PRELIMINARY EVALUATION REPORT ON LAND AND WATER MANAGEMENT PLANNING IN THE C-51 WATERSHED

Prepared by
Central and Southern Florida Flood Control District

for

Division of State Planning, State Department of Administration

October 1973

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INTRODUCTION

Certain necessary decisions must be made in the immediate future with respect to both the allocation of land resources and to water resource development and management in the West Palm Beach Canal (C-51) watershed. The array of questions which necessitates these administrative and political decisions cover a spectrum of implications and impacts ranging from local, through regional and state, to national. At various points in time over the past fifteen years specific questions have been addressed, and decisions made, by agencies at nearly all levels of government having very specific functional responsibilities and jurisdictions.

Throughout this period the private sector was not inactive. Decisions were being made, and actions taken and investments made pursuant to those decisions, relative to the use of the watershed's land resources and having impact on the area's water resource management systems. These private sector actions were undertaken in conformity with the then-existing institutional constraints concerning land use. They were also undertaken with the not unreasonable expectation that certain services related to public health, safety and welfare would be provided by governmental agencies having appropriate jurisdiction. In the water resources context flood control, primary drainage, waste water treatment and disposal, water supply and conservation, and water-based recreation would be among such services.

The governmental processes involving the perception of public needs within the watershed and the planning and implementation of actions to meet those needs culminated rather recently in two self-styled "comprehensive" plans. One, in the area of land resource allocation, is Palm Beach County's Comprehensive Land Use Plan adopted by the Board of County Commissioners in December, 1972. The other, in the area of water resource development and management, is the Plan of Improvement for the West Palm Beach Canal Area, as detailed in a design memorandum report of the U. S. Army Corps of Engineers dated May, 1972.

The decisions which now need to be made are those which can only be made by the State of Florida and which, indeed, must be made by State government.

Palm Beach County's Land Use Plan has official status as a result of its adoption by the Board of County Commissioners. However, through application of the "area of critical state concern" provisions of Chapter 380, F.S., the State has the authority to require modification of that land use plan and its associated codes, ordinances and regulations.

On the other hand, the water resources development and management plan for the watershed has no official status at the State level. Although it has been authorized for construction by the Congress and its funding has been successfully defended before the appropriate Congressional committees, it has not been approved by the State of Florida. Since funding is a joint Federal-State undertaking unilateral approval of the plan by the Federal Government does not confer official status upon the plan.

In fact, it is because of the need for State approval of the water resources development and management plan that the attention of State government has focused on the West Palm Beach Canal watershed. The State has recognized, legislatively and administratively, the fundamental interconnections between water resource use, environmental quality, and land resources allocation. Concern has been expressed at the highest level of State government that overall planning for the West Palm Beach Canal watershed may not adequately consider and address these interconnections.

The specific land use and water management factors pertinent to the Canal 51 basin can be identified; population growth, westward expansion of population distribution, flood protection of existing urban areas, over-drainage and lowering of shallow groundwater levels, association of more intensive land use with the need for water control, preservation of surface water quality, prevention of the present waste of fresh surface water, and protection of natural environmental values and quality in areas now under public management.

The West Palm Beach Canal watershed presents a case in which the interconnection of these factors are clearly displayed in their considerable complexity. If these complexities can be distilled to the form of a single question, that question might well be: "what is the structure of an optimal environmental land and water management plan for the watershed which will meet the identified local and regional needs for services and amenities and which, at the same time, will serve the overall objectives of the State to the extent possible and to the extent they have been defined?"

It had initially been thought that this question would be addressed through the mechanism of designating the watershed an area of critical state concern. However, in July 1973, the decision was made by the Division of State Planning to approach the problem by stimulating local and regional cooperation in an effort to provide an answer to the question posed; this cooperative effort to be under the general direction of the Division of State Planning.

The Flood Control District was requested to assume the role of "lead agency" in this effort. The first phase of this effort is the preparation of a preliminary report for the consideration of the ad hoc local-regional committee which was convened for the first time at West Palm Beach on August 10, 1973. This first phase assignment was accepted by the District with the understanding it was acting in this matter as an extension of the Division of State Planning staff and that the preliminary report would be completed within 60 days. This is the preliminary report.

METHODOLOGY

As noted in the introductory section a substantial planning effort, from two different functional standpoints, has been applied to the subject area and two functional plans have been produced. One of these addresses the land resource allocation function over a portion of the area. The other addresses a portion of the water resource management function over the entire area. A more than superficial examination of both plans indicates that they are generally compatible within the context of their more or less limited functional frameworks. Consequently, a logical point of departure for this study is the analysis of a system whose two major components are Palm Beach County's Land Use Plan and the Federally authorized Plan of Improvement for the West Palm Beach Canal Area.

A means for the reasonably systematic analysis of the physical-institutional system represented by the combination of the two plans as they would be made operative in the West Palm Beach Canal watershed must be found. Such a means is suggested by the position taken by the Division of State Planning in not considering this watershed, at least initially, for designation as an area of critical state concern. There is no question that the problem is one of environmental land and water management. Using the philosophy expressed in Chapter 380, F.S., as a basis, the alternative to treating this area as one of critical state concern is then to consider the physical-institutional system described above as, hypothetically, a "development of regional impact." The guidelines suggested by the Division of State Planning for assessment of development impact could then be used, with necessary amendments and/or additions to suit the case, in a reasonably systematic analysis of the watershed combined plan.

This is the approach taken by the District in this preliminary investigation and report.

The use of this technique will permit the following purposes to be served:

1. Detailed description of the impact of the plan on those environmental, social and economic factors upon which the various elements of the plan directly impinge.

2. Identification of the locational, functional or other inadequacies of the plan in terms of the specific problems or issues it fails to address, or addresses unsatisfactorily.

3. Description of the consequences of failure to remedy the inadequacies of the plan.

4. Suggestion of institutional and/or physical additions or modifications to the plan to remedy inadequacies in those cases where the affect of the failure to do so is consequential environmentally, socially or economically.

Using the Division of State Planning's DRI assessment factors as a general guide this analysis considers the following factors:

Water Resources

Quantity

A. Surface water
B. Groundwater
C. Water supply
D. Hydroperiods

Quality

A. Surface water
B. Groundwater

Land Resources

A. Soils and vegetation
B. Wildlife
C. Allocation as to use

Social-Economic Considerations

A. Population
B. Flood protection
C. Water supplies
D. Costs

Because of the particular nature of the plan its impact is felt, in terms of the water resource factors, outside the watershed area; i.e., in the Everglades Basin and in Lake Worth as well as within the watershed itself. Therefore, in this report the effects on each of the three geographic areas will be considered separately, where such treatment is pertinent.

The format to be followed in the main body of this report will be to consider the water resources and land resources assessment factors in terms of the four purposes listed on page 3. The discussion of the social-economic considerations will be presented in commentary form.

WATER RESOURCES
(C-51 Watershed)

Quantity

A. Surface Water

1. The surface water hydrology of a watershed can be characterized in general terms by its topography, degree of drainage development, rainfall patterns, water levels and basin discharge.

The C-51 watershed contains 174 sq. mi., all within Palm Beach County. The map of Figure 1 shows the boundaries of the C-51 watershed. The watershed boundaries are not naturally defined but, rather, have been established either by man-made structures or arbitrarily for hydraulic design purposes. An example of the former is the Conservation Area No. 1 levee (L-40) and an example of the latter is the south side boundary, east of S.R. #7, through the Lake Worth Drainage District. Accordingly, throughout the period of stage and discharge record keeping in the watershed from time to time, and from incident to incident, the contributory area may have been larger or smaller than the theoretical area.

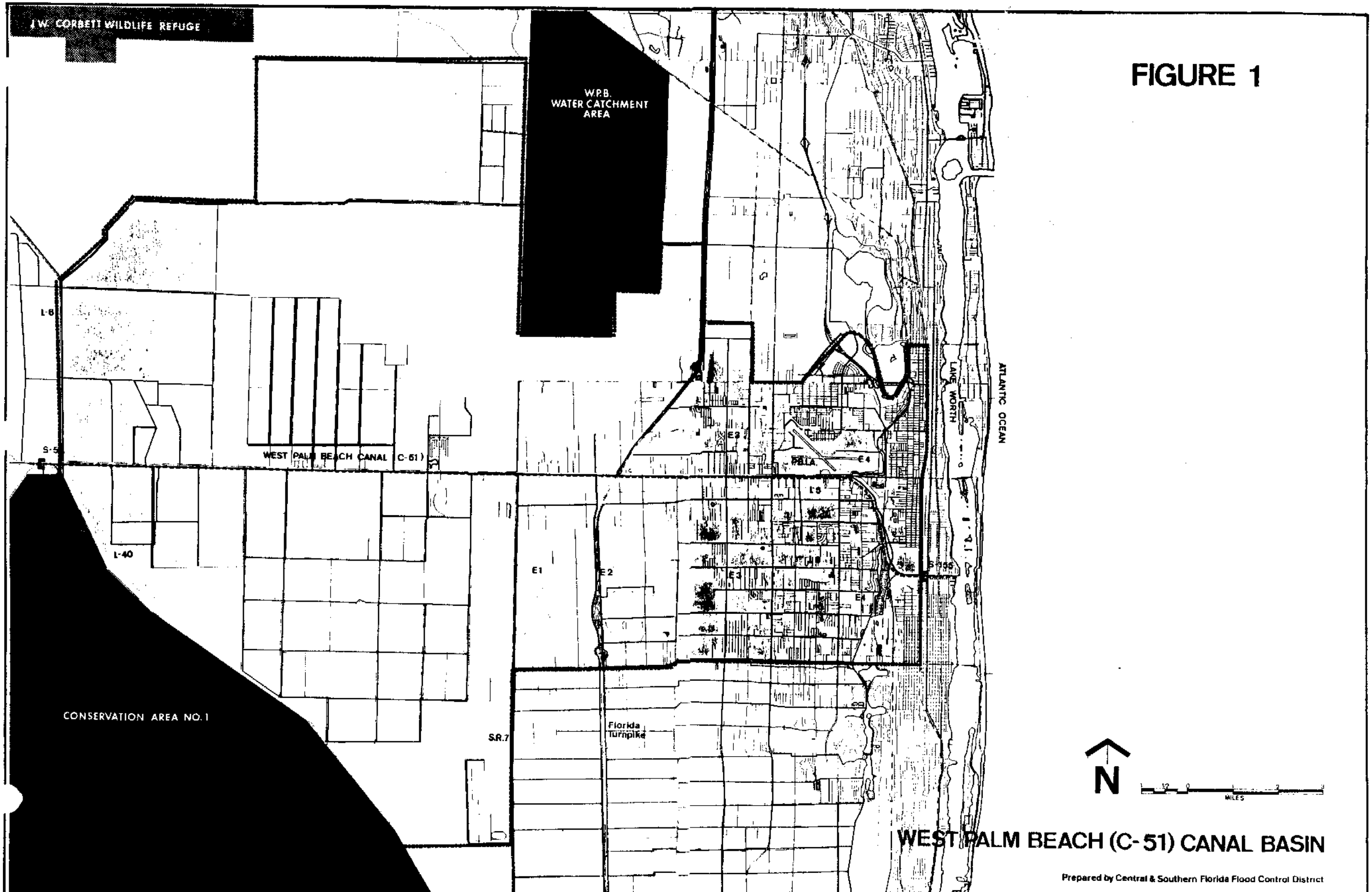
Since the completion of L-40, and particularly since the completion in 1954 of Pumping Station 5A, which reduced the size of the contributory area, the drainage area has become more stable. However, even since that date flows from the area south of the arbitrary boundary east of S.R. #7 and from the area north of the boundary west of S.R. #7 have entered C-51. In addition flows are manipulated at the S-5A complex, on occasion, to introduce water from outside the area into C-51, thus necessitating the correction of basin discharge data. Flows from the L-8 tributary area contribute to the total discharge recorded at the C-51 outlet, since flooding in that area is relieved whenever possible by diversions to the coast when C-51 flood stages have receded.

As shown on Figure 1 an 18 sq. mi. area in the southwesterly corner of the basin is excluded from the drainage area contributory to C-51. This is another man-made adjustment, but one which restores the natural drainage flow in this area. The excluded area, a portion of the Acme Drainage District, discharges excess surface water by pump directly into Conservation Area No. 1.

The map of Figure 2 shows natural ground contours within the basin. Throughout the majority of the basin ground elevations are higher to the north. East of S.R. #7 there is a slight gradient to the east, with the crest of the coastal ridge being just to the west of the line of the FEC Railroad. West of S.R. #7 the north-south gradient is somewhat more marked and south of C-51 the natural ground slope is to the southwest; i.e., toward Conservation Area No. 1 and the Everglades Basin.

There are no defined natural drainage-ways serving the watershed. The map of Figure 3 delineates the major man-made drainage facilities. C-51 is the primary drainage artery and provides the only outlet to tidewater.

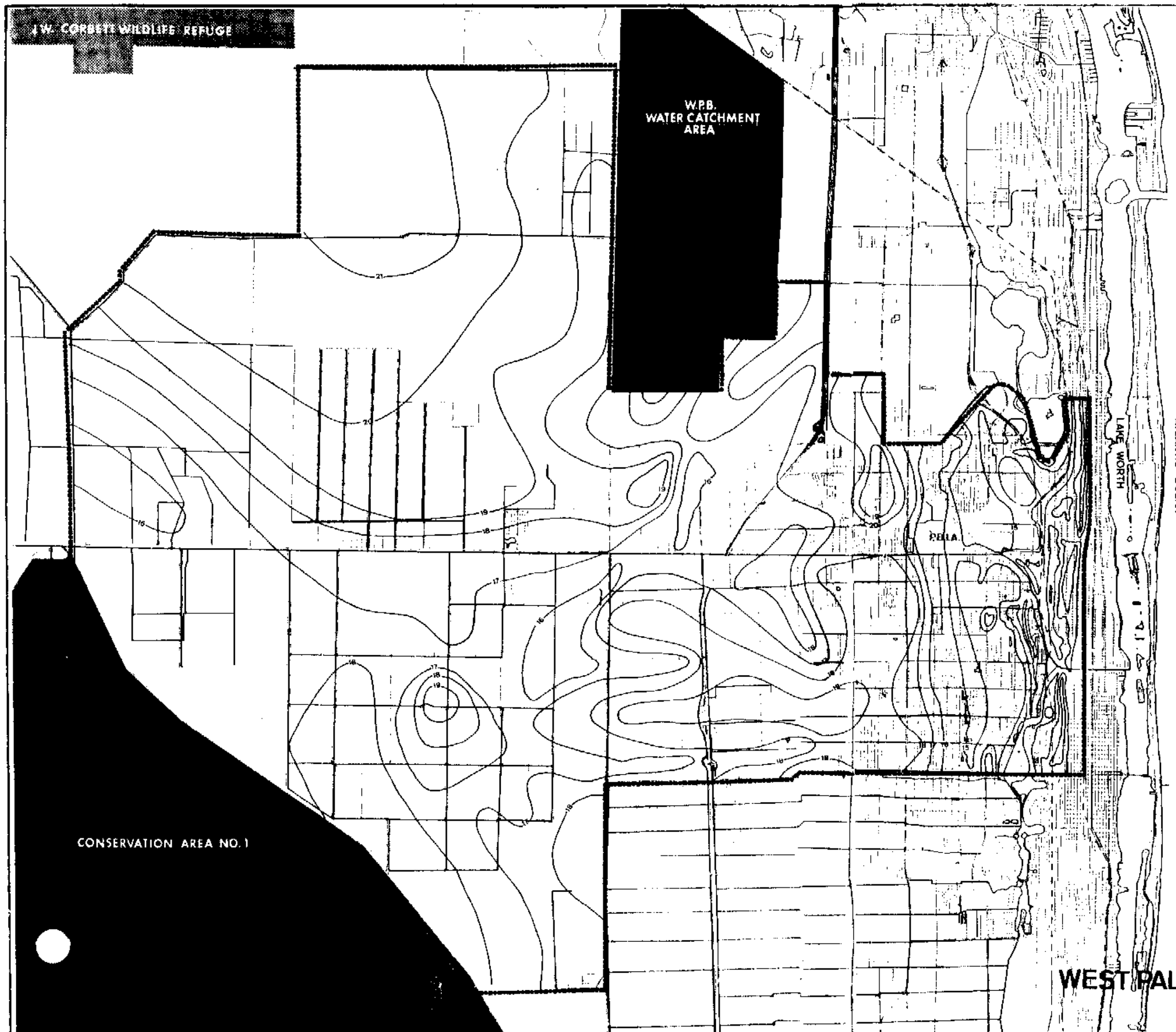
FIGURE 1



WEST PALM BEACH (C-51) CANAL BASIN

Prepared by Central & Southern Florida Flood Control District

FIGURE 2



TOPOGRAPHY

N

MILES

WEST PALM BEACH (C-51) CANAL BASIN

Prepared by Central & Southern Florida Flood Control District

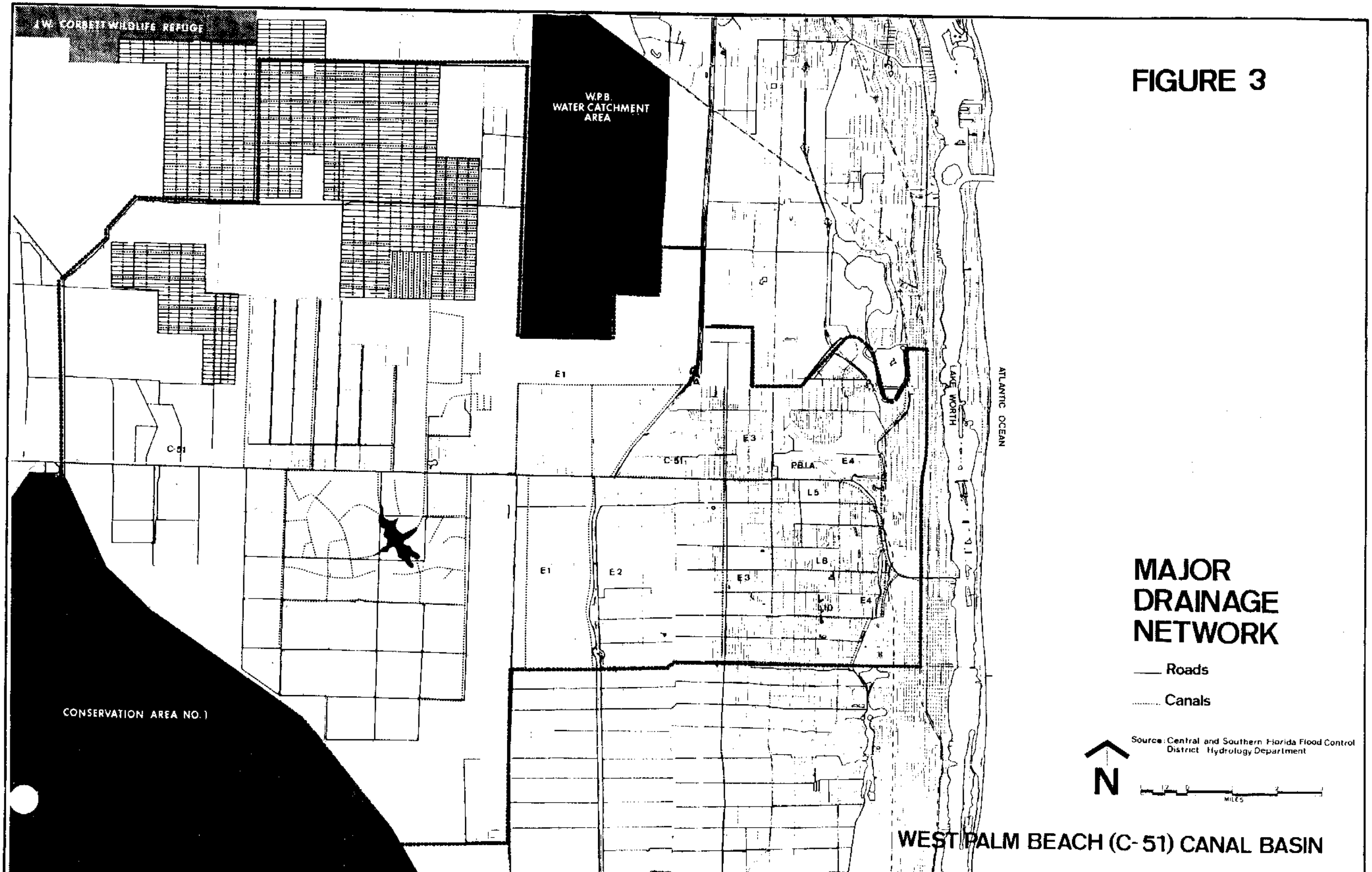


FIGURE 3
MAJOR DRAINAGE NETWORK
Roads
Canals
Source: Central and Southern Florida Flood Control District Hydrology Department
N
MILES
J.W. CORBETT WILDLIFE REFUGE
W.P.B. WATER CATCHMENT AREA
CONSERVATION AREA NO. 1
ATLANTIC OCEAN
LAKE WORTH
P.B.I.A.
C-51
E1
E2
E3
E4
L5
L8
L10
WEST PALM BEACH (C-51) CANAL BASIN

Figures 4A and 4B, show the bottom profile of C-51 between Twenty Mile Bend and Lake Worth, and shows typical canal cross sections at the indicated locations.

