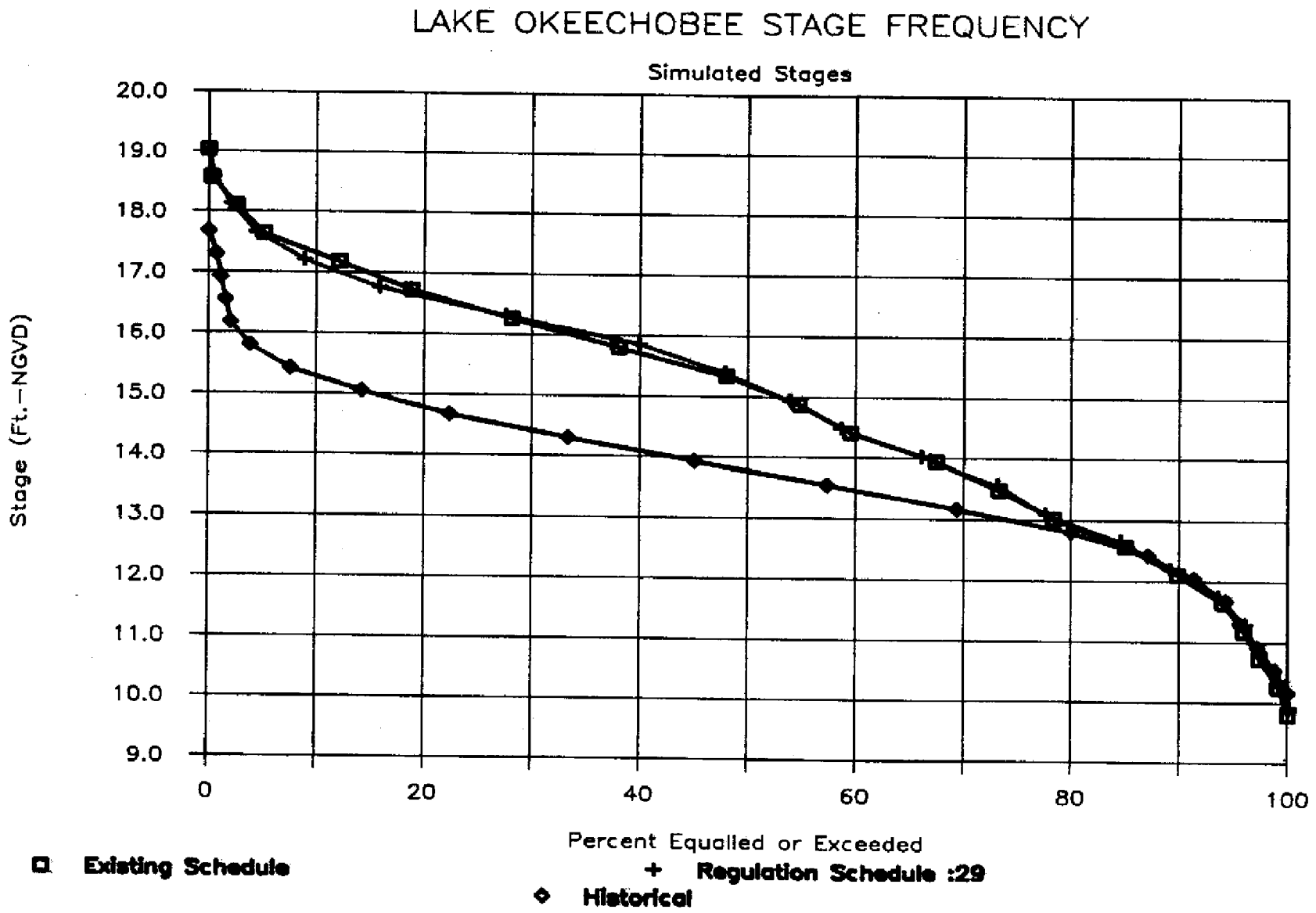

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.–NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :25
Historical