The most extensive and effective secondary drainage system in the watershed is that of the Lake Worth Drainage District whose Laterals E1, E2, E3, and E4, indicated on the map, discharge into C-51. The Royal Palm Beach - Indian Trail canal network has been designed to serve an approximate 45.0 sq. mi. area west of S.R. #7, north of C-51. The major outfall canals of the Acme Drainage District are indicated on the map as is the canal system of the Loxahatchee Drainage District. The heavily urbanized area of West Palm Beach is largely served by storm sewer systems discharging directly or indirectly to C-51, and are not shown.

The C-51 watershed evidences the seasonal rainfall characteristics typical of south Florida. Long-term (32 yr.) U. S. Weather Bureau records for Loxahatchee show an average annual rainfall of 64.04 inches. A minimum of 36.64 inches was recorded in 1961 and a maximum of 97.20 inches in1947. Average June, September and October rainfalls are 9.62, 9.31, and 7.70 inches, respectively; and recorded maximums are 22.71, 26.01 and 16.33 inches, respectively. A maximum monthly rainfall of 26.01 inches was recorded in September 1960. A maximum daily rainfall of 9.12 inches was recorded on September 18, 1960.

Basin discharges are measured at the C-51 spillway at Dixie Highway (U.S. No. 1). A major change in discharge volumes was effected by the reduction of drainage area which came with the completion of Pumping Station 5A. Prior to 1954 the average annual discharge volume was 776,000 A.F. Average annual volumes discharged at the Dixie Highway spillway since that date are shown in the following table, together with annual rainfall depths as recorded at Loxahatchee and at West Palm Beach:

Year	Volume(A.F.)	Precipitation (inches) Loxahatchee	W.P.B. Airport
1955	359,100	46.69	37.31
1956	138,600	43.93	38.40
1957	568,700	79.73	62.93
1958	593,600	62.32	65.18
1959	723,500	95.63	68.64
1960	796,900	77.74	66.77
1961	471,300	36.64	37.76
1962	267,900	55.70	48.56
1963	349,800	45.29	53.31
1964	444,600	59.46	79.30
1965	450,200	58.23	58.26
1966	635,800	79.76	79.75
1967	348,400	52.90	51.54
1968	533,000	65.87	77.42
1969	510,100	72.91	79.75
1970	481,200	60.47	55.28
1971	179,430	53.22	51.31

Average 461,890 Acre Feet.

Even with this 40% reduction in discharge, the average annual volume of water removed from this basin to tidewater is enormous. Making allowance for the indefiniteness of the drainage area boundaries during high discharge periods it is estimated that the average annual basin yield is between 20 and 25 inches per square mile. That is, from 35% to 40% of an average year's rainfall will run off through C-51 to tidewater. For specific storm events the values are approximately the same; 35% of the rainfall from the October 1959 event having been discharged at the spillway. In unusually wet years, such as 1959 and 1960, discharge is virtually continuous. In both 1959 and 1960 discharges were made at the spillway every day of the year.

Although annual discharge volumes were reduced in 1954 and subsequent years, peak rates of discharge at the Dixie Highway Spillway were not comparably decreased. The following table lists the five largest pre-1954 and post-1954 discharge rates recorded at the spillway:

Pre-1954		Post-1954	
Date	Discharge(cfs)	Date	Discharge(cfs)
April 18, 1942	5320	Oct. 21, 1959	5030
Oct. 13, 1947	5280	Sept. 19, 1960	4880
Oct. 7, 1948	4760	Sept. 26, 1960	4550
Sept. 29, 1947	4740	June 21, 1959	4300
Sept. 23, 1948	4430	Oct. 16, 1965	4290

The above comparison is a general indication that the reduction in size of the West Palm Beach Canal drainage basin (about a 50% reduction) did not result in any substantial increase in the ability of the C-51 portion of the canal to remove surplus surface water from the remaining portion of the watershed and reduce flooding therein.

The following table expresses peak daily discharges, for post-1954 major storm events, in terms of inches of runoff carried by C-51 per square mile of contributory area. A contributory area of 200 sq. mi. was used for this computation.

Date	Discharge(cfs)	Discharge(in/sq.mi.)
Oct. 21, 1959	5030	0.92"
Sept. 19, 1960	4880	0.90"
Sept. 26, 1960	4550	0.83"
June 21, 1959	4300	0.79"
Oct. 16, 1965	4290	0.78"

Since each of these events produced flooding in the watershed, the above tabulation indicates that C-51 is incapable of handling anything greater than an average basin runoff of approximately 1/2" to 3/4" per day without flooding.

Stages in C-51 are recorded regularly at the upstream side of the C-51 spillway. Maximum recorded stage at that location (post-1954) was 10.16 ft. msl. on October 21, 1959. Stages have been periodically observed during flood periods at or near S. R. #7. Maximum observed stage in that vicinity was 15.90 ft. msl., also on October 21, 1959. Stages at which flood damages begin to occur are 9.0 ft. msl. at the spillway and 15.0 ft. msl. at S.R. #7 and Twenty Mile Bend.

During non-discharge periods stages in the 20.7 mile length of C-51 are regulated only by the spillway at Dixie Highway. A regulated water elevation of 8.5 ft. msl. is maintained. The structure consists of a series of concrete box culverts and an adjacent gated former lock chamber. Discharges up to a rate of about 2100 cfs. are made through the box culverts. Discharge rates greater than this require operation of the lock chamber discharge bay. The operation is cumbersome and not as immediately responsive to water level changes as is desirable in an urban watershed.

The water resources development plan adopts the "back-pumping" concept; that is, the diversion of a portion of the surplus storm runoff generated in the watershed westward to the Everglades Basin by means of pumping. That plan consists of the following major elements:

a. Replacement of the Dixie Highway Spillway by a vertical lift-gated spillway (S-155) having a design capacity of 4800 cfs.

b. Construction just east of S.R. #7 of a gated spillway (S-155A) having a design capacity for eastward discharge of 1000 cfs. and capability to maintain a regulated water elevation of 13.0 ft. msl. in C-51 to the west, and possibly as high as 13.5 ft. msl.*

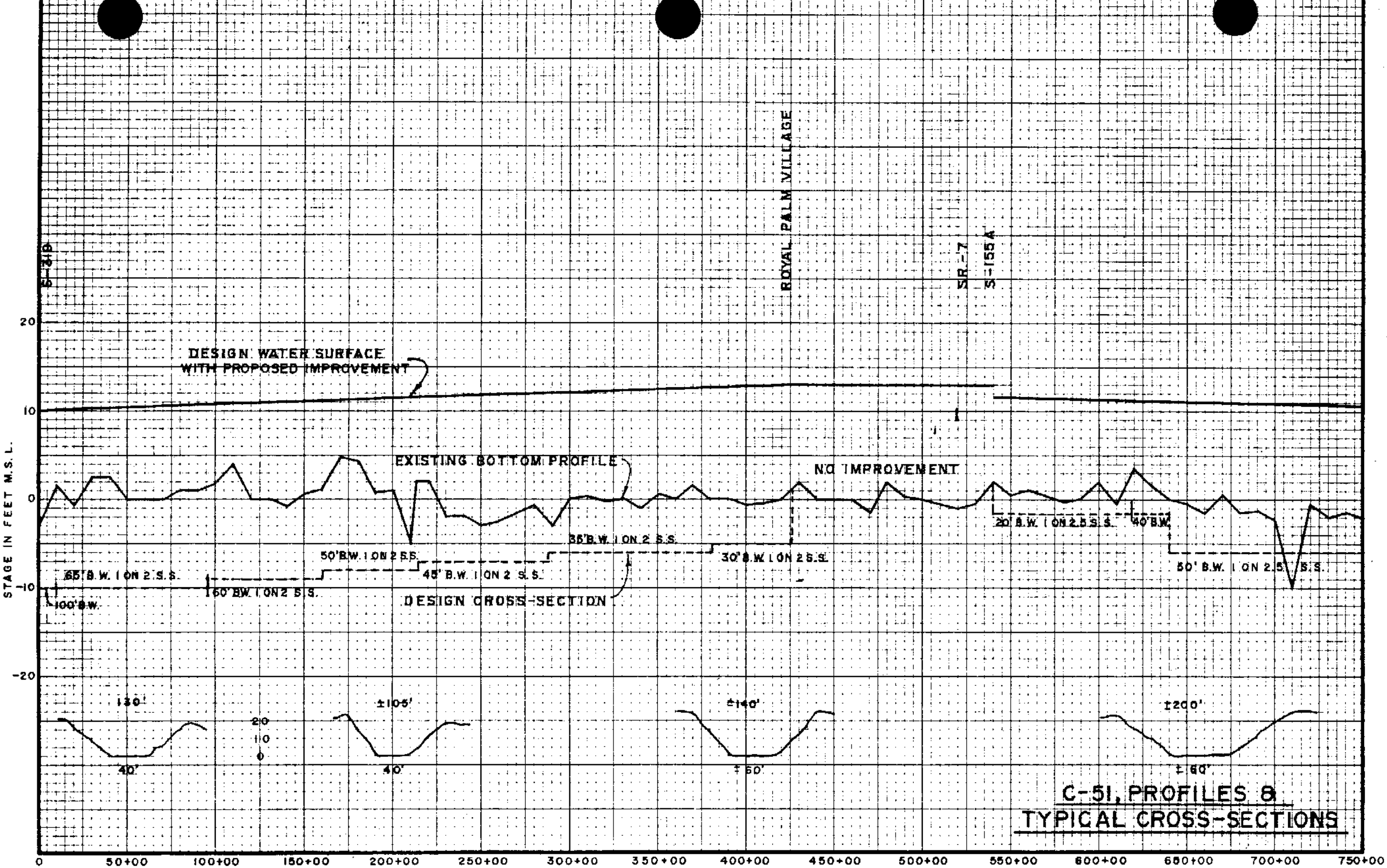
c. Construction of a pumping station (S-319) at Twenty Mile Bend, discharging to C. A. #1, having a design capacity of 5000 cfs.

d. Enlargement of C-51 between S-155A and S-319 and enlargement of certain reaches of C-51 east of S-155A.

Hydraulic design of the system is based on a runoff removal rate of 2 1/2"/day for the area east of S.R. #7 and slightly less than 2"/day for the area west of S.R. #7. The easterly area would be flood-free during a storm event having a frequency of occurrence of once in 25 to 30 years. The western area would have comparable protection with a once in 10 year frequency storm event. The estimated C-51 water surface profile for the design storm event is shown on Figures 4A and 4B. Design storm stages at specific locations are tabulated below:

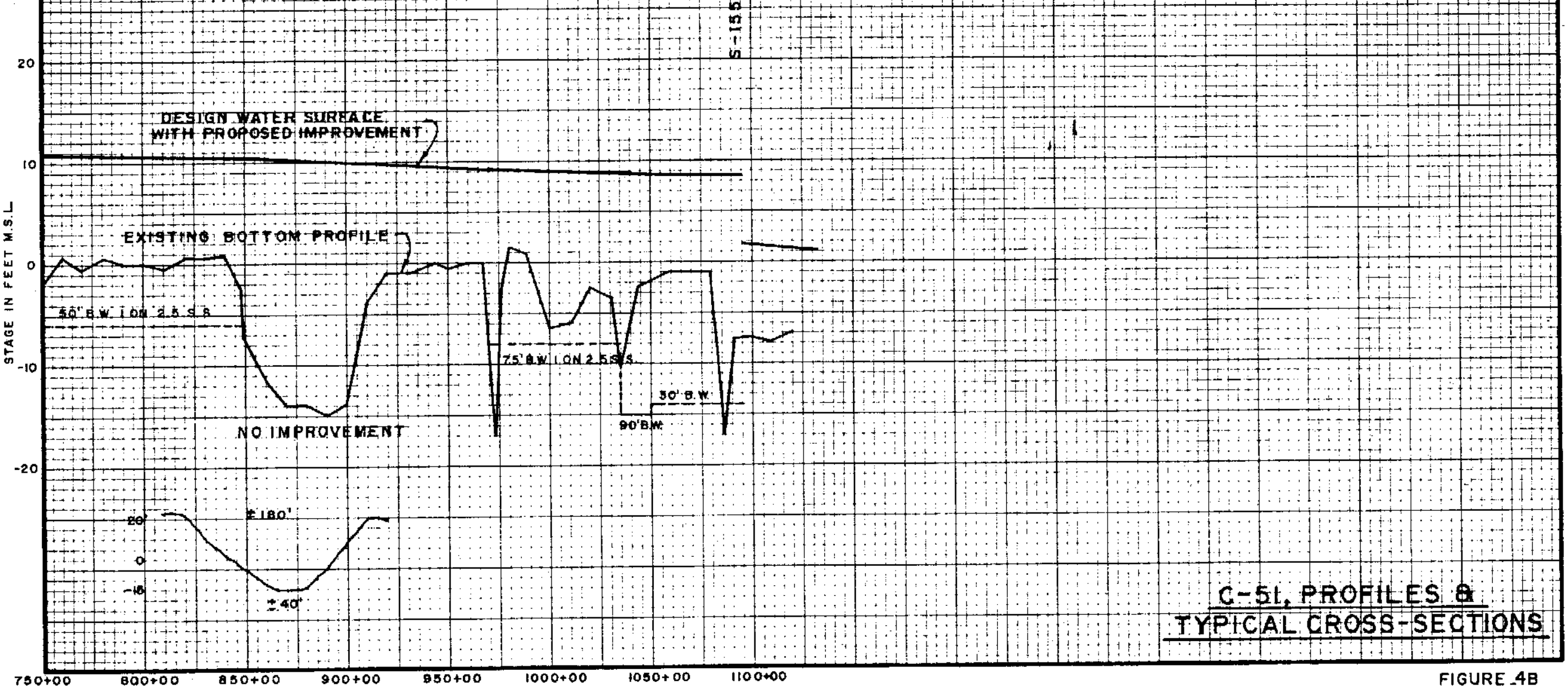
Location	Stage (ft.msl.)
U. S. Highway No. 1	8.5
Military Trail	10.4
S. S. Parkway	11.2
S.R. #7 (S-155A) - east	11.7
- west	13.0
S-319	10.0

*A 13.5 ft. msl. seasonal optimum has been recommended by the Flood Control District.



C-51, PROFILES & TYPICAL CROSS-SECTIONS

FIGURE 4A



C-51, PROFILES &
TYPICAL CROSS-SECTIONS

FIGURE 4B

A degree of flexibility in system operation is provided. At one end of the operating range all runoff generated west of S-155A can be pumped at S-319 into Conservation Area No. 1 up to a peak discharge rate of 5000 cfs. At the other end of the operating range, all runoff from the western portion of the basin up to a peak rate of 1000 cfs. can be discharged eastward by gravity.

2. The proper functioning of the primary water control system to serve its flood protection purpose is dependent upon the capability of the operating agency to regulate storm runoff inflow.

The responsibility for regulating inflow is placed upon the Flood Control District by the Congress of the United States as one of the conditions of District acceptance of "local responsibility" as sponsoring agency of the Central and Southern Florida Flood Control Project. A typical Flood Control District resolution accepting local responsibility contains this language:

> "The Governing Board of the Central and Southern Florida Flood Control District will prevent encroachments on the flood-carrying capacity of the improved channels."

The authority for regulation of inflow by the Flood Control District derives from Chapter 378.17, Florida Statutes, which states:

> "The governing board shall have authority to prescribe the manner in which local works provided by other districts or by private persons shall connect with and make use of the works of the district, to issue permits therefor, and to cancel the same for non-compliance with the conditions thereof, or for other causes. It shall be unlawful to connect with or make use of the works of said district without consent in writing from its governing board, and said board shall have authority to prevent, or if done to estop or terminate the same."

Based on this authority a system for the issuance of discharge permits has been developed by the Flood Control District. This system in the great majority of cases requires the provision by the permittee of structural facilities for the regulation of inflow; usually pipe culverts or similar devices. Reasonable design criteria related to the hydraulics of pipe culverts (or other devices) are applied to determine the size of the inflow regulation structures to be installed under permit.

Experience has indicated that this procedure, based on a limited statutory authority, is inadequate to provide the desired and necessary degree of inflow regulation under critical conditions, particularly in urban areas. The use to which the permittee's land is put (paving, removal of vegetative cover, number of buildings) and/or his internal drainage system design (ditch size, storm sewers, control structure operation) can create hydraulic conditions and loadings which will exceed the criteria on which the sizing of inflow regulation structures was based. These factors are in areas of regulatory responsibility outside the present jurisdiction of the Flood Control District but within the jurisdiction of other local governmental entities in the watershed.

Neither the water resources management plan nor the land use plan separately or combined, addresses this aspect of the problem of storm water inflow regulation in the C-51 watershed.

Earlier herein the indefiniteness of the drainage boundary east of S.R. #7 within the Lake Worth Drainage District was noted. The north-south canals of that district were designed to perform an "equalizing" function, providing flexibility within the drainage district to direct flows either northerly to C-51, or southward to Hillsboro Canal wherever the most favorable water levels existed. Proper functioning of the C-51 water management system requires that the integrity of the design drainage divide be maintained. Consequently, inflow to C-51 from the Lake Worth Drainage District's equalizing canals must be firmly and positively regulated consistent with the capacity of the C-51 system.

This specific surface water inflow regulation problem is not recognized, or addressed, by the land and water management plan being evaluated in this report.

Another major area of potential problems with respect to the regulation of the quantity of surface water inflow to C-51 is the Village of Royal Palm Beach - Indian Trail Ranch area. The internal secondary drainage system for this area is largely now in place, as shown on Figure 3. It is a "conventional" grid layout of comparatively wide, deep canals outletting to C-51 at a single point (Royal Palm Beach Canal). The canal system has the capability of handling a peak runoff removal rate of at least 4"/day. An inflow regulation control structure in the Royal Palm Beach Canal is presently being installed under permit from the Flood Control District. This control will regulate inflow to an overall peak runoff removal rate of 1"/day for the approximate 28.5 square miles of the Village of Royal Palm Beach - Indian Trail Ranch area. A second flow regulation control structure, consisting of a 48" culvert with riser, is also to be installed, under the Flood Control District permit, in the main outfall canal just north of where it crosses the City of West Palm Beach's "M" Canal. This upstream control effectively limits the area to be positively drained to C-51 to about 13.8 square miles, all located south of "M" Canal, and consequently permits a peak runoff removal rate of slightly greater than 2" per day for that area. The above arrangement requires the retention of surplus water on the remaining area north of the "M" Canal, and is necessitated by the restrictions presently imposed by the Flood Control District in view of the limited hydraulic conveyance capability of C-51. The continued ability of the Flood Control District to maintain such restrictions is questionable.

The water resources management element of the combined plan addresses this specific problem to a degree. With the improvement in the hydraulic conveyance capability of C-51, an overall peak runoff removal rate of nearly 2" per day can be applied to the entire Village of Royal Palm

Beach - Indian Trail Ranch area. This would lift the severe restriction now placed on runoff on over half of the area in question. The potential conflict, however, results from the fact that an internal drainage system has been designed having the capability of delivering to C-51 peak runoff at rates in excess of those for which the primary system is designed.

Furthermore, the Village of Royal Palm Beach - Indian Trail Ranch area is not subject to the land use controls associated with Palm Beach County's Comprehensive Land Use Plan. (This will be discussed in some detail subsequently in this report). As a result, land use in this area has to some degree been already committed in a form not consistent with the Land Use Plan. In addition, in the context of surface water quantity, this fact is of some importance in that the opportunity does not exist through application of sub-division regulation procedures to require maximum reasonable on-site retention of surface runoff in this area (creation of lakes or temporary detention areas, for example).

The concern here, therefore, is that the proposed land use, together with the internal drainage system design may create conditions which will either permit larger inflows to be introduced into C-51 or create undesirable uncontrolled flooding within the area.

The conflicts, if such exist, in terms of the quantity impact of storm runoff from this area on C-51 must be specifically and rigorously identified. The resolution of such conflicts will undoubtedly have to take place through mechanisms external to the combined plan being considered herein.

3. All of the inadequacies of the combined plan identified in item 2, above, and which are specifically related to surface water quantity deal with the question of regulation of inflow to C-51. The probable consequences of not recognizing and treating with these inadequacies are the hydraulic overloading of C-51 with resultant reduction in the flood protection and flood damage prevention benefits of the plan.

These are serious consequences since they affect the justification for the expenditure of public funds for the provision of flood protection facilities and will increase private sector costs for flood damage repairs.

4. It is suggested that these inadequacies can be rectified by providing:

a. That sub-division regulations be modified, as necessary, to require the design of internal, on-the-land drainage systems to be such as to positively limit peak runoff rates to the values established by the Flood Control District.

b. That agreement be reached between the Flood Control District and the governmental agencies having jurisdiction over sub-division approval as to the method to be used for runoff calculations, and that internal drainage system design and calculations be certified by registered professional engineers and be approved by both the local agency having jurisdiction and the Flood Control District.

c. That the Lake Worth Drainage District and the Flood Control District agree as to the size and method of operation of structures to be installed in the equalizing canals at the C-51 drainage divide; to be installed at Lake Worth Drainage District cost.

d. That a complete report by a registered professional engineer be furnished the Flood Control District by the Village of Royal Palm Beach - Indian Trail Ranch on the design and functioning of that internal drainage system.

e. That the Village of Royal Palm Beach - Indian Trail Ranch agree to provide those facilities and/or to modify its internal drainage system to the extent necessary to ensure, to the satisfaction of the Flood Control District, that the design performance of C-51 will not be impaired by the functioning of the Village of Royal Palm Beach - Indian Trail Ranch system.

Quantity

B. Groundwater

1. The majority of the West Palm Beach Canal watershed, beneath the surficial sands, is underlain by the Anastasia Formation. This formation represents the major portion of the non-artesian, groundwater table aquifer in this portion of Palm Beach County. The aquifer has a thickness of at least 250 feet near the coast, tapering off to the west to a thickness of less than 100 feet. The aquifer consists of beds of sand, shell, limestone, sandstone, and marl and is variable in permeability.

In the West Palm Beach Canal watershed shallow aquifer recharge is almost exclusively achieved by local rainfall. Groundwater discharge is by way of the canal system during periods when control structures are opened to remove excess surface water. By far the greatest share of aquifer discharge results from evapotranspiration.

Groundwater levels fluctuate in response to seasonal rainfall distribution. Long-term groundwater records are available at only two locations: one (PB99) in West Palm Beach and the other (PB109) west of Loxahatchee Slough and north of Canal M. The range of water level fluctuations at both locations are on the order of four to five feet with extreme conditions producing greater fluctuations.

As noted in the previous section, normal water elevations in C-51 are maintained at a stage of 8.5 ft. msl. In the easterly portion of the watershed, except for a relatively narrow strip adjacent to C-51, groundwater gradients are toward the coast. This strip widens to the north during dry periods and assists in maintaining the 8.5 ft. stage in C-51. West of S.R. #7, and north of C-51, gradients are towards C-51 throughout the year. South of C-51 the gradients are generally toward E-1 and the Lake Worth Drainage District system.

Canal 51 is connected to Lake Okeechobee and that supply can be used to maintain the 8.5 ft. stage in C-51. In dry periods, the Lake Worth Drainage District has, on occasion, taken water from C-51 to maintain its dry season control elevation of 12.0 to 15.0 ft. msl. within a portion of its system.

Proposed Structure 155A is designed to maintain an optimum water control elevation of 13.5 ft. msl. in C-51 west of S.R. #7. This will assist in minimizing the occasional severe reductions in groundwater levels which can occur in that portion of the basin north of Canal 51.

Of more importance, however, will be the reduction of unnecessary loss in groundwater storage which is a by-product of operation of the present single-control structure system. The present system requires continuous discharge at the Dixie Highway spillway until stages recede to, and can be maintained at, an elevation of 8.5 ft. msl. throughout the 20.7 mile length of the canal. This necessarily means the removal of groundwater from storage down to groundwater levels associated with the 8.5 ft. canal stage. With the water resources plan in operation discharges will be terminated once C-51 stage in the western reach has stabilized at a 13.5 ft. elevation and can be maintained at that stage.

No firm estimate can be made at this time as to the average annual volume of water which will be retained within the basin as a result of this feature of the plan which raises the canal operating level west of S.R. #7 four feet. A "figure of merit" estimate, however, is 30,000 A.F. annually.

The artesian aquifer (Floridan) is not affected, either adversely or beneficially, by the plan being examined herein.

2. Sufficient groundwater base-flow will be available to permit the optimum stages of 13.5 ft. msl. and 8.5 ft. msl. to be maintained in the western and eastern reaches of C-51, respectively, under all but the most severe drought conditions. The water resources management plan does not provide the capability to maintain the higher 13.5 ft. stage under these circumstances.

The proposed water control stage of 13.5 ft. msl. in C-51 west of S.R. #7 is quite satisfactory with respect to that portion of the watershed lying south of C-51. Ground elevations increase to the north, however, and additional water level control facilities may be required to minimize groundwater depletion in that area. This is of particular importance in the Village of Royal Palm Beach - Indian Trail Ranch area where much of the internal canal system is in place.

As will be noted subsequently, the Village of Royal Palm Beach - Indian Trail Ranch area is not subject to the land use controls of the County's Land Use Plan and associated regulations and ordinances. The water management element of the combined plan being reviewed herein also does not address the potential problem of unnecessary groundwater depletion in areas such as this.

3. The maintenance of a 13.5 ft. stage in the western reach of C-51 can be virtually guaranteed by installation of a small water supply pump at S-319. The consequences of failing to do this, however, are not considered to be serious. It is possible that on infrequent occasions stages may drop below 13.5 ft. msl., but it is unlikely that they will recede to stages more than 2 feet below this. This is still 2 feet above the stage which is presently maintained by the existing system.

The consequences of potential overdrainage in the Village of Royal Palm Beach - Indian Trail Ranch area, in terms of groundwater loss, are more difficult to evaluate. Nevertheless, the potential for loss of some portion of the resource exists and the issue must be addressed in factual terms.

4. It is suggested that the following be done to rectify the inadequacy identified above:

a. Require the installation of interior water level control structures within the Village of Royal Palm Beach - Indian Trail Ranch drainage system unless it can be demonstrated to the satisfaction of the Flood Control District that lack of such controls will not materially affect groundwater loss.

b. Require the installation in this area, by the Village of Royal Palm Beach - Indian Trail Ranch interests, of a groundwater level monitoring network adequate to provide the data base for shallow groundwater management in the area.

C. Water Supply

1. The major municipalities lying wholly or partially within the C-51 watershed are the cities of West Palm Beach and Lake Worth.

Municipal water supply for West Palm Beach is derived from surface water sources. The location of the city's water catchment area, a natural surface water reservoir, is shown on Figure 1. Storage in the catchment area can be supplemented with water from Lake Okeechobee. Such supplemental water is delivered to the catchment area via "M" Canal which connects with the Levee 8 Canal. The city has constructed, and operates, a lift station at the L-8 Canal - "M" Canal junction to pump supplemental water from L-8 and Lake Okeechobee to the catchment area.

The city of Lake Worth derives its water supply from the shallow, groundwater table aquifer in the coastal ridge area near the south boundary of the C-51 watershed. Both the present Dixie Highway spillway in C-51 and the Lake Worth Drainage District system of controls assist in maintaining satisfactory groundwater elevations in that portion of the aquifer body from which the city of Lake Worth extracts its supplies. Salt water encroachment into this portion of the aquifer is neither a present problem nor a foreseeable future problem.

The water resource management element of the plan being examined herein will not adversely affect either of these major water supply systems.

The city of West Palm Beach's catchment area itself is outside the watershed boundaries and the preservation of its integrity as a catchment area is adequately covered under existing covenants and agreements. The "M" Canal system for supplemental water delivery is similarly protected by agreements.

In regard to the city of Lake Worth's system, the same water level control elevation will be maintained in the eastern reach of C-51 as under present conditions. Protection of this area from salt water encroachment will continue as a result of maintenance of this regimen.

In the western portion of the watershed the only significant municipal supply is that of the Village of Royal Palm Beach. A utility company has been formed and the water source is local groundwater. A population of about 2500 is served by this system.

Although, as will be noted in a later section, the quality of the groundwater in the western portion of the watershed is poorer than that in the coastal ridge area, it is reasonable to assume that water supplies for the majority of the future population resident in this western area will be developed locally. Of interest, then, is the matter of maintenance of sufficient local recharge capability in that portion of the watershed west of the Turnpike.

Population projections presented later herein indicate that there is an excellent correlation between those projections and the projections contained in the Corps of Engineers' report which describes the water resources management element of the combined plan being examined herein. Those projections shown on Figure 25, indicate for year 2020 a total County population of about 1.5 million and a population of 440,000 in the C-51 watershed. Our estimate of population distribution in year 2020 shows that there will be approximately 140,000 people resident in the area west of the Turnpike at that time.

Based on an estimate furnished by a committee of the Palm Beach Chapter of the Florida Engineering Society, application of the requirements of the County's PUD ordinance will result in from 35% to 55% "open space" in a development of this type. This provides ample area for shallow aquifer recharge. This, however, must be related to demand on the aquifer. The supply-demand relationship is examined herein on a 50-year basis; i.e., to year 2020, since an evaluation of this sort on a population "saturation" basis to be attained at some remote point in time is subject to substantial challenge for a variety of reasons.

A very rough test can be applied to develop an approximation of the probable relationship between water supply and demand. It can serve only as an indicator of whether or not the shallow groundwater resource will receive significant stress under average conditions of supply and demand and on a long-term basis. Such a test is by no means a substitute for a detailed water resources survey. It is applied herein only for the purpose of preliminary identification of potential adverse impact with implementation of the considered plan.

The area west of the Turnpike contains approximately 83,000 acres. Based on the above-indicated "open space" requirements of the County's PUD ordinance, but recognizing also that all of the area will not be developed in this fashion and that a portion of the area is not subject to the requirements of the County's Land Use Plan and associated ordinances, it is reasonable to assume that under "saturation" conditions at least 35% of the area will remain as "open space." Under the less than "saturation" conditions of year 2020 at least 70% of the area west of the Turnpike, or about 60,000 acres, will be "open space" and thus available to accept recharge from direct rainfall.

With normal rainfall the average annual amount of water entering the shallow aquifer through this "open space" area will approximate 90,000 acre feet. This is 250 acre feet per day, or about 83MGD. With an average per capita use of 150 gpd, and assuming the major portion of the population resident west of the Turnpike receiving its supply from local shallow aquifer sources, the estimated year 2020 demand would be on the order of 21 MGD.

This rough approximation of the supply-demand relationship does not indicate the existence of a potential severe impact on the area's shallow groundwater resource.

2. Inadequacies of the plan being considered with respect to water supply within the C-51 watershed itself, have not been revealed as a result of this examination. Actually, some benefits in this regard will result from the provision of Structure 155A which will reduce the amount of groundwater loss from the basin. In addition, it should be noted that groundwater management authority for the purposes of maximizing the beneficial use of water and preventing the development of stress on that resource, has been vested in the Flood Control District as the regional water management district in the subject area, under Chapter 72-299, Florida Statutes.

Quantity

D. Hydroperiod

1. The term "hydroperiod" is very nearly synonymous with the term "stage regime" and in the literature, is used in the context of natural systems which are dependent upon some seasonal variations in surface water levels. For the first portion of this discussion, which relates to Canal 51 itself, the alternative term "stage regime" is more appropriate.

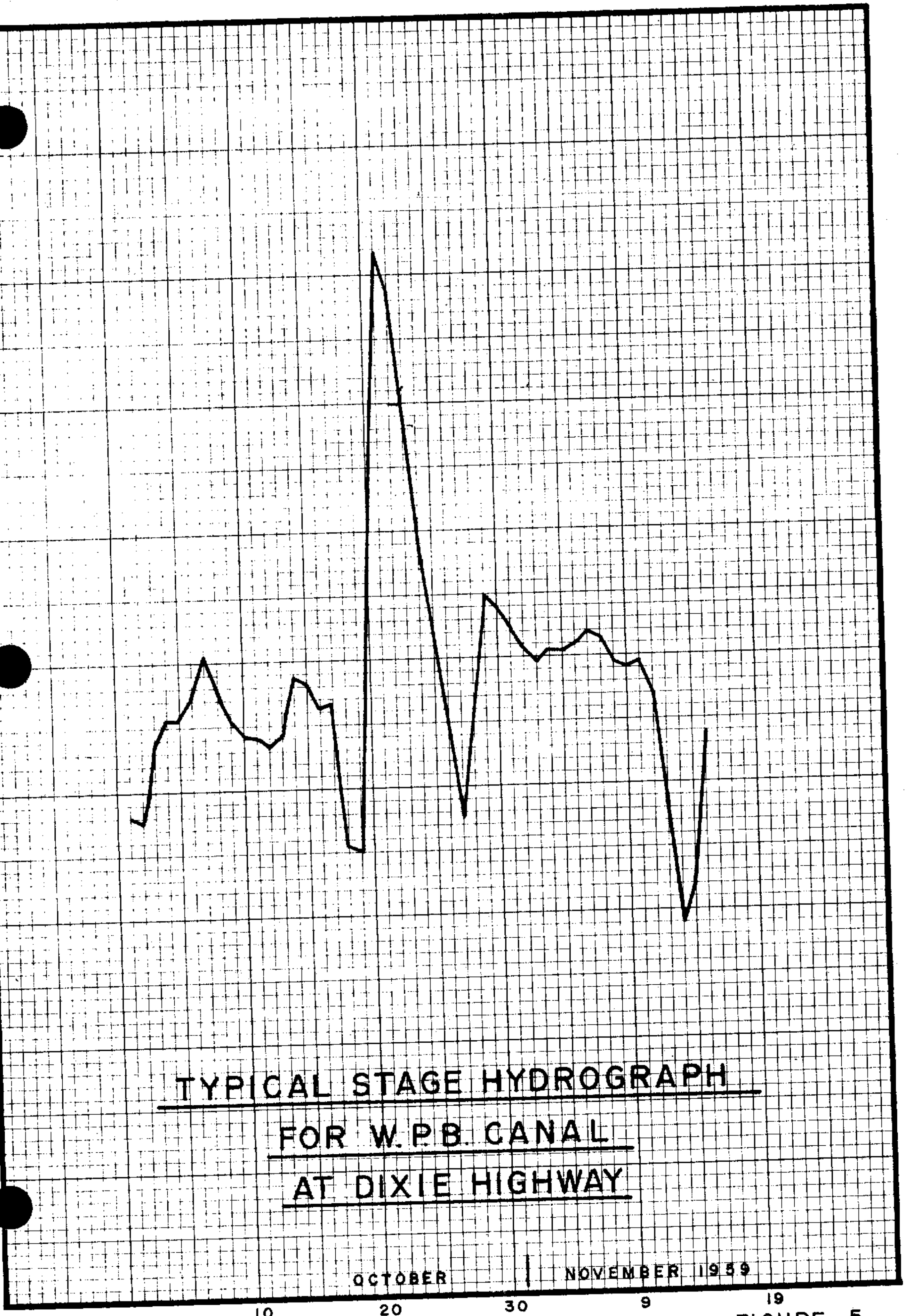
The present normal water level condition in C-51, as noted earlier, is a stage of 8.5 ft. msl. During periods of heavy discharge resulting from flood producing rainfall, stages will rise above this elevation and remain above for some period of time dependent upon the total amount of surplus rainfall to be removed from the basin. A typical stage hydrograph at the Dixie Highway spillway for a flooding incident is shown on Figure 5. This is the hydrograph for the October 1959 occurrence. Starting stage was below 8.5 ft. in this case because of drawdown at the spillway due to an antecedent condition of sustained discharge throughout the late summer and early fall. As noted earlier herein, flood damages in this reach begin to occur at a stage of 9.0 ft. msl.