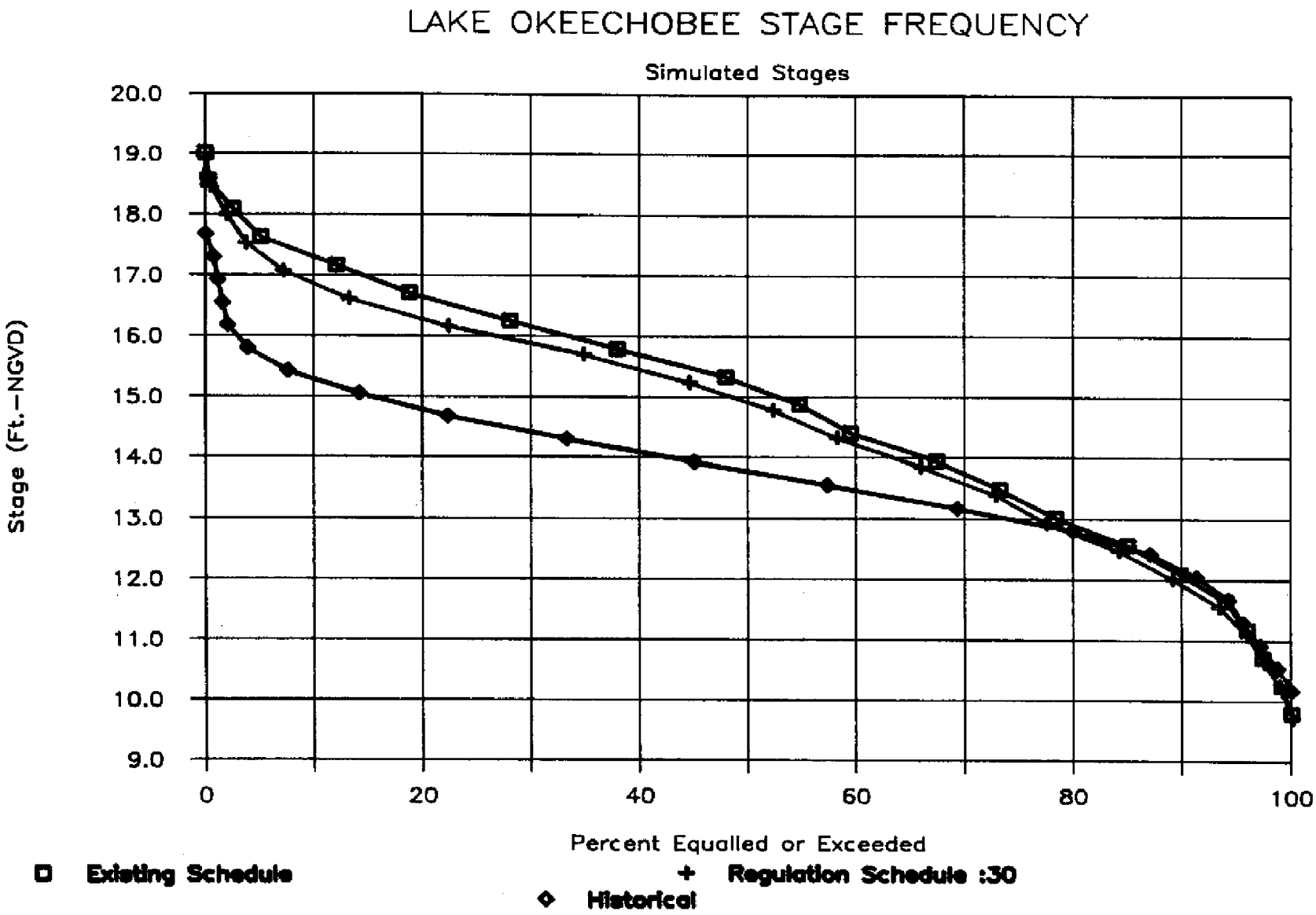
LAKE OKEECHOBEE STAGE FREQUENCY



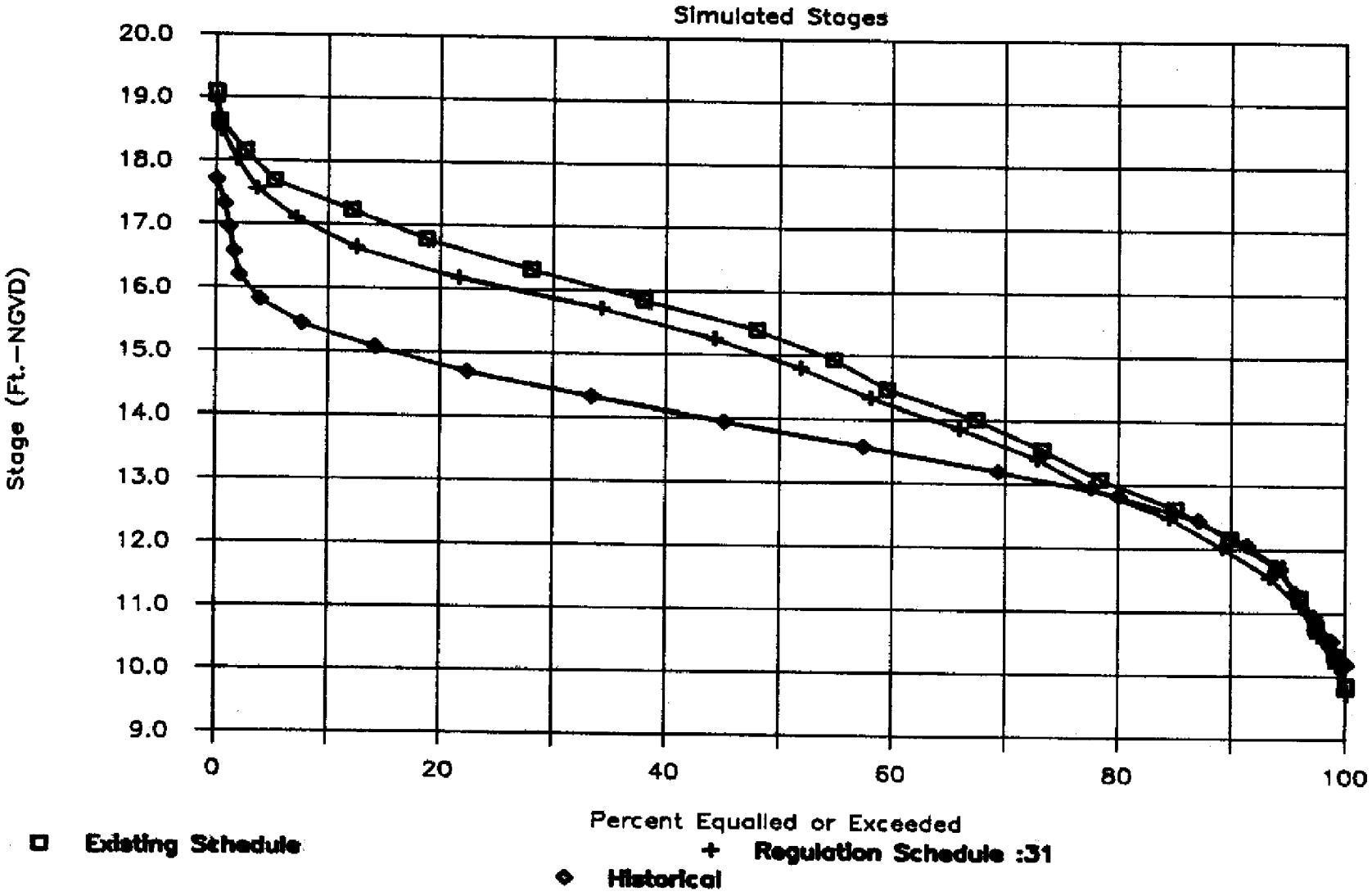

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.-NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :27
Historical


LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.-NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :28
Historical


LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.–NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :29
Historical