Actual stage hydrographs at the Dixie Highway spillway and at S.R. #7 for two other major storm events are shown on Figures 6 and 7. These again demonstrate the character of the flood stage regime of C-51 under present conditions.

Under the water resources plan the C-51 "hydroperiod". as reflected by the stage hydrographs for flood periods, will be modified. First, for similar rainfall events, the flood peaks will be reduced when compared with the existing system hydrographs. Second, the duration of high canal stages will also be reduced. Figures 8, 9 and 10 compare actual observed water surface profiles during three major storm events with calculated profiles for the same events, assuming the water management plan in effect. These profiles illustrate both features of the stage regime modification which would take place.

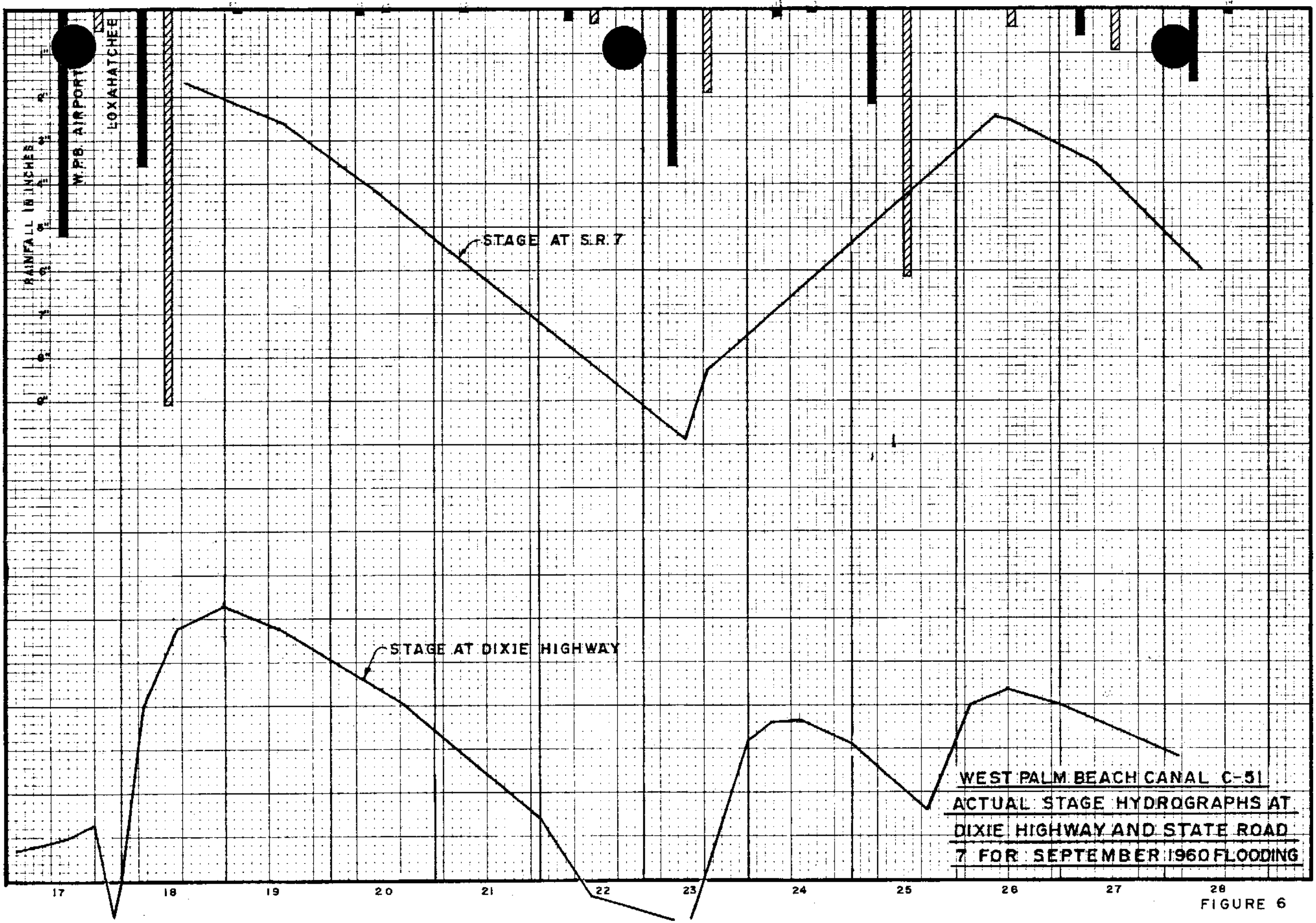
Whatever natural hydroperiod may have existed at one time in what is now the C-51 watershed was substantially modified by the original construction of the West Palm Beach Canal. That natural regime was further modified by the urban development of the City of West Palm Beach, the works of the Lake Worth Drainage District, the Loxahatchee Drainage District, and the more recent development of drainage systems in the Royal Palm Beach area, Acme Drainage District, Callery-Judge Groves, and elsewhere. As a result there are few areas remaining within the watershed which experience now anything like the "natural" hydroperiod.

With the proposed plan in effect there will be further alterations to existing hydroperiods on lands now relatively unaffected by existing



TYPICAL STAGE HYDROGRAPH
FOR W.P.B. CANAL
AT DIXIE HIGHWAY

FIGURE 5


RAINFALL IN INCHES
W.P.B. AIRPORT
LOXAHATCHEE
STAGE AT S.R. 7
STAGE AT DIXIE HIGHWAY
STAGE IN FEET M.S.L.
16
15
14
13
12
11
10
9
8
17
18
19
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21
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25
26
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28
WEST PALM BEACH CANAL C-51
ACTUAL STAGE HYDROGRAPHS AT
DIXIE HIGHWAY AND STATE ROAD
7 FOR SEPTEMBER 1960 FLOODING

FIGURE 6

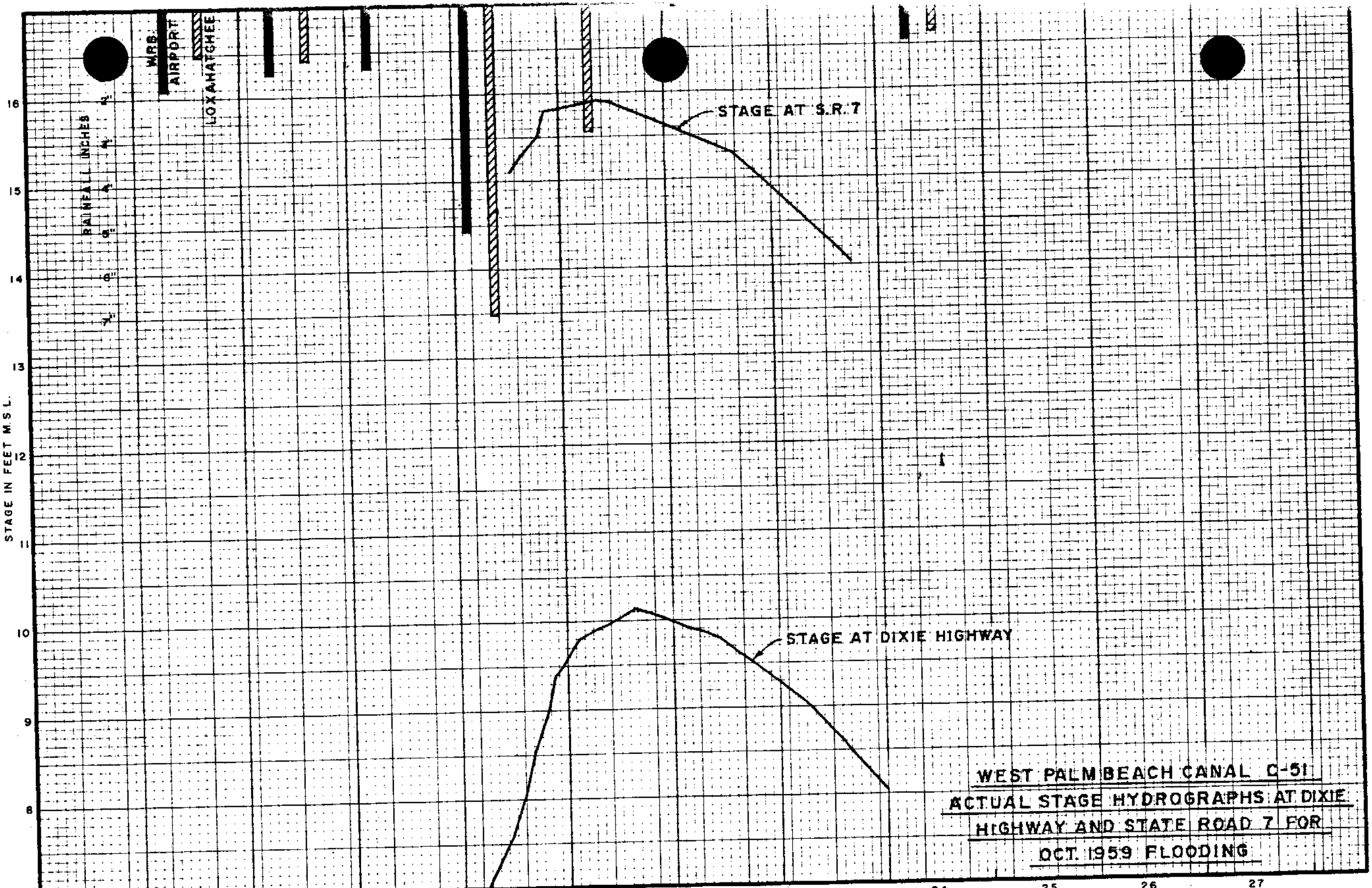
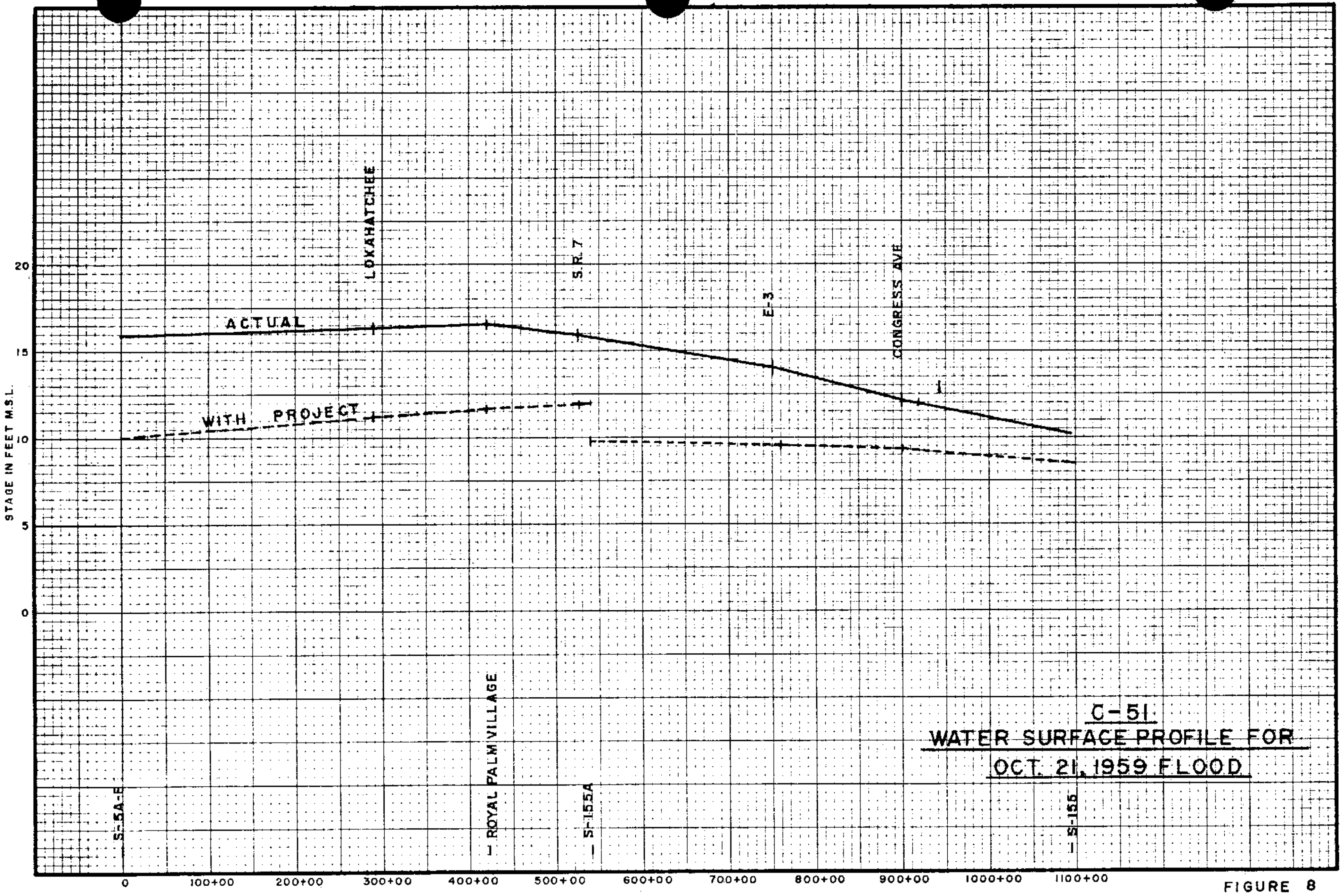


FIGURE 7

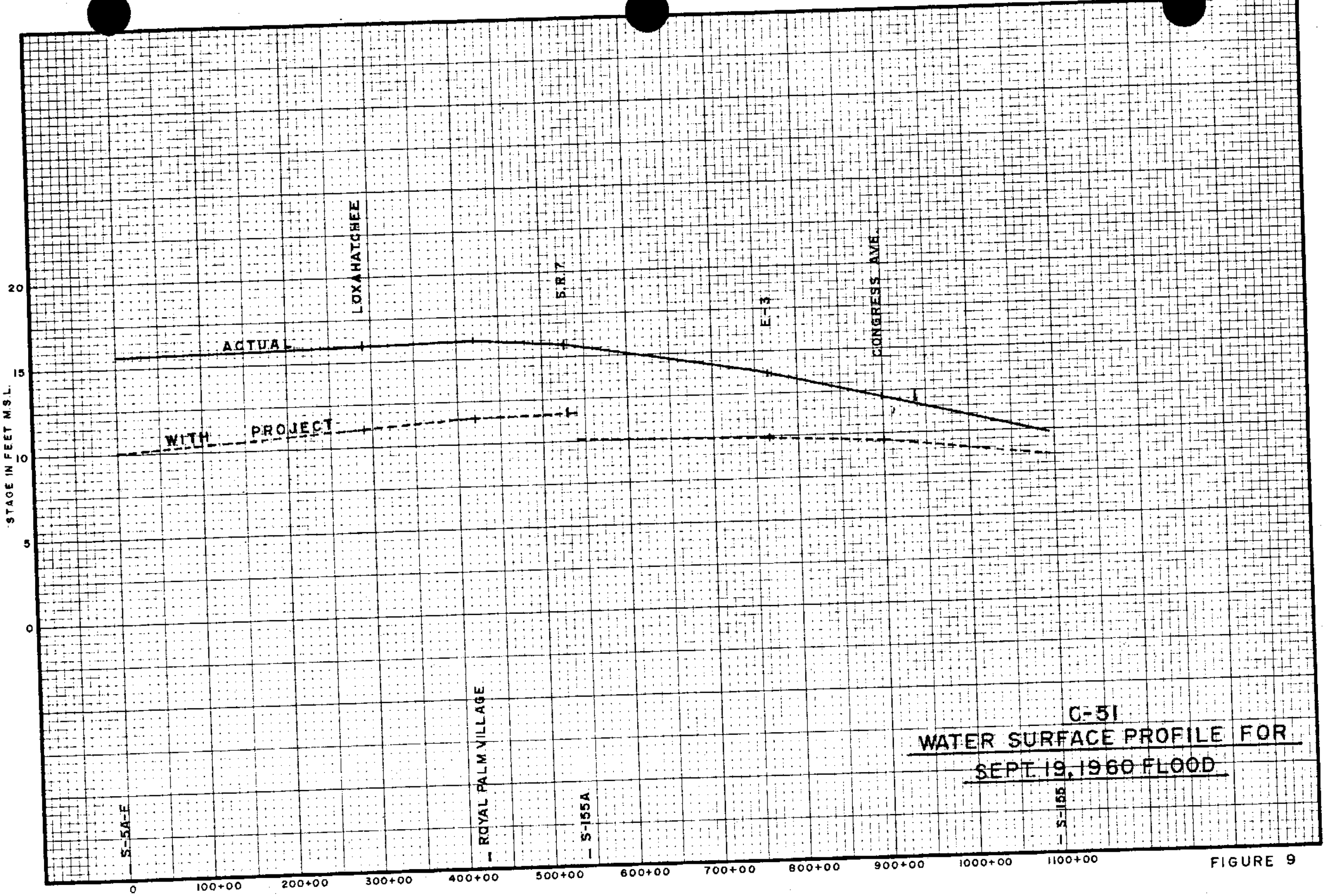
10 X 10 PER INCH

MADE IN U. S. A.



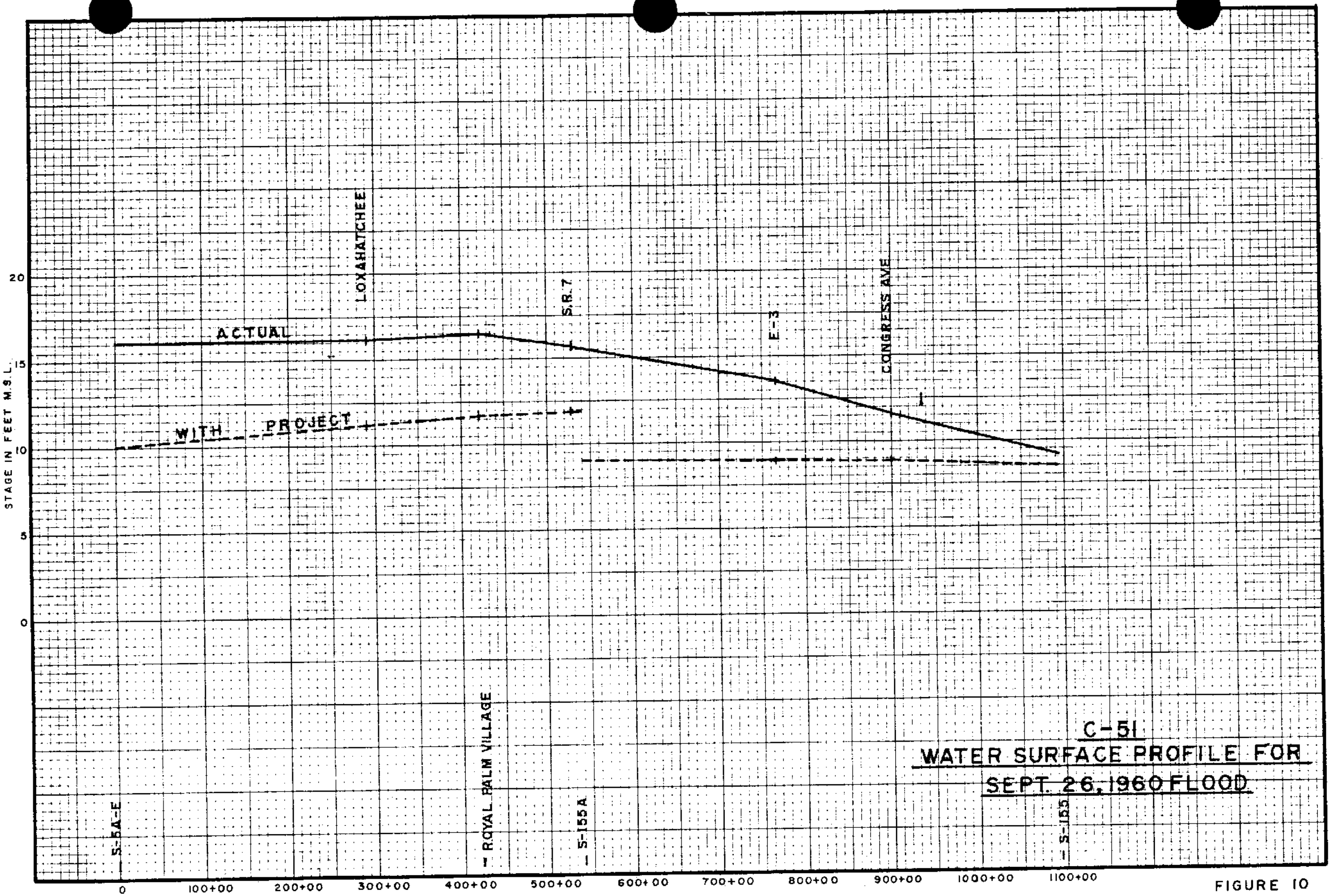
ACTUAL
WITH PROJECT
LOKAHATCHEE
S.R. 7
E-3
CONGRESS AVE
S-5A-E
ROYAL PALM VILLAGE
S-155A
S-155
STAGE IN FEET M.S.L.
20
15
10
5
0
100+00
200+00
300+00
400+00
500+00
600+00
700+00
800+00
900+00
1000+00
1100+00
C-51
WATER SURFACE PROFILE FOR
OCT. 21, 1959 FLOOD

FIGURE 8



C-51
WATER SURFACE PROFILE FOR
SEPT. 19, 1960 FLOOD

FIGURE 9



C-51
WATER SURFACE PROFILE FOR
SEPT. 26, 1960 FLOOD
ACTUAL
WITH PROJECT
LOXAHATCHEE
S.R. 7
E-3
CONGRESS AVE
S-5A-E
ROYAL PALM VILLAGE
S-155A
S-155
STAGE IN FEET M.S.L.
20
15
10
5
0
0
100+00
200+00
300+00
400+00
500+00
600+00
700+00
800+00
900+00
1000+00
1100+00

FIGURE 10

drainage systems. However, in areas where the County Land Use Plan is applicable the areas affected can be held to a reasonable minimum. As noted in a previous section between 35% and 55% of a planned unit development will be devoted to "open space" under the requirements of the County's PUD ordinance. The opportunity thereby is provided for judicious allocation of environmentally desirable lands to this open space category. Hydroperiods approximating the "natural" can be maintained in such areas.

In the Indian Trail Ranch area, the existing grid systems of canals and the associated street network has already, to a large extent, effectively altered the previously existing hydroperiod within its area. Little or no possibility exists for restoration of those conditions. In any event, the natural system which existed in that area can hardly be considered as unique to this portion of south Florida. The cost of restoration, or even partial restoration, is not justified in these terms. It is in this case solely a question of aesthetics.

2. The County Land Use Plan with associated ordinances and regulations does not specifically require that environmentally desirable areas be maintained as a portion of development "open space."

3. The consequences of failing to maintain such areas in their present state can be expressed only in terms of aesthetics or the maintenance of "quality environment", unless it can be demonstrated that such areas are environmentally unique. Nevertheless, it can be considered a desirable objective in just those terms alone.

4. If the above is, in fact, an inadequacy, it can be mitigated by developing criteria, on an ecological basis, for defining environmentally desirable areas and requiring such areas to remain in their existing state under development plans which are subject to local governmental approval.

Quality

A. Surface Water

1. Because of the nature of the water resources management element of the plan being considered in this report it is both logical and convenient to examine the quality characteristics of the water in, and entering, C-51 in two separate reaches; the reach between the S-5A complex and S.R. #7, and the reach between S.R. #7 and the Dixie Highway Spillway. Conservation Area No. 1 and the conservation areas as a whole will be the recipient of some portion of the water entering the western reach of C-51, and Lake Worth will be the receiving body for water from the eastern reach plus some portion of that from the western reach.

Tables 1 and 2, at the end of this Section, present water quality data for the western reach obtained from wet season and dry season sampling runs respectively. The source of these data is "Interim Water Quality Management Plan for Palm Beach County" and the Palm Beach County Health Department. The locations of the sampling sites are shown on Figure 11.

These data show high wet season values for total inorganic nitrogen (2.29 mg/l) and relatively low dry season values for the same parameter (0.78 mg/l). U.S.G.S. data, published in Open File Report 73006, "Appraisal of the Water Resources of Eastern Palm Beach County," were obtained from a single station just west of S.R. #7. The average from two wet season samples (September 1970 and September 1971) show a total inorganic nitrogen value of 0.44 mg/l. The average of two dry season samples (March 1971 and March 1972) show a total inorganic nitrogen value of 0.63 mg/l. The dry season values from the two sets of data are comparable. The wet season values differ substantially and are perhaps indicative of a high degree of variability in pollutant loadings dependent on runoff and flow conditions.

The U.S.G.S. data show wet and dry season values for PO_4 as P of 0.085mg/l and 0.065 mg/l respectively. These are to be compared with the Table 1 values for this parameter of 0.34 mg/l and 0.11 mg/l respectively. Again the dry season values are reasonably close whereas the wet season values differ considerably.

The data from Table 1 show some depression of dissolved oxygen levels below the State standard of 4.0 mg/l at certain sites during the wet season. These are accompanied by higher nitrate nitrogen values. The depression of dissolved oxygen is possibly attributable to:

(a) Groundwater (of lower D.O. concentration) movement into canal.

(b) Surface runoff, resulting in higher BOD and suspended solids loading, which would indirectly affect productivity by increasing turbidity.

(c) Higher water temperature, which would affect both the solubility of O_2 in water and primary productivity.

(d) Other factors which would affect primary productivity, including oxidation of detritus and dead algal matter and decreased reaeration loading.

Species diversity studies and analyses conducted by the Corps of Engineers developed index values indicating that C-51 water in the western reach (S-5A to the Turnpike) was in the "clean water" category.

Discharge of treated domestic wastewater, although a contributor to alteration of water quality, cannot be considered as a major source of water quality degradation in the western reach of C-51. There are only two wastewater treatment plants in this portion of the basin, only one of which discharges into C-51. Data on these plants are listed below:

	Lion Country Safari	Village of Royal Palm Beach
Design Capacity (MGD)	0.02	0.250
Actual Flow (MGD)	0.031	0.119
BOD_5 (lbs/day)	6	23
SS (lbs/day)	3	-
Discharge to	Secondary Canal	C-51
Meets SDPC Requirements	Marginal	No

It appears then, that any water quality problems in the western portion of C-51 are primarily derived from diffuse sources, but additional data is needed to fully substantiate the relative contributions of stormwater runoff and other diffuse sources to water quality in this reach of C-51.

Tables 3 and 4, at the end of the Section, present water quality data for the eastern reach of C-51. The source of the data is the same as that for Tables 1 and 2. Sampling site locations are shown on Figure 11.

U.S.G.S. data from the report cited earlier show wet and dry season values for inorganic nitrogen in this reach of 0.50 mg/l and 0.40 mg/l respectively compared with values of 1.34 mg/l and 0.96 mg/l from Tables 3 and 4. The U.S.G.S. values for PO_4 as P are 0.04 mg/l and 0.06 mg/l, respectively, compared with values of 0.50 mg/l and 0.20 mg/l from Tables 3 and 4. Again, a degree of variability shows up in these comparisons.

The data in Table 3 show depressed dissolved oxygen levels throughout most of this reach for the wet season samples. Analysis of the data indicates an increase in phosphorous and nitrate nitrogen levels, in general, as wet season flows move eastward through the more heavily urbanized areas.

Water quality degradation in this reach of C-51 is further evidenced by data from limited coliform studies conducted by the U.S.G.S. Average coliform counts were 4000/100 ml. with a range of 500 to 16,000/100 ml. and with higher concentrations at the more easterly sampling stations. State standards for coliform are 1000/100 ml.

Contributors to water quality degradation in this reach of C-51 are wastewater treatment plant discharges, septic tank inflow via groundwater discharge and other groundwater discharges, and surface water runoff.

Table 5 lists the wastewater treatment facilities in that portion of the C-51 basin east of S.R. #7. Source of the data given is the Palm Beach County Health Department's annual data for 1972. Assuming all effluent discharged by these facilities reaches C-51 (that is, without losses enroute) total average inflow is 1.9 MGD. This is equivalent to a sustained flow at a rate of a little less than 3 cfs or 6.0 acre feet per day. In view of the normally large volumes of wet season flows in C-51 (on the order of 1000 cfs) and the resultant potential for dilution, discharge from these facilities, even though sub-standard in quality, can probably not be considered the major contributor to wet season degradation of water quality in this reach of C-51. Areas served by Sewers and Septic Tanks are shown on Fig. 18.

Septic tank effluents appear to be perhaps more influential in wet season degradation of water quality in the eastern reach of C-51. District analysis of the limited U.S.G.S. coliform data cited earlier indicated a degree of association of the higher coliform counts with heavier precipitation over the eastern portion of the basin.

Approximately 45,000 people utilize septic tanks in this portion of the C-51 basin, most at what would be considered urban density. Rules governing the issuance of septic tank permits are given in Ch. 17-13, Florida Administrative Code. The fundamental criteria used in evaluating septic tank suitability include: (a) availability of central sewer system, (b) groundwater elevations, (c) soil suitability, (d) flooding susceptibility, and (e) percolation rates. In this portion of the C-51 watershed, the soils present severe limitations for septic tank use, according to the criteria of Ch. 17-13. Groundwater elevations are not always in compliance with State regulations, which is evidenced by data collected on several wells monitored by the U. S. Department of Agriculture Soil Survey Party. Also, portions of the area are subject to periodic flooding as noted earlier herein. Finally, this area exhibits relatively dense septic tank use. This is a particularly pertinent factor when these septic tank areas are in close proximity to surface waters, as is the case in this portion of the C-51 watershed.

Other groundwater contributions, although the relative magnitude of the problem is not known, include evaporation-percolation ponds utilized by wastewater treatment plants for disposal of effluents. There are ten "on-site" facilities currently in operation in the area, and at least two more have been permitted. See Section B, immediately following this Section for further treatment of this question.

The final contributor to wet season water quality degradation in the eastern reach of C-51 is storm water runoff. Even though higher flows of the summer months provide larger volumes of water for assimilation of pollutants, the vehicle is also provided for transport of larger pollutant loads to the receiving stream. Thus, the violation of State standards for dissolved oxygen and total coliform could in large measure be attributed to surface runoff, both directly from surrounding developed areas and from tributary canals.

In addition to increases in nitrate and phosphorous levels from runoff, there are corresponding increases in BOD and suspended solids loadings to the surface waters. A recent report* presented data on the relative contributions of BOD and suspended solids of specific urban land uses for several test areas. These data are given below:

Land Use Category	No. of Test Areas	BOD (mg/l)	SS (mg/l)
Residential	7	12.3	216
Commercial	2	9.5	235
Industrial	1	13.0	2052
Recreational	1	11.0	445

* Water Pollution Control Research Series 11034 FKL 07/70, Storm Water Pollution From Urban Land Activity, Federal Water Quality Administration, July, 1970.

A rough-cut approximation of the storm water runoff problem is presented in the (draft) Palm Beach County Water Quality Management Plan, July 1973. Using two standard engineering references, the Federal Water Quality Administration report cited above, and specific conditions applicable to Palm Beach County, estimates of BOD and suspended solids for each major watershed were determined. It was found that the runoff contribution to water quality degradation appears to be on the same order of magnitude as point source discharges. Projections of future loading from runoff indicate that there will be significant increases in BOD and suspended solids loading with increasing urbanization, if control measures are not initiated.

2. The impact of the combined plan being considered in this evaluation report on surface water quality is most difficult to assess. There is little question, from the data presented above and other information from sources not cited, that increased urbanization can result in degradation of surface water quality from storm water runoff. Such degradation as may exist in the eastern reach of C-51 is readily attributable to the urban character of the watershed. This condition can logically be extrapolated to some future condition in the western reach of C-51 with urbanization of that portion of the watershed.

In evaluating impact, then, the question becomes one of the extent to which the water resource management element of the plan is the cause of urban development of the western portion of the watershed. There appears to be a body of opinion which believes this to be the case; that urbanization of this area can be virtually stopped by cancellation of this element of the plan. However, it is the consensus of opinion among the planners having knowledge of this area that although cancellation of that plan may affect to some extent the rate of urbanization, it will not affect the fact of urbanization. Logic appears to support this view. The temporary constraints imposed by limited primary drainage capability are insufficient in the face of other massive external pressures which will develop. This view is adopted herein as the basis for analysis.

From this viewpoint, then, the water resources management element of the plan has of itself no adverse impact on C-51 surface water quality. On the other hand, the land use element of the plan has the potential for creating adverse impact simply by virtue of the fact it contemplates and provides for an increasing population in the watershed. That element of the plan, and therefore the combined plan, does not address the problems of surface water quality degradation which may result from increasing the proportional contribution of urban runoff to total watershed runoff.

Quality problems associated with urbanization are not all attributable to surface water runoff. As indicated earlier in this section, wastewater discharge is a factor. It is pertinent to note here, therefore, the regional wastewater management plan and its affect within the C-51 basin.

Implementation of the regional systems proposed in the Palm Beach County Water Quality Management Plan in the C-51 basin would have little or no effect in that portion of C-51 from S-5A to S.R. #7. Only one facility (Royal Palm Beach) has been discharging directly into C-51 or its tributaries in this area. However, the utility company has been granted a construction permit for a new facility to be located approximately 2 miles north of C-51, northwest of the present Royal Palm Beach Village limits. In addition, current regulatory agency policies indicate that no new plants will be permitted to discharge to inland surface waters of eastern Palm Beach County. The implementation schedule proposed in the Water Quality Management Plan projects that the area west of S.R. #7 will not be served by the regional system until approximately 1980 or after.

The regional system, when implemented, will however, have a substantial impact on the small, inefficient treatment operations and the dense concentrations of septic tank areas in the C-51 basin between S.R. #7 and S-155. According to the recommended compliance schedule in the (Draft) Water Quality Management Plan, all the facilities in this portion of the C-51 basin will be required to meet joint State and Federal water quality standards by approximately 1980. The facility owners can meet this obligation by either upgrading the existing plant to meet water quality standards (advanced wastewater treatment, then on-site containment; low-rate land-spreading of secondary effluent; secondary treatment, then deep well injection; or secondary treatment and ocean outfall), or join the regional system, which will also meet water quality standards by one of the recommended methods. Either of these alternatives, in conjunction with serving of those areas currently served by septic tanks, should improve the water quality of the tributary canals and C-51 itself

However, it is evident that abating point source pollution will not totally solve the water quality problems of this area. Adequate measures should be taken for control of diffuse source wastewater in order to effectively manage surface water quality and, as noted above, this problem is not addressed by the combined land and water management plan.

3. The immediate consequences of the failure to acknowledge the existence of this problem and attempt to effectively address it will, of course, be felt in C-51 itself. Of possibly more concern is the effect on the ultimate receiving bodies; in particular, the water conservation areas. Those effects are examined in detail subsequently in this report.

4. Recommendations concerning the manner in which the problem of quality control of urban storm water could be approached were solicited from a committee appointed by the Palm Beach Chapter of the Florida Engineering Society. That committee's recommendations follow

> "Recommendations for improving the quality of storm water runoff in the C-51 basin.
>
> "Recent research in the area of improvement of storm water quality has indicated that most of the highly contaminated storm water reaches a storm drainage system from the first one-quarter inch of rainfall falling on an urbanized area after a lengthy dry period. Little is known about the time relationship of runoff from agricultural areas as it affects water quality. Since the C-51 Basin Study is primarily concerned with the effects of urbanization, it is the recommendation of the Committee that steps be taken to incorporate in subdivision regulations, requirements that construction of storm drainage facilities be designed in such a way as to minimize water quality degradation. These regulations could be written along the following guidelines:
>
> "1. Systems should encourage maximum percolation of rainfall and runoff into pervious areas.
>
> "2. Runoff from all impervious areas should be directed to areas where percolation into the soil can be accomplished.
>
> "3. Any runoff which must be carried into the storm drainage system should be discharged into natural, or artificial on-site bodies of water to promote deposition of silt and uptake of nutrients or other undesirable constituents in the water.

"4. Such natural, or artificial bodies of water shall be required on all developments exceeding 100 acres.

"The Commitee considered possible modifications to regulations for the issuance of permits for connections to C-51 Canal. It was the opinion of the Committee that modification to the regulations, insofar as structures regulating the inflow into the canal was concerned, would accomplish little regarding water quality at that point. However, if the District has the authority, permits could be withheld from those developments which did not incorporate on-site storm water management techniques. A regulation of this type, together with modified subdivision regulations would provide the best double barreled approach to storm water quality management.

"All drainage districts discharging storm water into C-51 should be required, as a condition of FCD permit issuance, to adopt regulations calling for storm water quality control practices incorporating the guidelines previously discussed.