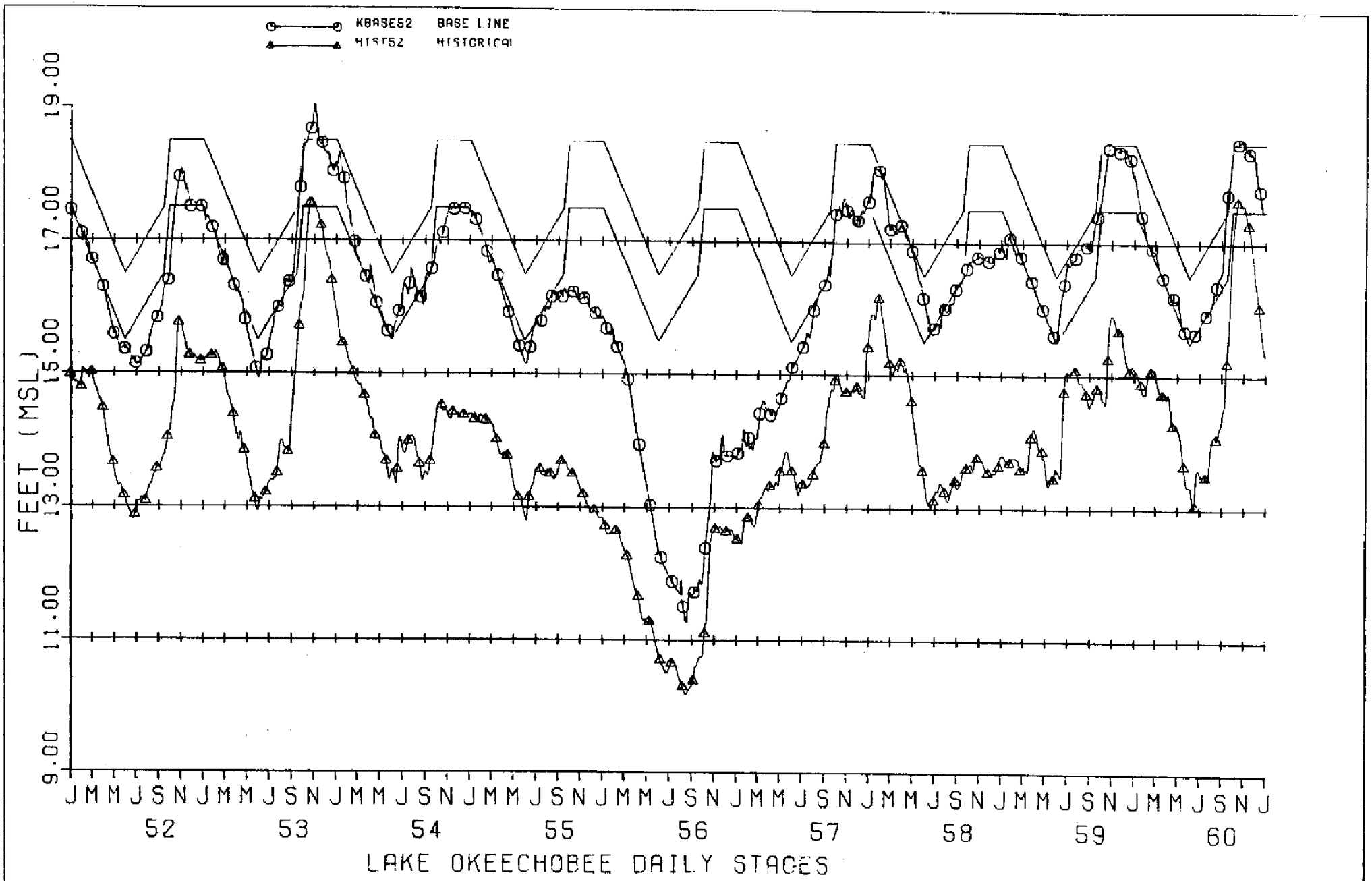

LAKE OKEECHOBEE STAGE FREQUENCY
Simulated Stages
Stage (Ft.-NGVD)
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
0
20
40
60
80
100
Percent Equalled or Exceeded
Existing Schedule
Regulation Schedule :30
Historical

LAKE OKEECHOBEE STAGE FREQUENCY

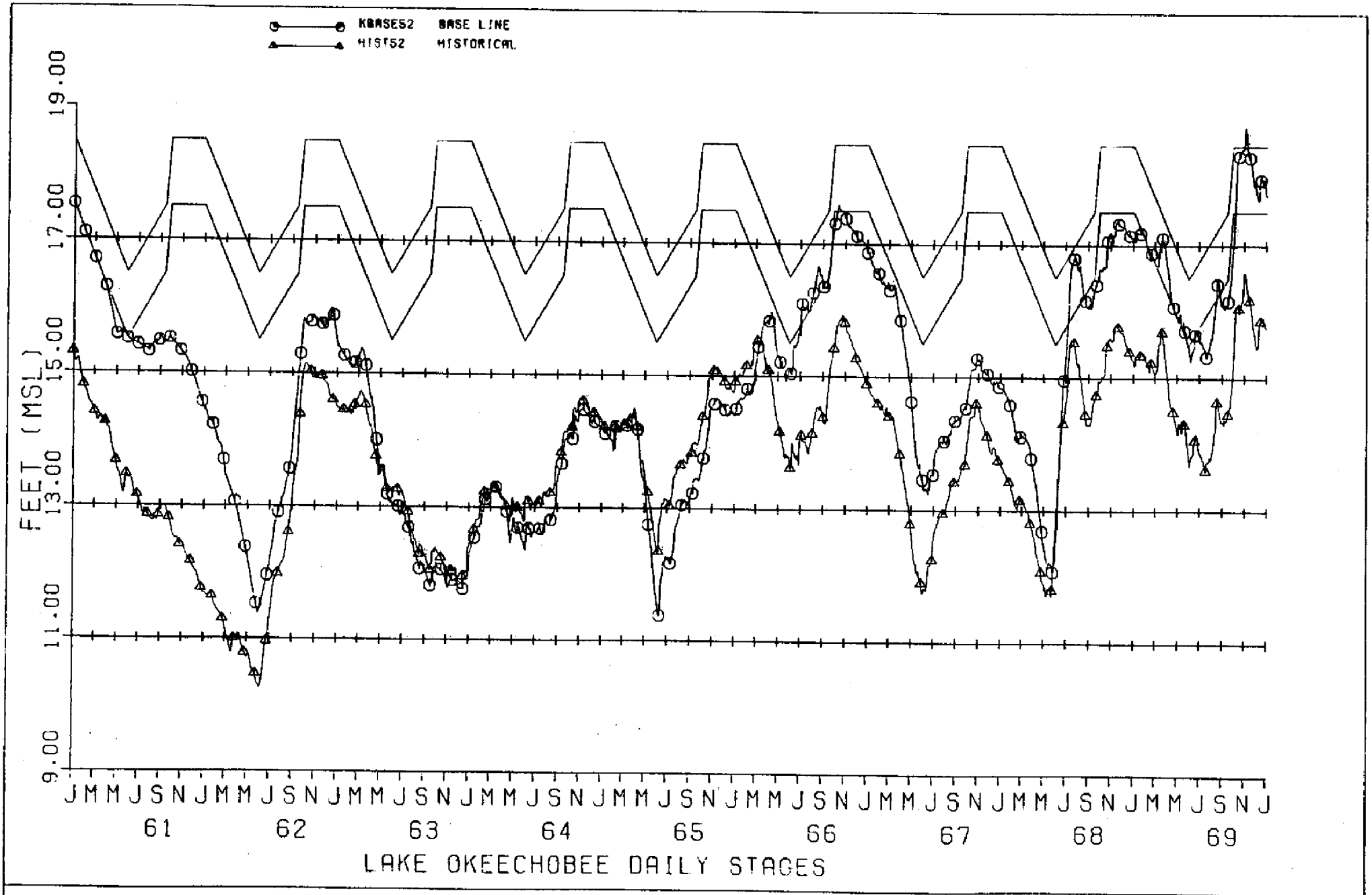


APPENDIX D

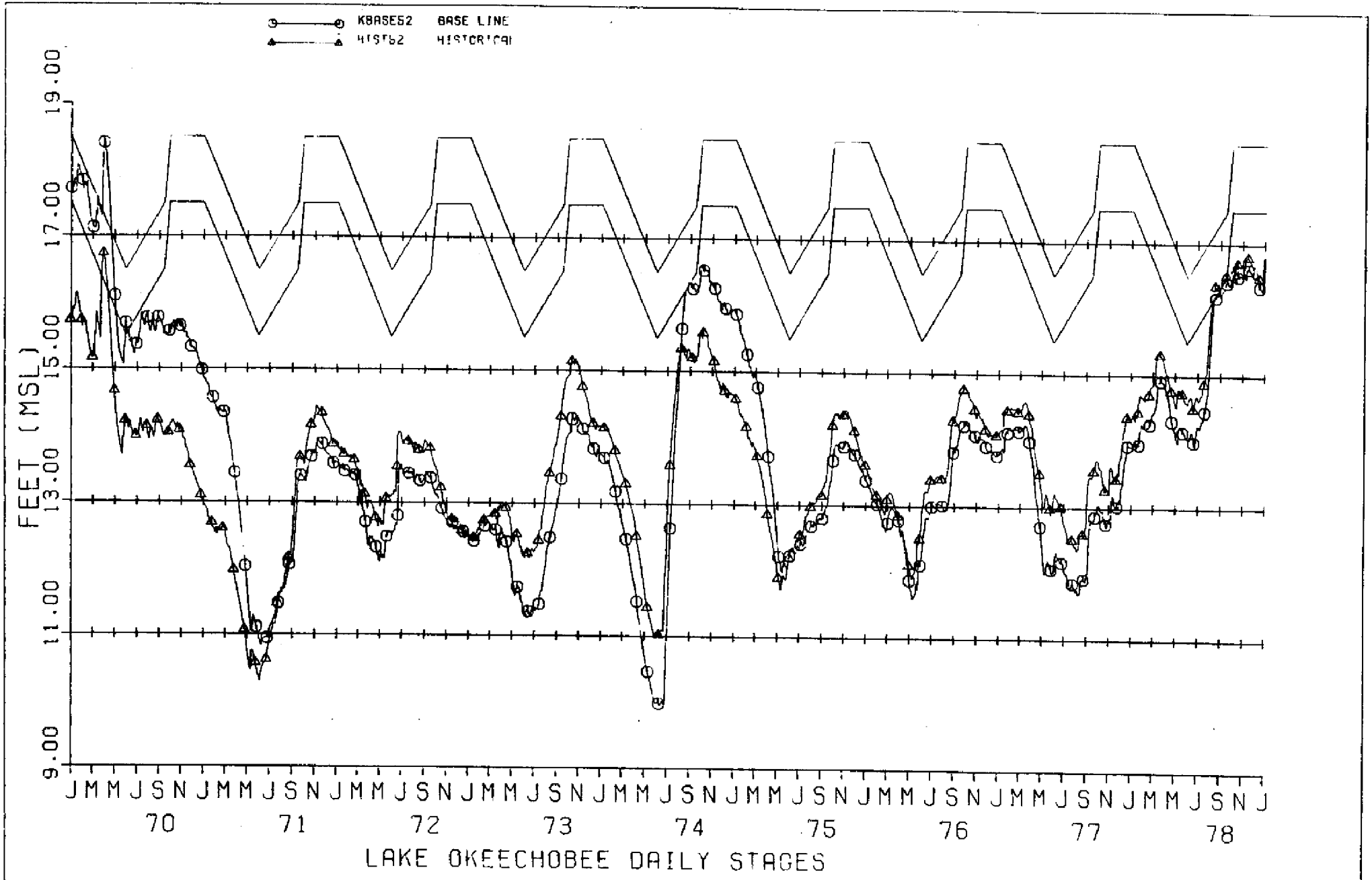
Hydrographs for Schedules 1, 24, and 25