"The Committee would like to draw attention to Chapter XII, Storm Water Runoff, of the Water Quality Management Plan for Palm Beach County, prepared by William M. Bishop and Associates of Tallahassee. This Chapter provides a detailed discussion of storm water quality in the Palm Beach County area, much of which is applicable to the C-51 Basin area. The recommendation at the end of this chapter is that a technical coordinating committee of those agencies responsible for water quality management, be established for the purpose of exchanging and coordinating water quality data related to storm water runoff pollution problems. The establishment of this Committee will provide a mechanism for identifying and quantifying storm water quality problems in the County and can be utilized to great advantage in the C-51 Basin."

This is a far-reaching and forward-looking recommendation and is accepted as a recommendation of this preliminary evaluation report.

Table 1. C-51 Water Quality Data (S-5A to S.R. #7)
Wet Season Study, September 1972

Parameter	Mean all Samples	Station Number						
		553	554	555	556	557	558	559
Dissolved Oxygen	3.9	5.8	3.5	4.4	5.5	4.6	3.2	0.3
BOD_5	2.42	2.5	2.3	1.9	1.7	1.9	3.2	3.5
p^H	7.4	7.7	7.5	7.5	7.5	7.5	7.4	7.4
(asp)PO_4^{-3} (Total)	0.34	0.26	0.06	0.16	0.11	0.65	0.48	0.67
NH_3 as N	0.83	0.86	0.72	0.85	1.27	0.77	0.78	0.59
NO_2^- as N	0.055	0.040	0.130	0.070	0.029	0.062	0.041	0.016
NO_3^- as N	1.41	1.37	1.97	1.13	1.17	1.03	1.10	2.10
Organic Nitrogen	1.62	1.92	2.23	1.22	1.35	2.00	1.38	1.23
Alkalinity	226.8	241.8	279.1	212.4	215.4	218.3	221.9	199.0
Chloride	44.1	60.9	75.8	30.7	33.1	30.6	33.2	18.7

Table 2. C-51 Water Quality Data (S-5A to S.R. #7)
Dry Season Study, May 1973

Parameter	Mean all Samples	Station Number		
		553	558	559
Dissolved Oxygen	4.9	5.7	4.5	4.6
BOD_5	5.8	5.9	5.7	5.8
p^H	7.6	7.7	7.5	7.5
PO_4^{-3}(Total)-P	0.11	0.16	0.11	0.06
NH_3 as N	0.39	0.41	0.42	0.34
NO_2^- as N	0.029	0.082	0.003	0.003
NO_3^- as N	0.36	0.45	0.32	0.32
Organic Nitrogen	1.83	1.87	1.89	1.72
Alkalinity	162.0	133.5	170.5	182.1
Chloride	54.1	55.9	38.2	68.2

Table 3. C-51 Water Quality Data (S.R. #7 to Spillway
Wet Season Study, September 1972

Parameter	Mean all Samples	Station Number						
		562	563	569	572	574	579	576
Dissolved Oxygen	3.5	4.1	0.7	0.5	2.8	7.8	3.8	4.7
BOD_5	3.5	2.7	6.9	3.4	2.8	2.1	3.4	3.4
p^H	7.4	7.3	7.1	7.2	7.5	8.0	7.5	7.4
(as P)PO_4^{-3}(Total)	0.50	0.09	0.96	0.23	0.50	0.56	0.69	0.48
NH_3 as N	0.50	0.41	0.91	0.45	0.45	0.40	0.38	0.51
NO_2^- as N	0.043	0.059	0.128	0.040	0.034	0.017	0.015	0.013
NO_3^- as N	0.80	1.23	1.80	0.37	0.63	0.50	0.57	0.50
Organic Nitrogen	1.33	1.36	1.28	1.57	1.14	1.07	1.61	1.29
Alkalinity	175.0	230.5	237.1	154.5	208.9	152.4	117.9	123.5
Chloride	29.6	48.0	22.9	18.0	36.0	23.9	25.4	33.1

Table 4. C-51 Water Quality Data (S.R. #7 to Spillway)
Dry Season Study, May 1973

Parameter	Mean all Samples	Station Number						
		562	563	569	572	574	579	576
Dissolved Oxygen	6.2	5.5	5.3	5.8	6.8	7.8	6.1	6.0
BOD_5	5.6	6.3	5.9	6.0	5.6	2.1	6.3	6.7
p^H	7.8	7.7	7.5	7.6	7.6	8.0	7.9	8.0
PO_3^{-3}(Total) as P	0.20	0.10	0.13	0.13	0.20	0.56	0.14	0.12
NH_3 as N	0.37	0.38	0.39	0.39	0.37	0.40	0.41	0.24
NO_2^- as N	0.010	0.02	0.005	0.002	0.002	0.017	0.015	0.006
NO_3^- as N	0.58	0.56	0.38	0.32	0.88	0.50	1.08	0.32
Organic Nitrogen	1.67	1.73	1.73	1.71	1.61	1.07	2.21	1.61
Alkalinity	170.3	175.7	185.7	173.4	166.9	152.4	165.3	172.5
Chloride	49.4	66.0	46.1	50.5	45.5	23.9	68.3	45.3

Table 5. Wastewater Treatment Facilities in C-51 Basin (East of S.R. #7)

NAME	Design Capacity (MGD)	Actual Flow (MGD)	BOD_5 (lbs/day)	Suspended Solids (lbs/day)	Discharge to:	Meets SDPC Requirements
Palm Beach I'natl. Airport	0.54	0.169	51	28	West Palm Beach Canal	No
Forest Hill Village Subdivision	0.35	0.321	123	104	Lake Worth Drainage District E-3 to West Palm Beach Canal	No
Sunshine State Parkway #2	0.075	0.039	-	-	Drainage Ditch to West Palm Beach Canal	Yes
Fred Mims Labor Camp	0.012	0.020	6	13	Range Line Canal to West Palm Beach Canal	No
Century Village #1	0.50	0.218	14	24	Drainage Canal to West Palm Beach Canal	Yes
Century Village #2	0.40	0.193	16	24	Drainage Canal to West Palm Beach Canal	Yes
Royal Sky Campgrounds	0.015	0.008	2	2	Lake Worth Drainage District L-1	Yes
Golfview Junior High School	0.024	0.023	0.6	3	Drainage Canal to Lake Worth Drainage District E-3	Marginal
Meadowbrook Subdivision	0.35	0.21	105	172	Lake Worth Drainage District L-2 to LWDD E-3	No
Belvedere Homes Subdivision	0.144	0.212	81	81	Lake Worth Drainage District L-2	No
Sunset Homes	0.218	0.10	26	20	Lake Worth Drainage District L-2	No
Polo Grounds Mall	0.0135	0.004	0.6	0.8	Lake Worth Drainage District L-5	No
Farmer's Market	0.025	0.007	3	5	Lake Worth Drainage District L-6	No
Holiday Ranch Mobile Homes	0.035	0.035	6	9	Lake Worth Drainage District L-7	Yes
Sherwood Apts.	0.0083	0.008	0.5	2	Lake Worth Drainage District L-7	No
Polo Club Estates	0.175	0.106	41	32	Lake Worth Drainage District L-7	Marginal

Continued on next page

Table 5 (Continued)

Palm Beach Care Nursing Home	0.01	0.01	3	13	Lake Worth Drainage District L-11	No
Lake Worth Hills Subdivision	0.175	0.139	20	20	Lake Worth Drainage District L-11	No
Green Acres Trailer Park	0.0086	0.004	0.6	1	Lake Worth Drainage District L-10	Yes
Mason's Nursing Home	0.005	0.005	0.3	1	Lake Worth Drainage District L-10	No
Lake Worth Village Mobile Home Park	0.10	0.075	36	49	Drainage Canal to Lake Worth Drainage District E-3	No

Quality

B. Groundwater

1. The quality of the groundwater resource underlying the Canal 51 watershed is, as in the remainder of Palm Beach County, quite variable. The quality of the water in the shallow aquifer system can often be related to the permeability of the aquifer in the proximity of the sampling location. Portions of the aquifer with higher permeabilities have higher groundwater velocities which tend to keep the mineralized water flushed from the system. In addition, the character of the surficial materials (muck, limestone or sand) will influence the types of materials leached by the percolating rainfall and which will contribute to groundwater quality characteristics.

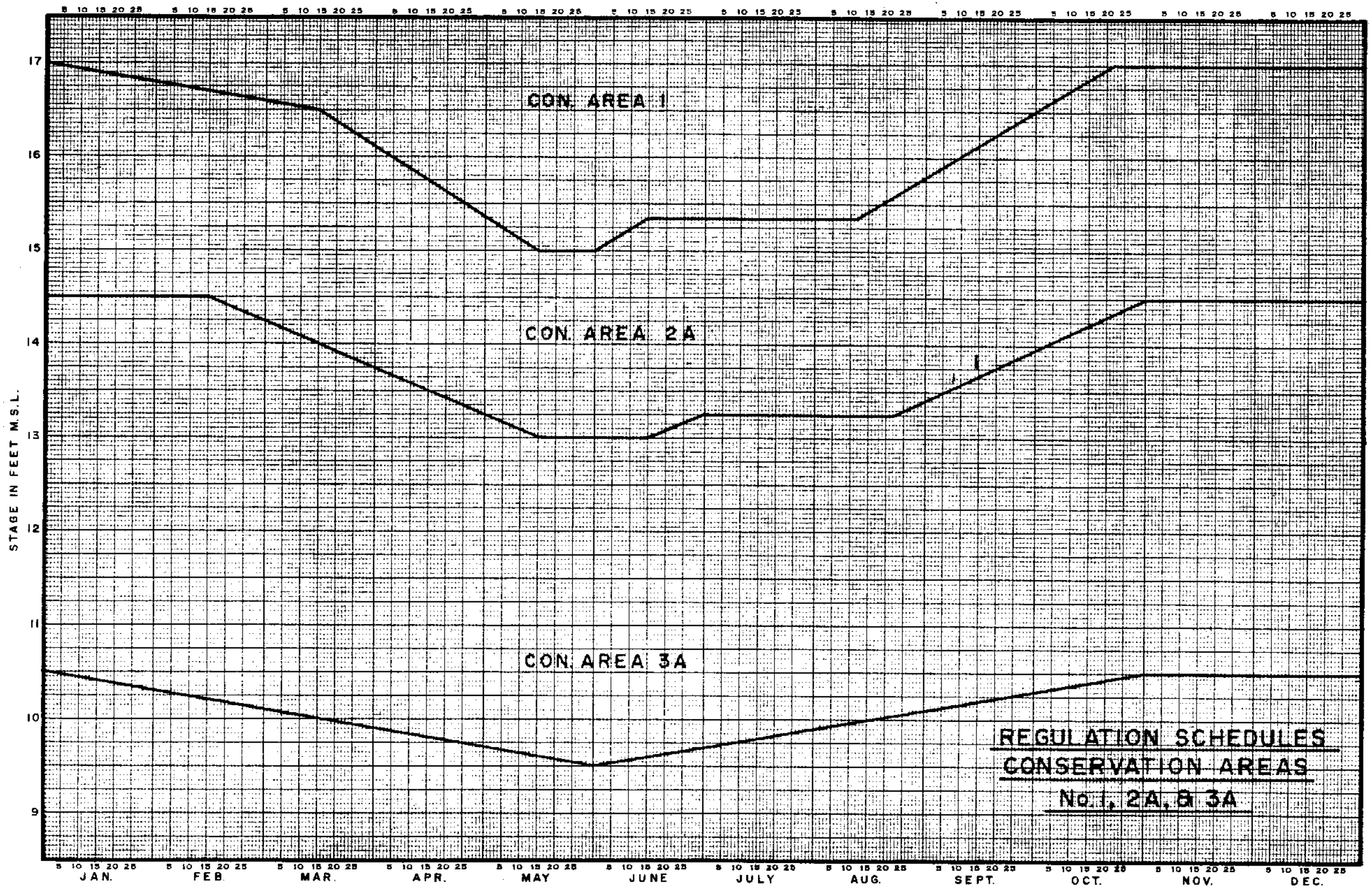
In the C-51 area waters in the shallow aquifer system tend to become poorer in quality as one moves westward from the coastal ridge and also with increasing depth in the aquifer. Figure 11 shows the position of three wells sampled by the U. S. Geological Survey to determine the chemical quality of the shallow aquifer. The following table lists the values of certain chemical and physical characteristics of the sampled groundwater.

Well No.	Specific Conductance	Dissolved Solids	Chloride	Total Hardness	Well Depth
GS-7	6150 umho	3600 mg/l	1380 mg/l	492 mg/l	50 feet
GS-8	1630 umho	869 mg/l	288 mg/l	427 mg/l	44 feet
PB-584	583 umho	323 mg/l	45 mg/l	234 mg/l	111 feet

Physical and Chemical Characteristics of Three Wells in the West Palm Beach Canal Basin - U. S. Geological Survey data.

An examination of this data illustrates the lessening of water quality in the shallow aquifer from east to west until the well at Twenty-Mile Bend (GS-7) indicates a quality of water requiring extensive treatment for most uses.

As can be seen from the data there is approximately a ten-fold increase in the specific conductance of the groundwater from the coastal ridge area to Twenty-Mile Bend, the western terminus of C-51. Specific conductance is an indication of the level of total dissolved minerals present in the groundwater. At all locations the hardness of the water is such that treatment (softening) is required.



CON. AREA 1
CON. AREA 2A
CON. AREA 3A
STAGE IN FEET M.S.L.
17
16
15
14
13
12
11
10
9
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
REGULATION SCHEDULES
CONSERVATION AREAS
No. 1, 2A, & 3A

FIGURE 12

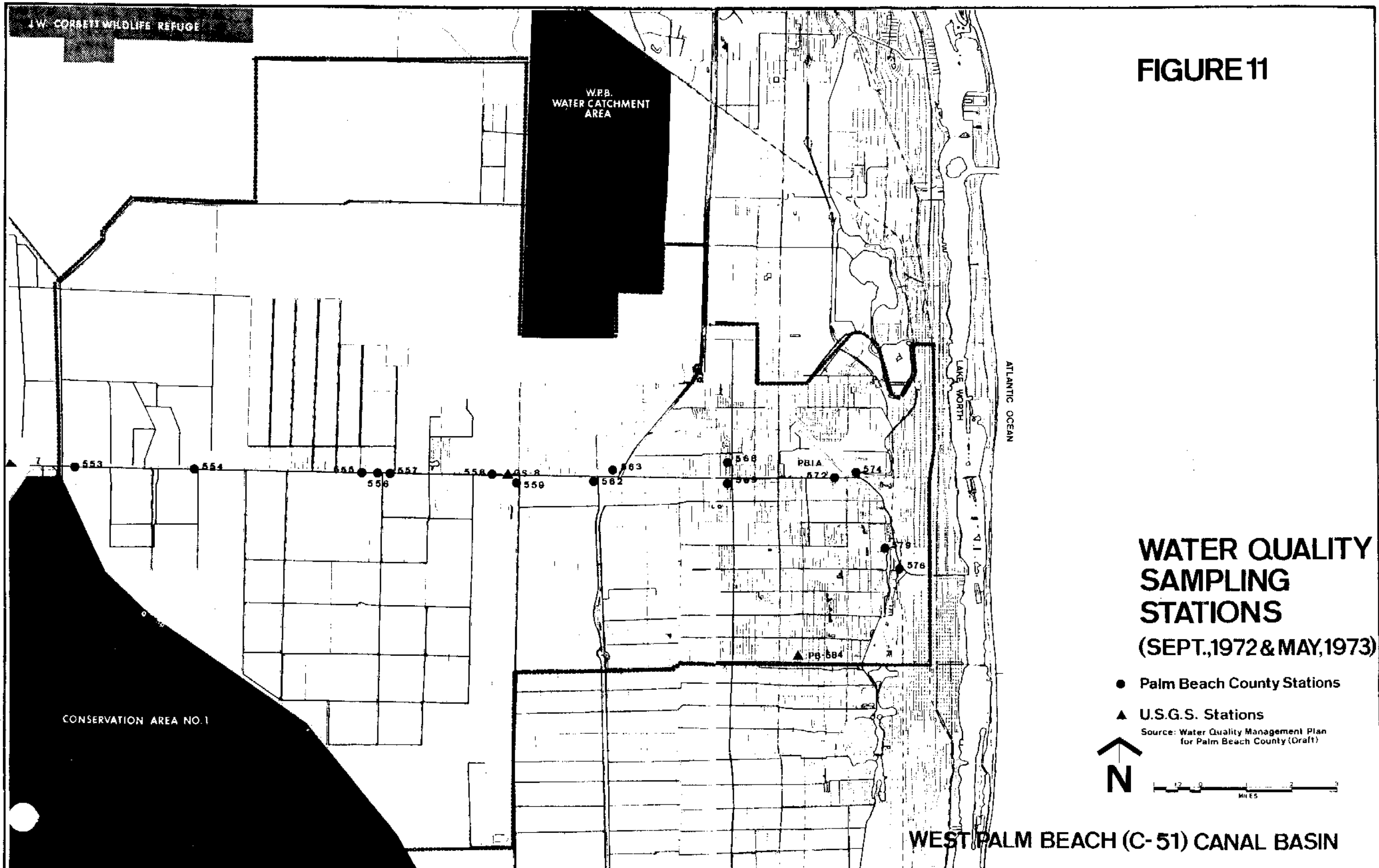


FIGURE 11
WATER QUALITY SAMPLING STATIONS
(SEPT.,1972 & MAY,1973)
Palm Beach County Stations
U.S.G.S. Stations
Source: Water Quality Management Plan for Palm Beach County (Draft)
N
WEST PALM BEACH (C-51) CANAL BASIN
J.W. CORBETT WILDLIFE REFUGE
W.P.B. WATER CATCHMENT AREA
CONSERVATION AREA NO. 1
ATLANTIC OCEAN
LAKE WORTH
PBIA
553
554
556
557
558
559
562
563
568
572
574
576
PB-584

2. & 3. Neither the County Land Use Plan nor the C-51 water management program appear to have the potential to create significant groundwater quality problems. Factors which may create such problems are outside the scope of the combined plan being considered herein.

4. One factor which can influence the quality of groundwater in the basin in a significant manner is the disposal of treated wastewater by percolation into the ground. A recent memorandum by Mr. S. A. Berkowitz, Chief, Bureau of Sanitary Engineering, Division of Health, Florida Department of Health and Rehabilitative Services, which included Dr. C. L. Brumback of the Palm Beach County Health Department as an addressee, states:

> "There has been considerable concern with respect to potable water supply quality in the South Florida area for some time due to the shallow waterbearing strata that is utilized as a source for public supplies in the area. The cause for concern was brought out very vividly by the recent typhoid outbreak and the resulting water resources study. The pollution control or environmental decision to require on-site disposal of effluent from wastewater treatment plants where connection to a municipal or county system is presently unavailable increases our concern manyfold.
>
> "Meetings have been held by me with selected and involved county sanitary engineers and members of my staff to review the potential health hazards of the above mentioned concerns. The various aspects of the problem were fully explored, and it was the consensus that the matter is critical to the point that steps must be taken to protect the public from these additional health hazards. Our discussions, it must be noted, were laid against the background of recent studies by the Division's Epidemiological Research Center with findings of virus particles in waste water treatment effluents after infiltration through sandy soils. Such findings magnify in our view the problem which may develop in the South Florida area.
>
> "It is therefore required that adequate treatment, including chemical preparation, filtration and chlorination shall be provided on all water supply installations in consonance with the requirements of Chapter 10D-4.02 of the Florida Administrative Code."