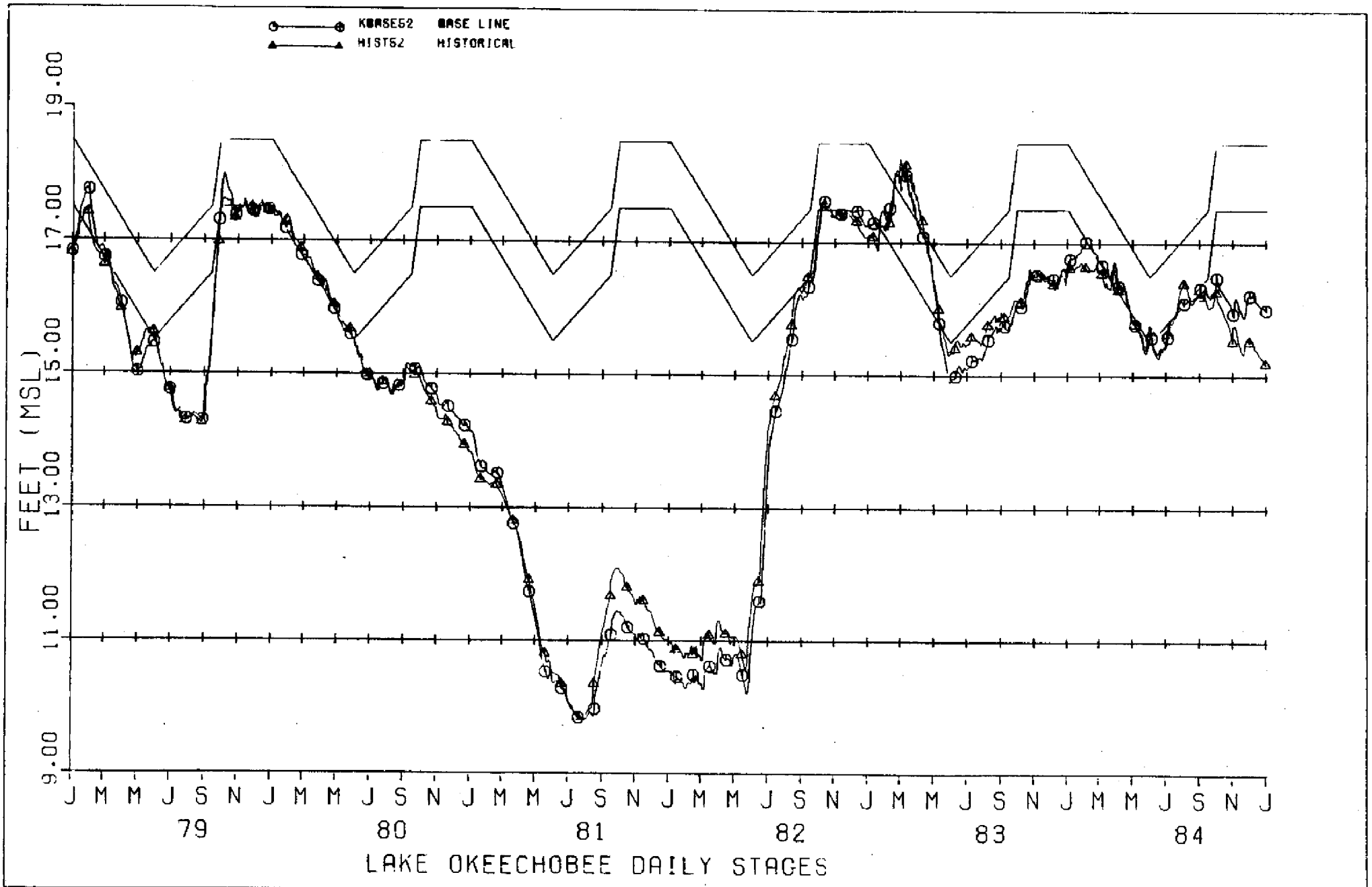
COMPARISON OF SIMULATED AND ACTUAL STAGES



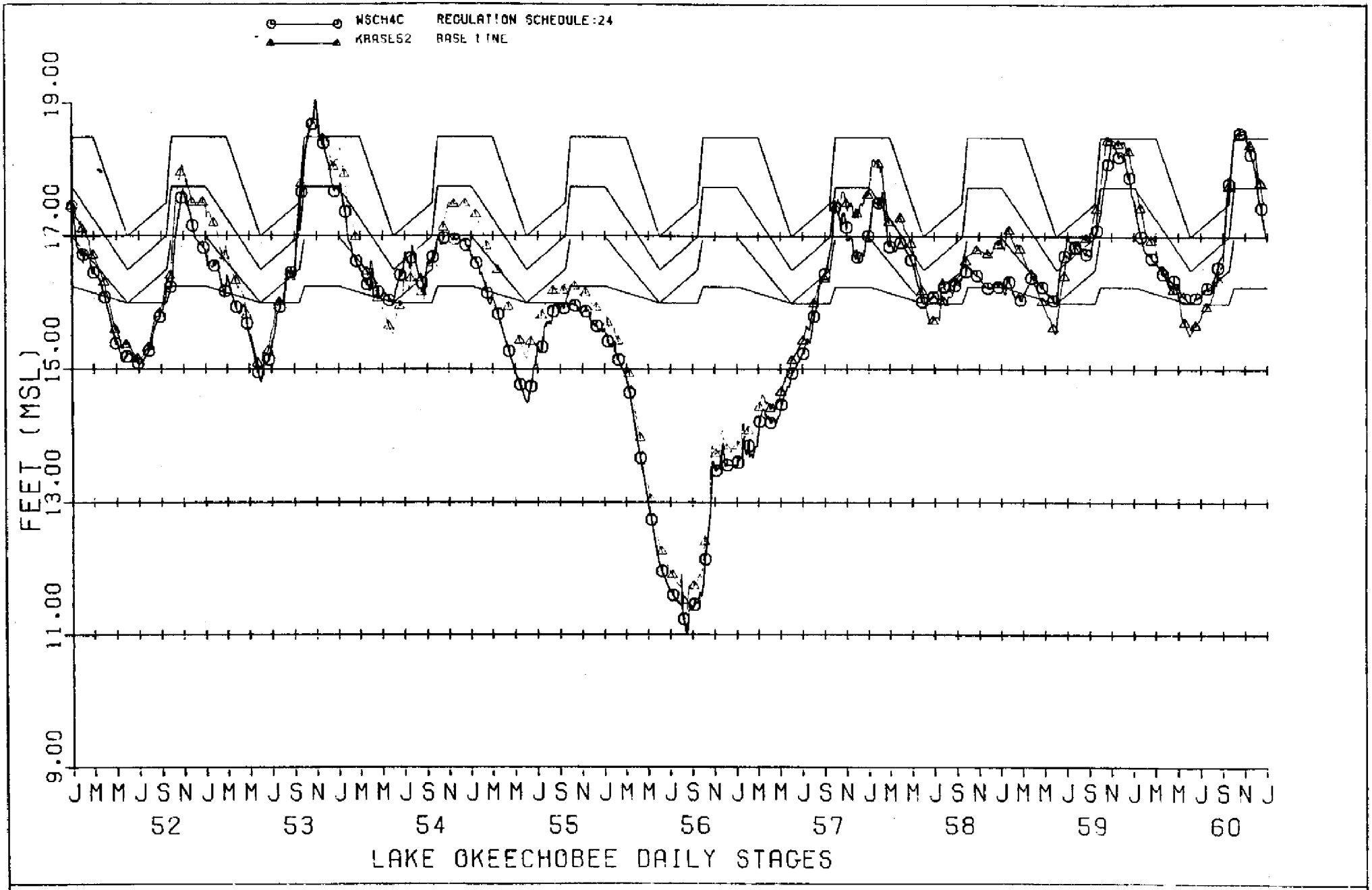
COMPARISON OF SIMULATED AND ACTUAL STAGES



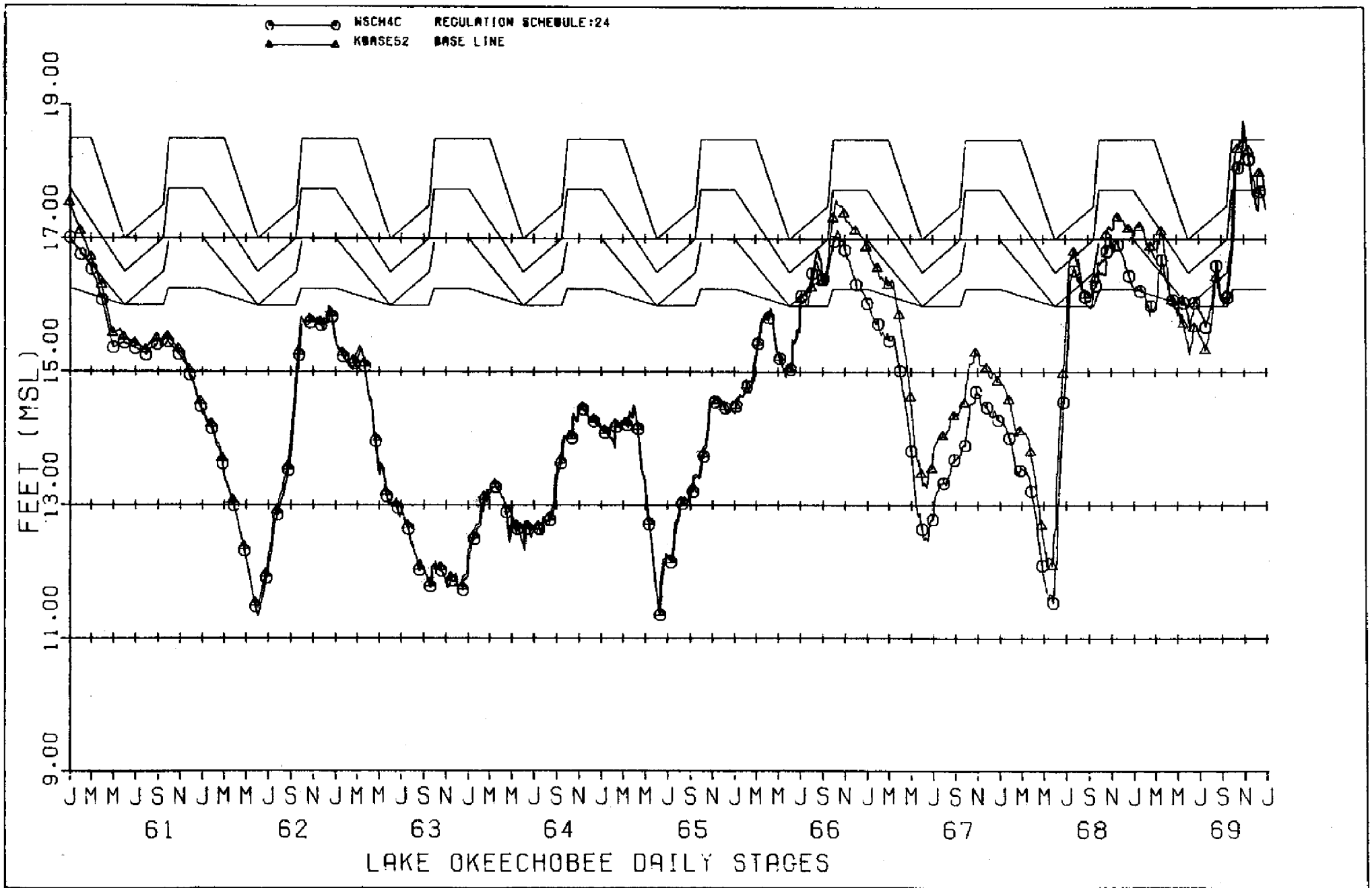
COMPARISON OF SIMULATED AND ACTUAL STAGES



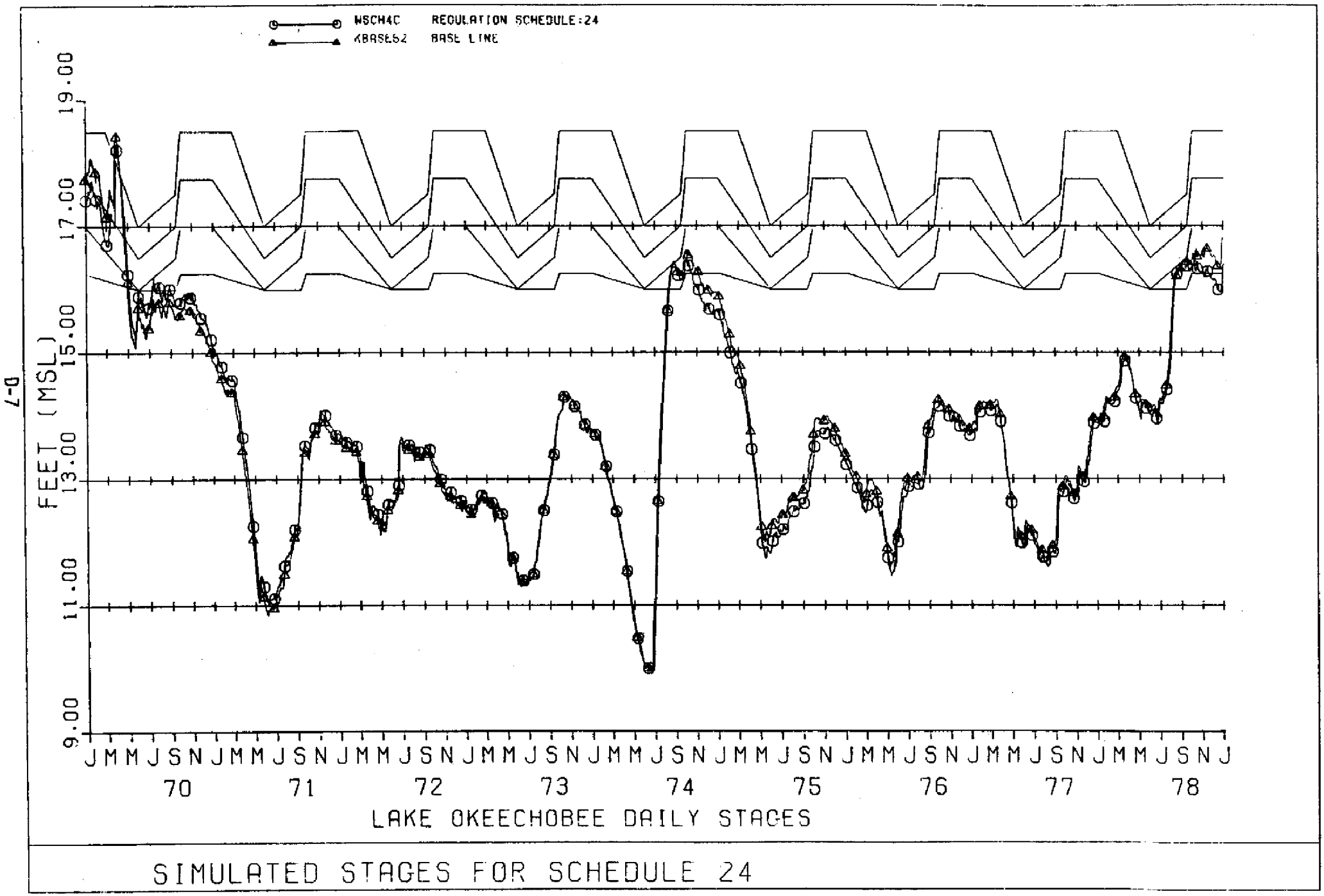
COMPARISON OF SIMULATED AND ACTUAL STAGES