This is a factor which must be addressed by the regulatory agencies having appropriate jurisdiction. The above quotation is included herein as evidence that this potential problem is recognized by one of the State agencies having major responsibility in this regard.

WATER RESOURCES
(Conservation Areas)

Quantity

A. Surface Water

1. The three water conservation areas act as both water storage areas and as a floodway system for the conveyance of excess water from north to south within the Everglades Basin. They do not serve both purposes concurrently. Ordinarily the water storage function is dominant during the period November through July and the conveyance function in August through October.

Conservation Areas 1, 2 and 3 contain 221, 210, and 914 sq. mi., respectively. Areas 2 and 3 have been sub-divided into A & B pools. Pool 2A contains 173 sq. mi. and Pool 3A, 786 sq. mi.; 82% and 86% of the total areas of Conservation Areas 2 and 3, respectively. The north-south conveyance function in Areas 2 and 3 is limited to Pools 2A and 3A. Except in extraordinary high water conditions the water storage function in Areas 2 and 3 is also limited to Pools 2A and 3A. Under extreme high water conditions, however, Pools 2B and 3B are used for temporary detention of surplus flood waters which are routed into those pools from the main conveyance system.

The main pools of the water storage-floodway system are operated in accordance with a seasonal regulation schedule, or rule curve. These schedules are shown on Figure 12. The rule curve is a theoretical stage hydrograph. It does not necessarily represent a "desirable" condition which should be achieved at all times. More importantly, it should not be interpreted as representing a condition which can be achieved. The rule curve is simply an operating guide, basically for flood control purposes, which tells the manager when the system must be operated in the water storage mode and when it must be operated in the conveyance mode. Using the schedule for Conservation Area No. 1 as an example, it informs the manager that if stage is at 16.0 ft. msl. and rising on September 10, he should start conveying water downstream (that is, stop storing water in the pool). On the other hand, if stage is at 16.0 ft. msl. and rising on September 30, the manager knows that he can safely continue to store water in the pool.

The only exception to the "either-or" application of the rule curves with respect to storage-conveyance is the requirement for minimum water deliveries to Everglades National Park. Since 1969 it has been a requirement, by Congressional mandate, that minimum water deliveries be made to the Park in accordance with a specific monthly schedule. These deliveries are to be made regardless of whether or not the conservation areas are above or below the prescribed regulation schedule levels. Ordinarily, under present conditions, these requirements can be met from storage in the Conservation Area system. Occasionally, however, transfers must be made from storage in Lake Okeechobee. There are provisions for reducing deliveries to the Park under certain circumstances and in accordance with a specific formula. The formula is too complex to detail and is not particularly pertinent to this report and is included only to acknowledge the fact that water deliveries to the Park can be curtailed during water short periods.

Deliveries above the minimum amounts are, of course, made whenever water levels in Conservation Pool 3A are above the prescribed rule curve stages; these are the so-called regulatory discharges. Monthly discharges to the Park since July 1969 are shown in the following table together with the prescribed minimum deliveries.

Monthly Discharges to National Park (A.F.)

Mo.	Prescribed Minimum	1969	1970	1971	1972	1973
Jan.	22,000		126,300	22,600	24,350	28,380
Feb.	9,000		152,300	10,000	10,160	12,110
Mar.	4,000		182,500	4,160	4,150	5,450
Apr.	1,700		186,600	1,550	1,280	2,440
May	1,700		67,170	2,670	9,300	1,650
June	5,000		146,400	2,250	32,100	7,140
July	7,400	212,970	124,400	7,540	30,700	6,380
Aug.	12,200	195,030	67,630	11,550	16,200	
Sept.	39,000	181,750	24,530	30,900	41,800	
Oct.	67,000	193,510	68,890	51,830	55,150	
Nov.	59,000	269,060	56,010	58,450	48,040	
Dec.	32,000	218,180	37,780	36,460	35,940	

The water quantity effects of the water resources management plan for C-51, because of the backpumping feature, have the potential of being felt throughout the entire Everglades Basin; the Conservation Areas and Everglades National Park. More water will be introduced into that system. If downstream withdrawals from that system remain the same as they now are then, except for some reduction due to increases in evapotranspiration losses, on a long-term basis all of the additional water introduced will wind up flowing into and through Everglades National Park. This will not be the actual case, however, since it is logical to assume that demands on water in temporary storage in the Conservation Areas will increase with time. Therefore, it is difficult to project future water quantity conditions in the Everglades Basin, and evaluate impact, without making assumptions in regard to a demand-time function.

The extreme case condition can be examined and evaluated, however, without great difficulty. This is the case wherein the assumption is made that there will be no increase in downstream withdrawals from the Everglades Basin with time. Figures 13, 14, and 15 show sets of comparative stage hydrographs for Conservation Areas 1, 2, and 3, respectively. On each figure are shown the following for the period 1961 through 1970:

a. Actual historical stage hydrograph.

b. Computed stage hydrograph with maximum C-51 backpumping.

c. Computed stage hydrograph with minimum C-51 backpumping (first 1000 cfs released to the east).

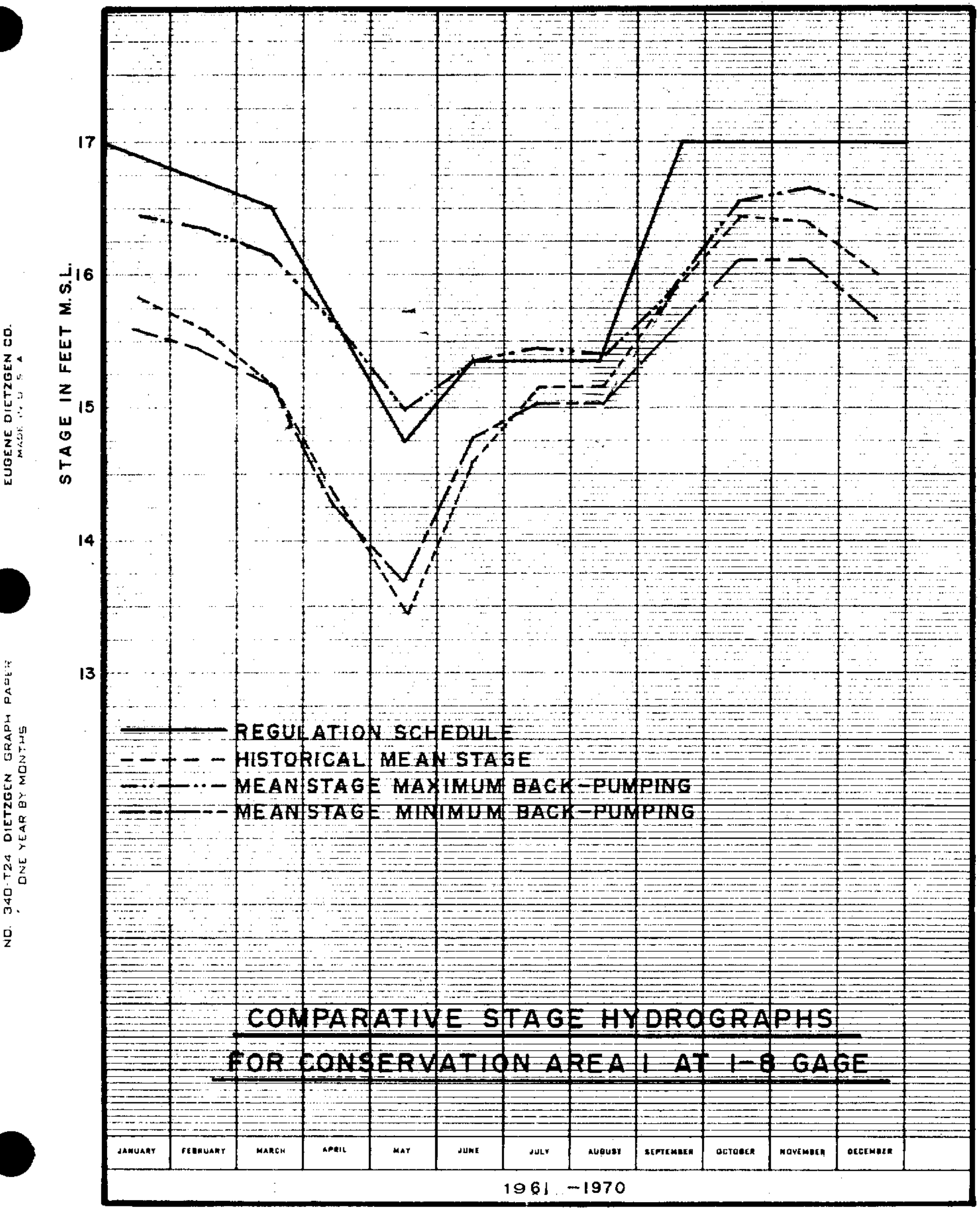
d. Present regulation schedule.

Quantity impact on the conservation areas is examined herein in terms of Conservation Area No. 1 as an example. Inflow to Conservation Area No. 1 has two components: direct rainfall on the area and surface water runoff from contributory areas. The surface water inflow component enters at two locations: the S-5A complex and Pumping Station 6. The S-5A complex inflow derives largely from the Agricultural Area, but also includes runoff from the L-8 area and to a much lesser extent runoff from the west end of the C-51 basin. For the same historical period as used for the stage hydrographs of Figures 13, 14, and 15, inflows from the above sources are listed in the following table:

Year	Direct Rainfall		Surface Inflow(A.F.)			Total Inflow A.F.	% Surface Inflow Total
	Inches	A.F.	S-5A	S-6	Total		
1961	40.67	479,400	104,200	43,150	147,350	626,750	23.5
1962	45.18	532,500	188,600	60,280	248,880	781,380	31.8
1963	44.64	526,200	117,200	61,590	178,790	704,990	25.4
1964	55.22	650,900	360,500	148,300	508,800	1,159,700	43.9
1965	48.43	570,800	342,200	153,200	495,400	1,066,200	46.5
1966	68.21	804,000	409,900	347,500	757,400	1,561,400	48.5
1967	45.39	535,000	123,100	130,000	253,100	788,100	32.1
1968	53.61	631,900	445,700	251,100	696,800	1,328,700	52.4
1969	55.96	659,600	360,700	297,700	658,400	1,318,000	50.0
1970	46.25	545,100	351,700	196,750	548,450	1,093,550	50.1
Total	503.56	5,935,400	2,803,800	1,689,570	4,493,370	10,428,770	
Avg.	50.36	593,540	280,380	168,957	449,337	1,042,877	43.1

The above tabulation indicates that on an annual basis direct rainfall is the major contributor to the total volume of water entering Conservation Area No. 1. For any specific event, however, the proportions can change.

Backpumping at C-51 will increase the surface water inflow component. The following table, for the same historical period, lists, again, the actual surface water inflows (from the previous table) together with computed inflows for the maximum and minimum backpumping operations:



STAGE IN FEET M.S.L.
17
16
15
14
13
REGULATION SCHEDULE
HISTORICAL MEAN STAGE
MEAN STAGE MAXIMUM BACK-PUMPING
MEAN STAGE MINIMUM BACK-PUMPING
COMPARATIVE STAGE HYDROGRAPHS
FOR CONSERVATION AREA 1 AT 1-8 GAGE
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
1961 -1970
EUGENE DIETZGEN CO.
NO. 340-T24 DIETZGEN GRAPH PAPER
ONE YEAR BY MONTHS

FIGURE 13

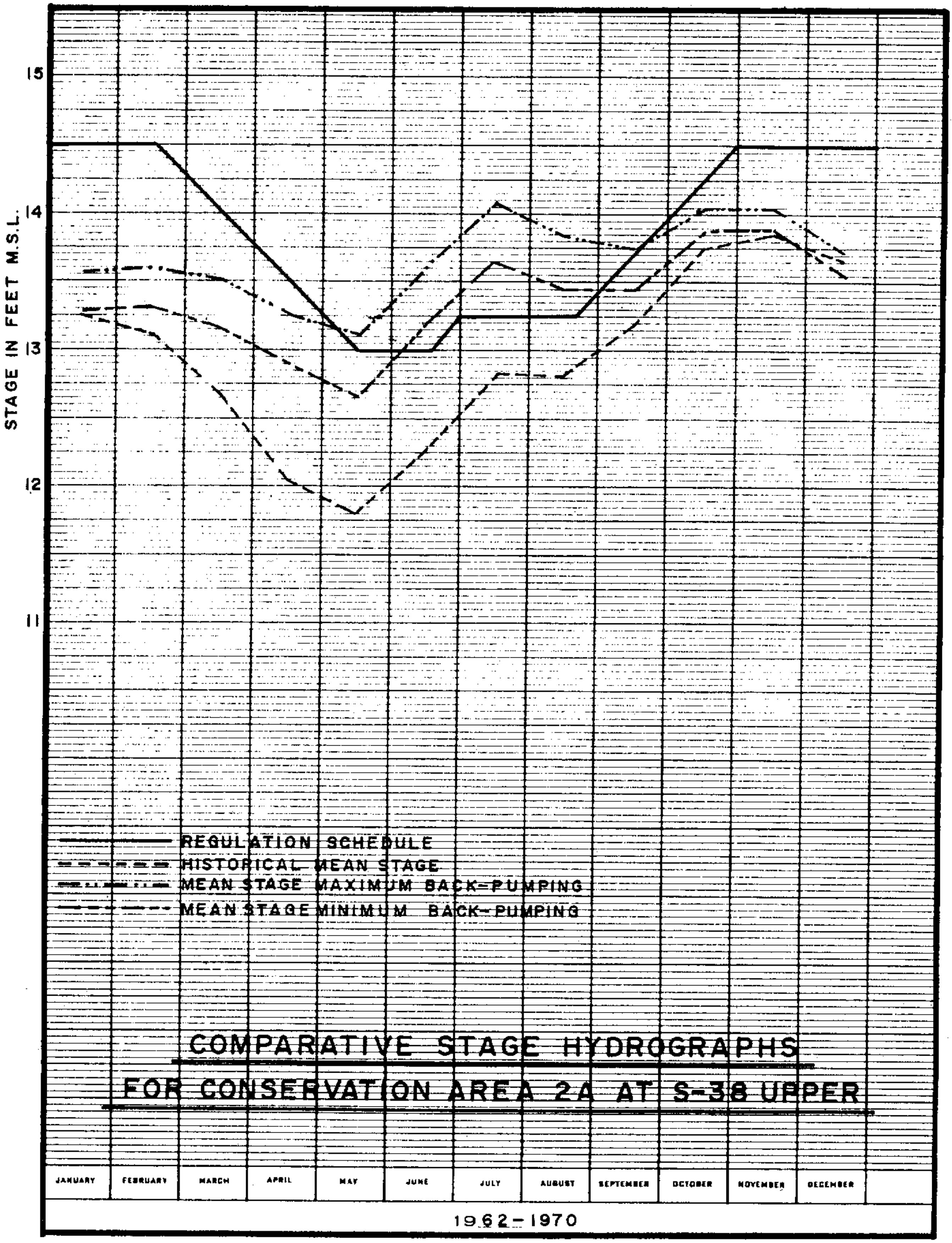
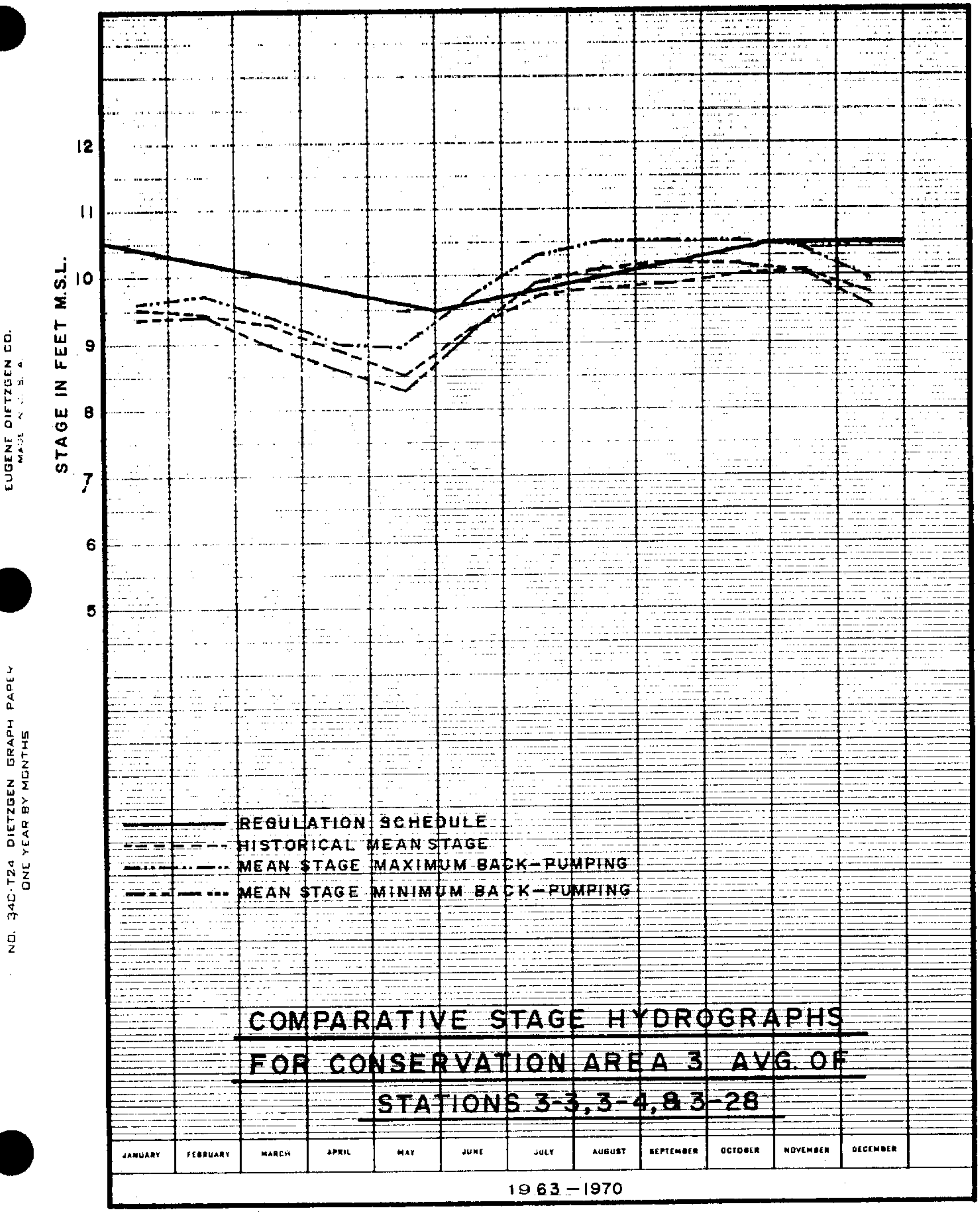

STAGE IN FEET M.S.L.
15
14
13
12
11
REGULATION SCHEDULE
HISTORICAL MEAN STAGE
MEAN STAGE MAXIMUM BACK-PUMPING
MEAN STAGE MINIMUM BACK-PUMPING
COMPARATIVE STAGE HYDROGRAPHS
FOR CONSERVATION AREA 2A AT S-38 UPPER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
1962-1970

FIGURE 14



STAGE IN FEET M.S.L.
12
11
10
9
8
7
6
5
REGULATION SCHEDULE
HISTORICAL MEAN STAGE
MEAN STAGE MAXIMUM BACK-PUMPING
MEAN STAGE MINIMUM BACK-PUMPING
COMPARATIVE STAGE HYDROGRAPHS
FOR CONSERVATION AREA 3 AVG. OF
STATIONS 3-3, 3-4, & 3-28
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
1963 – 1970
EUGENE DIETZGEN CO.
MADE IN U.S.A.
NO. 340-T24 DIETZGEN GRAPH PAPER
ONE YEAR BY MONTHS

FIGURE 15

Year	Historical Surface Inflow(A.F.)	Maximum Operation Additional Inflow(A.F.)	Maximum Operation % Incr.	Minimum Operation Additional Inflow(A.F.)	Minimum Operation % Incr.
1961	147,350	230,900	156.7	7,200	4.9
1962	248,880	236,000	94.8	2,500	1.0
1963	178,790	212,700	119.0	3,500	2.0
1964	508,800	338,700	66.6	31,190	6.1
1965	495,400	344,600	69.6	108,500	21.9
1966	757,400	519,200	68.6	173,000	22.8
1967	253,100	211,700	83.6	23,450	9.3
1968	696,800	477,000	68.4	326,500	46.8
1969	658,400	399,500	60.7	116,600	17.7
1970	548,450	447,600	81.6	131,300	23.9
Total	4,493,370	3,417,900		923,790	
Average	449,337	341,790	76.1	92,379	20.5

The additional quantities of water tabulated in columns 3 and 5 above represent the approximate limits of the amounts of water, now going to tidewater, which can be recovered under the water resources management plan. Between these limits the amounts of water to be recovered on an annual basis can be varied. These amounts of water reflect, in general fashion, the capabilities of the plan with respect to meeting additional regional demands on the surface water resource.