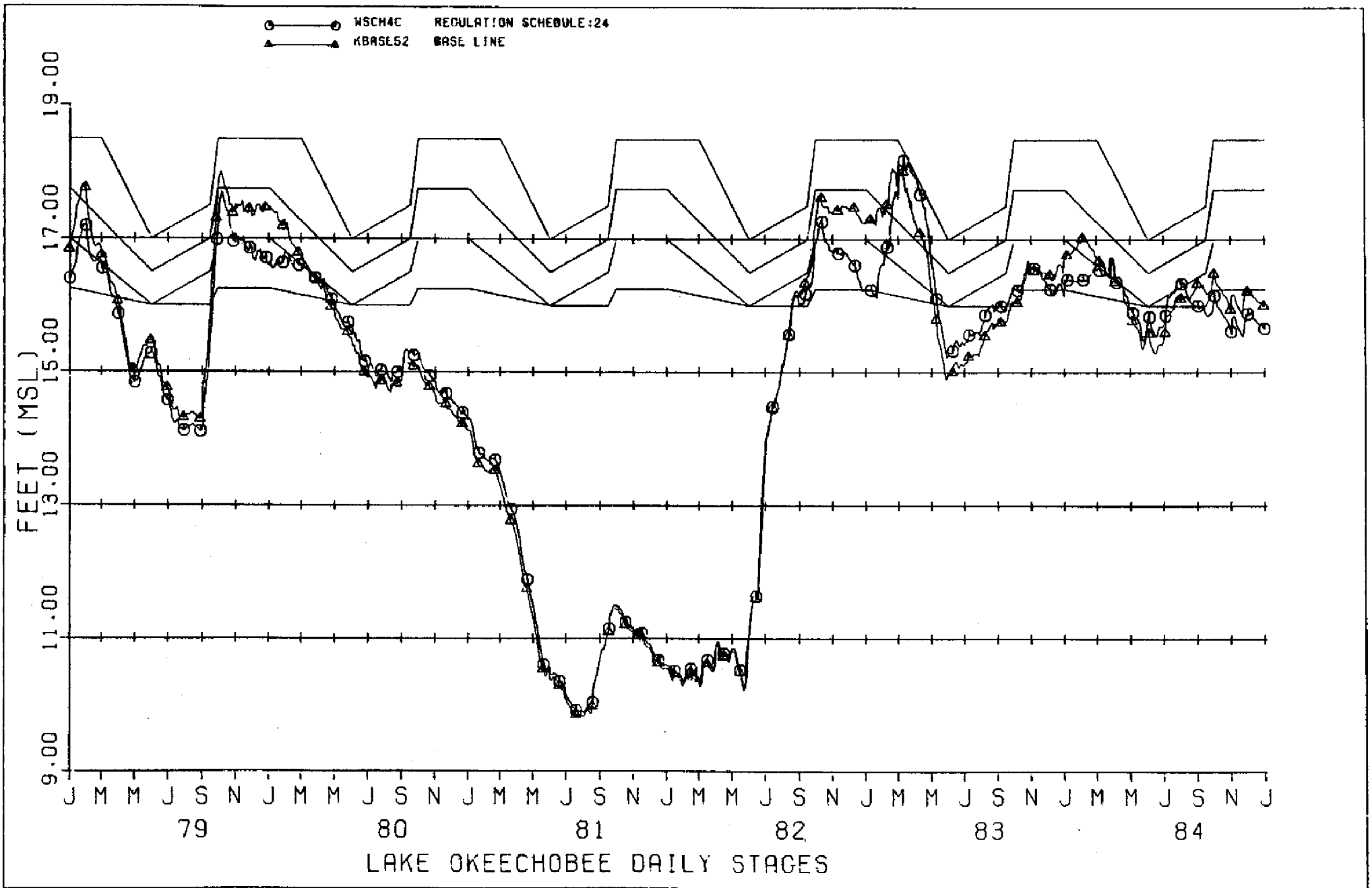
SIMULATED STAGES FOR SCHEDULE 24



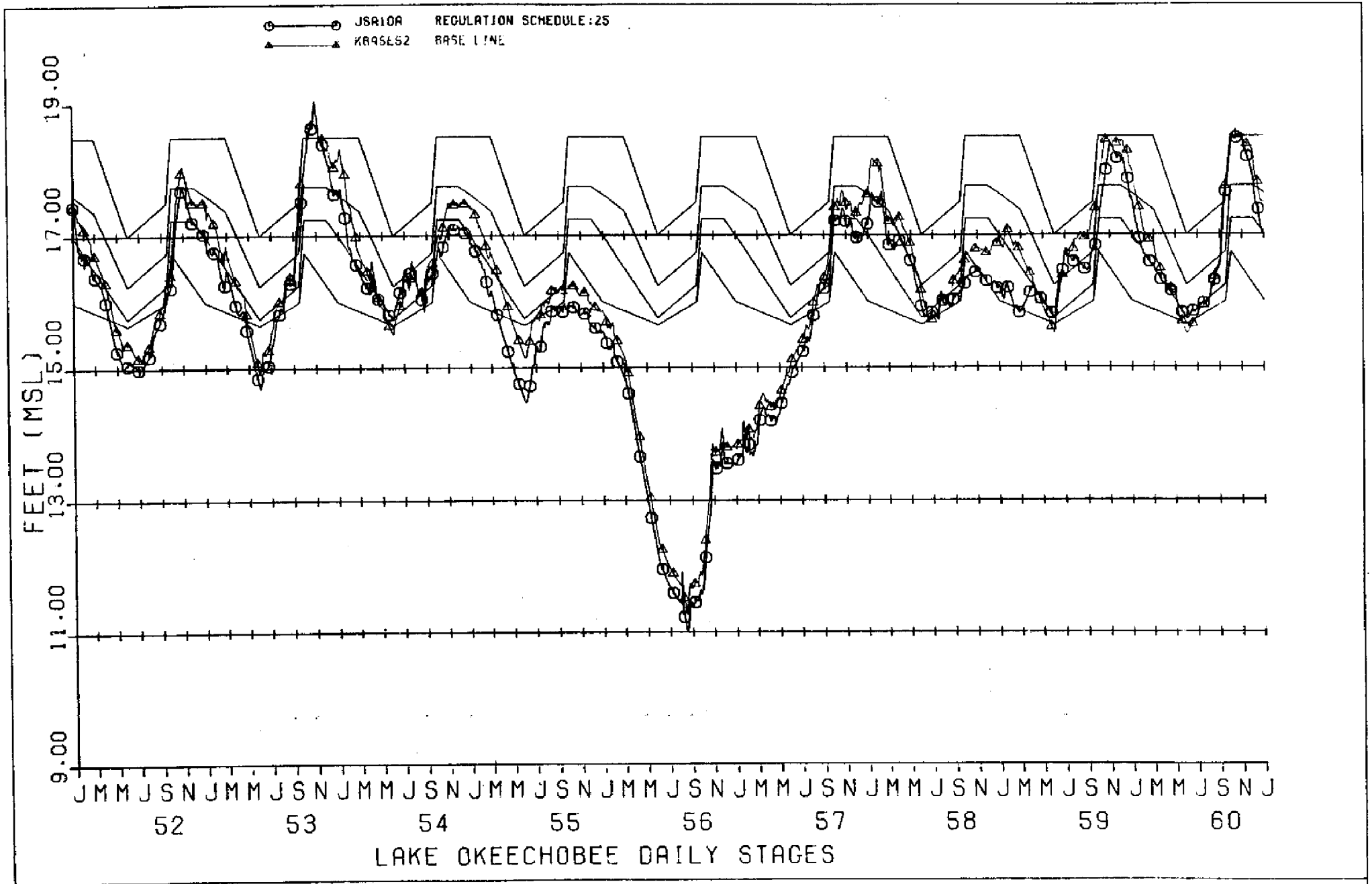
SIMULATED STAGES FOR SCHEDULE 24



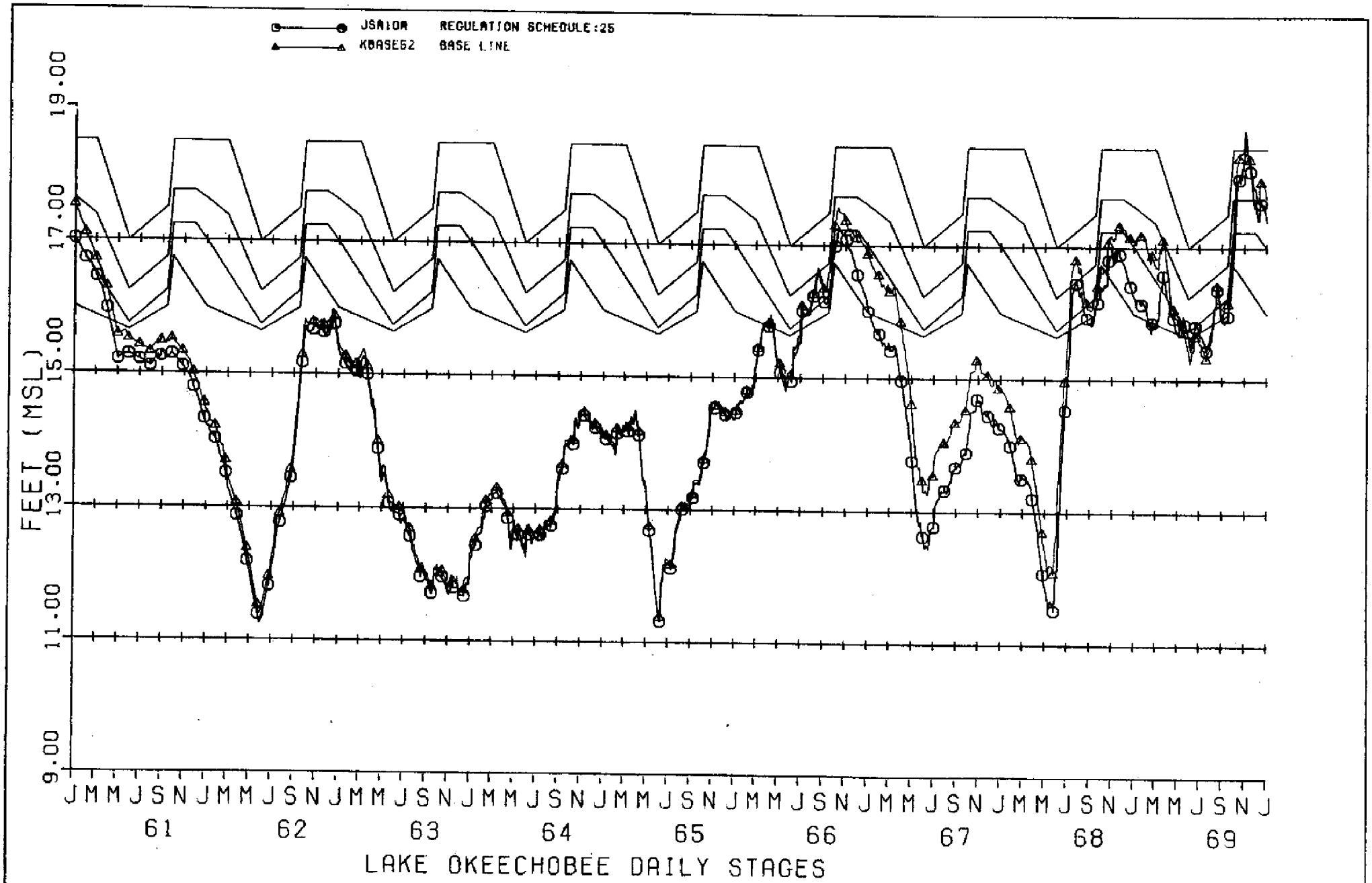
SIMULATED STAGES FOR SCHEDULE 24



SIMULATED STAGES FOR SCHEDULE 24



SIMULATED STAGES FOR SCHEDULE 25



SIMULATED STAGES FOR SCHEDULE 25