A degree of operational flexibility is present in the plan. For example, it is entirely possible to initially operate the system in the minimum backpumping mode. As downstream demands increase with time operations can be adjusted to increase backpumping volumes. Within such a framework of long-term operational strategy it would be possible, as well, to decrease or increase backpumping volumes (within system limits) to suit specific conditions of need.

2. It would perhaps be theoretically desirable to implement a water resources management plan having complete flexibility; that is, one which would permit the choice of "no backpumping" to be made at any time as an alterantive to backpumping at rates up to the design capability (5000 cfs) of S-319. Although the plan being evaluated herein has a degree of flexibility, the "no backpumping choice", or a choice even approaching that option, is not present.

The cost of providing complete flexibility is substantial and is estimated to approximate $14 million at 1972 price levels, an 80% increase in the public cost of implementing the present plan. Cost considerations aside, the lack of complete flexibility can nevertheless be considered to be an inadequacy of the plan. The extent to which this theoretical inadequacy is considered to be serious is dependent upon an evaluation of the consequences in relation to costs.

3. & 4. The consequences of the limited degree of operational flexibility in the plan with respect to surface water quantity impact on the Everglades Basin are most appropriately expressed in terms of the hydroperiod. Accordingly, this evaluation will be made in Section C, following.

Quantity

B. Groundwater

1. The three water conservation areas are underlain by water-bearing formations having varying hydraulic characteristics.

On the north, in Conservation Area No. 1 and westerly into the eastern portion of the Agricultural Area, the upper water-bearing formation is the Anastasia. This is the same formation which underlies the C-51 watershed and, in fact, nearly all of eastern Palm Beach County.

To the southwest in the western portion of Conservation Area No. 2, and the northwestern portion of Conservation Area No. 3, the upper formation, immediately below the surface organic soils, is the Fort Thompson Formation. Although this formation is the major component of the prolific Biscayne Aquifer of eastern Broward and Dade Counties, to the north it becomes increasingly less permeable. In the northerly portion of the Everglades Basin the Fort Thompson Formation grades on the east into the Anastasia Formation, from which the domestic supplies of most of the municipalities of eastern Palm Beach County are taken.

To the south and southeast, in the eastern portion of Conservation Area No. 2 and in southern and eastern Conservation Area No. 3, the upper formation of the Biscayne Aquifer is the Miami Oölite which, in turn, is underlain by the Fort Thompson Formation. This is the same sequence of formations which extend eastward and underlie eastern Broward County and all of Dade County.

Groundwater gradients are generally to the east and southeast; that is, from the general area of the conservation areas toward the east and southeast coasts. It is quite probable, however, that groundwater flow also takes place to the south. There is, then, a general flow of groundwater towards the urban coast; rates and volumes of flow dependent on water depths in the conservation areas.

Since the highly permeable Biscayne Aquifer is continuous under the Conservation Area No. 2 and No. 3 east levees, excessive seepage to the east with high stages in the conservation pools was initially a matter of some concern. This condition was mitigated by the construction of the interior levees which divided these two areas into the A and B pools.

The Anastasia Formation is less permeable than the Biscayne. Consequently, eastward seepage from Conservation Area No. 1 has not presented significant problems except under high stage conditions in Area No. 1 (17.5 ft. msl. and above).

In terms of protection of the aquifers to the east it is desirable to maintain the general west to east and southeast groundwater gradient. This hydrostatic head is developed as a result of maintaining seasonal surface water storage in the conservation areas. The plan being reviewed herein, to the extent it returns additional volumes of water to the Everglades Basin, will serve to maintain the general west to east and southeast groundwater gradient.

2. The plan has no identifiable inadequacies with respect to protecting and maintaining the integrity of the shallow aquifer underlying the conservation areas and maintaining the present west to east and southeast groundwater gradient.

WATER RESOURCES
(Conservation Areas)

Quantity

C. Hydroperiod

1. No information of substantitive nature is available as to historical natural water elevations in the Everglades Basin. At best only descriptive, somewhat subjective, information is available. Moreover, water level data from even the more recent past is scarce.

Generalized qualitative estimates can be made as to whether or not there was "more" or "less" water within the Everglades Basin during one period as compared with another through use and analysis of observed hydrological data other than stage data within the basin itself. This was most successfully done by Leach, Klein and Hampton in U.S.G.S. Open-File Report No. 60, entitled "Hydrologic Effects of Water Control and Management of Southeastern Florida," dated 1972. By examination of long term discharge records of the West Palm Beach, Hillsboro, North New River and Miami Canals the authors concluded that since 1963 approximately 25% more water was being retained within the Everglades Basin in comparison with the previous 20 years.

Qualitative estimates of changes of the "more or less" type can also be made through observation and documentation of vegetative changes. Examination of aerial photography has indicated that a condition of the system getting "dryer" developed in the period between the 1940's and the early 1960's. More recent observations of vegetative changes by the District indicate a "wetter" condition developing in Pool 2A since 1963. These latter observations tend to confirm the conclusions reached by Leach, Klein and Hampton.

Because of the lack of historical stage data it is not possible to discuss hydroperiods in terms of specific water levels when comparing present conditions with natural conditions. However, certain general observations can be made in the broader sense of the term "hydroperiod."

In Section A, above, the comparative influences of direct rainfall and surface inflow on water quantities entering Conservation Area 1, and hence water levels, was indicated. Other analyses made by the District (see report entitled "Some Aspects of the Hydrology of Conservation Area No. 3", dated 1971) and for the District (see J. P. Heaney and W. C. Huber report entitled "Hydrologic Reconnaissance of Conservation Areas 1, 2 & 3," dated June 1971) indicate that water levels in Conservation Area No. 3A respond strongly to rainfall. The latter report indicates a strong response of water levels to rainfall in Conservation Area No. 2A, but also a high degree of sensitivity to inflows from Conservation Area No. 1.

Under natural conditions, therefore, it can be safely assumed that water levels in the Everglades Basin were as sensitive to rainfall intensities, durations and distribution as they are now. Then, as now, the seasonal hydroperiod was fundamentally a reflection of the region's rainfall patterns. Superimposed on this were the periodic extremes of flood and drought, caused by cyclical meteorological factors.

Figures 26, 27, and 28 show the historical stage hydrographs for the three conservation areas for the period 1961 through 1970. These reflect both the seasonal and cyclical water level fluctuations. There is no reason to assume that the natural system did not evidence a very similar pattern of fluctuation. Natural water levels may have been somewhat higher or lower than those shown, but the general pattern was undoubtedly the same.

On a smaller time scale it is quite probable that the natural hydrographs differed in shape from those which now obtain. Under present conditions surface water inflow enters the Basin comparatively rapidly. Although on the rising side the natural and present hydrographs would look about the same due to the generally dominating influence of direct rainfall, the recession side under natural conditions would probably have been extended because of the slower rate of surface water inflow.

The above general observations are made in order to indicate that as long as the Everglades Basin, as represented by the Conservation Areas, remains under public ownership and public management for its intended purposes it will always support a wetlands environment of some type. This conclusion naturally follows from consideration of the morphology and topography of the basin, and from recognition of the influential, if not dominating, role played direct rainfall in determining the hydroperiod, or stage regime, of the basin.

Consequently, man's activities in regard to altering water quantities (surface inflow amounts) is properly considered only in terms of what type of wetlands environment may result from these alterations. The water resources management plan for C-51 will add more water to the basin, thus presumably, making it "wetter." Estimated quantities of added water on an annual basis were given in Section A, above, for Conservation Area No. 1. The environmental effect can be better assessed by examination of stage hydrographs.

For this analysis the following conditions were considered, and for the historical period 1961 through 1970:

a. Maximum backpumping at C-51, and

b. Minimum backpumping at C-51.

Stage hydrographs for these two conditions were developed and are plotted on Figures 29, A through J; Figures 30, A through I; and Figures 31, A through H. On these figures condition "a" is entitled "First 1000 cfs Released to East Coast: and condition "b" is entitled "No Release to East Coast." Also plotted on these figures for comparative purposes is a simulated hydrograph with no C-51 backpumping, entitled "No Backpumping." This latter is the actual historical hydrograph adjusted for changes which have been made over the period in question in regulation schedules and water delivery schedules for Everglades National Park. These adjustments were made in order to have a directly comparable basis for evaluation.

The same stage hydrographs, on a monthly basis, are shown on Figures 26, 27 and 28.

The hydrographs for Conservation Area No. 1 for the period 1961-1970 indicate that much closer water control can be effected. The pool could, for all practical purposes, be managed to very nearly approximate the present seasonal regulation schedule. However, the difference between the amount of water available to be backpumped and that which of necessity must be backpumped allows for some degree of choice in the management of the water levels in the pool. This same general statement applies to Conservation Area No. 2A.

Backpumping the maximum amount of water from the C-51 basin will apply a standard of water regulation in both Conservation Area No. 1 and Conservation Area No. 2 heretofore unattainable. Near perfect water regulation as related to present regulation schedules will result in many years. Backpumping somewhat less than the maximum amount of water available leaves some degree of flexibility to operate the pools at lower stages (similar to the past ten year period of record) if lower water conditions are desired.

In this regard it is significant to note the effects of backpumping flexibility in the cases of the high stage conditions which occurred in Conservation Area No. 2A in July 1966, July 1968, and March 1970. Minimum backpumping results in stages equivalent to simulated actual stages whereas maximum backpumping results in peak stages 0.3 ft. to 0.5 ft. higher. The same is true with respect to peak stages in Conservation Area No. 3 in the same years.

Under a maximum backpumping plan of operation Conservation Area No. 3 would experience extended high water periods of significant magnitude. Here, again, however, a rather large range of options for water level management will be available as reflected by the stage hydrographs for Area No. 3.

It should be remembered that these simulated hydrographs reflect the historical level of demand on water in the conservation areas. As demands increase with time, stages in the conservation areas will accordingly be influenced.

The analysis of these hydrographs shows that the seasonal character of the present, and former natural, hydroperiod will be maintained under either backpumping regime. Although extreme lows, in some instances, would be moderated by maximum backpumping it appears that if such conditions are periodically desirable they could be produced by changing the backpumping strategy. It appears, also, that changing the operational regime would also tend to moderate the possible adverse effects of maximum backpumping during high water periods in the conservation areas.

2. The ecology of the conservation areas is not specifically dependent upon water backpumped from the C-51 watershed. There is, however, probably some degree of dependence on backpumped water in general when it is recognized that much of the area formerly contributing water at certain times to what is now the conservation areas (the agricultural area south of Lake Okeechobee) is now hydraulically separated from the system except at pumping stations 5A, 6, 7 and 8. The analogy to the relationship between the conservation areas and Everglades National Park is apparent, since the Park Service has stressed the importance of surface inflow and the Congress has recognized it by mandating a specific delivery schedule.

This assessment of some degree of dependence upon backpumped water is in the nature of a qualitative, not quantitative, judgment. The data presented in the table on page 36 of this report which shows surface water inflows to Conservation Area No. 1 ranging from 23% to 50% of the total inflow indicates the general validity of this assessment particularly when coupled with our finding that Conservation Area No. 1 represents a typical, viable Everglades marsh system.

The ramifications of introducing more water into the conservation areas are not quite clear. Although some portions of these areas can probably withstand more inundation than has been the case in the past ten years, it should be recognized that occasional drying may be necessary. The plan being considered satisfactorily addressses this question by providing a degree of flexibility offering a rather wide range of options in terms of water wolumes which can be introduced into the system. A much wider range of options is, of course, possible. But, as noted on page 37 of this report, the consequences of failure to provide this flexibility are not serious enough to warrant the public expenditure involved.

3. The backpumping of water from the C-51 watershed in terms of quantity and hydroperiod is of no consequence to the conservation area system other than the manner in which it is handled once it gets there. The manner of handling involves "retention (storage)" and "conveyance", as described on page 34 of this report. These, in turn, are dependent on regulation schedules and the physical (structural) capability to transfer water from pool to pool and to Everglades National Park.

These two factors are not specifically related to the C-51 water resources management plan. They are, however, correlative factors in the context of the regional water management system as represented by the Central and Southern Florida Project. Within that framework the mechanisms are already available to analyze and positively address these factors.

The means are available, and have been since the inception of the Project, for continual review and evaluation of regulation schedules and for their modification when mutually agreed upon by all concerned parties. The regulation schedules for Areas 1 and 2 have been modified by this means several times in the past ten years. The parties to these modifications are the Corps of Engineers and Flood Control District, and the U. S. Fish & Wildlife Service, the Game & Fresh Water Fish Commission, and the National Park Service as their respective interests may be involved.

Any of the above interested parties may initiate the request for review, evaluation and modification. Congress has specifically given the Corps of Engineers the responsibility for regulation of the conservation areas for flood control purposes. The Congressional authorization rests the final responsibility for decisions on regulation schedules and their modification with the Secretary of the Army. Despite the fact that final authority rests with a Federal officer, coordination and cooperation on these matters has in the past been excellent. There is no basis for belief that it will not so continue. There is no reason for tampering with the existing mechanism for effecting regulation schedule modifications. It may, in fact, be impossible to do so.

In the matter of water transfer capability, this factor is under continuous surveillance by both the Corps of Engineers and the Flood Control District. Of particular importance in this regard is the transfer capability from Conservation Area No. 3 to Everglades National Park. One plan for some improvement here was proposed several years ago but was rejected by the National Park Service.

4. The above two factors not being specifically related to the C-51 plan, no recommendations in regard to them are being made herein. The normal, established procedures based on the Project relationship between the Corps of Engineers and the Flood Control District will be followed to address these matters. They will have to be addressed whether or not the C-51 plan is implemented, and the implementation of that plan does not substantially add to, or detract from, the need to do so.

WATER RESOURCES
(Conservation Areas)

QUALITY

A. Surface Water

1. Conservation Area No. 1 is separated into two distinct water quality entities; the canal system and the marsh. Water samples from the marsh indicate pristine conditions, while samples from the canals indicate strong signs of degradation. The District's observations in regard to the good quality of the water resident in the marsh itself and the seasonally poor quality of the water in the perimeter canals are confirmed by data collected by the U. S. Geological Survey. The District's investigations into the marsh ecology of Conservation Area No. 1 indicate that it is a typical, viable Everglades system. We have found nothing to indicate that the past 19 years of pumping at S-5A has done any environmental damage to the marsh.

However, the canals of Conservation Area No. 1 are directly affected by input from S-5A, S-6 and several private pumps. The water quality of the canals varies with the season. At the end of the dry season in May 1973, the dissolved oxygen content of surface water was 6.8 $\pm$ 1.8 ppm in the canals. Specific conductivity was high but variable. Total PO_4 and Ortho-PO_4 as P was .05 ppm and .004 ppm respectively. The Nitrogen levels were: TKN 2.74 ppm, NH_3 0.16 ppm, NO_3 0.167 ppm and NO_2 0.014 ppm.

These values are contrasted with those at the beginning of the rainy season. July samples contained only 2.5 $\pm$ 1.3 ppm dissolved oxygen. The specific conductivity was elevated, indicating higher dissolved solids. The total PO_4-P was 0.31 ppm and Ortho-PO_4-P 0.29 ppm. The nitrogen forms were similarly elevated.

Tracing of chlorides (a conservative parameter) indicates canal values ranging from 83 ppm to 376 ppm. Marsh values range from 11 ppm to 64 ppm. The highest marsh values are near the canals. These findings of the District are confirmed by the U. S. Geological Survey data which indicates the influence of canal water is limited to a comparatively narrow band adjacent to the perimeter canals.

Conservation Area No. 2A is showing signs of environmental stress. Two variables are presently working on the Conservation Area No. 2A Everglades environment; generally elevated water levels and nutrient enrichment from the canal system of Conservation Area No. 1.

Sufficient background information has been collected to indicate: (1) large increases in phosphorus content in sawgrass tissue below the S-10 spillways which discharge water from Area 1 to Area 2A; (2) loss of two formerly dominant plants (Rhynchospora tracyi and Panicum hemotomen) over about 75% of the area since 1958; (3) replacement of these plants by white water lily and bladderwort; (4) an increase in depth of flocculant organic sediments causing (a) fish kills during low water and (b) loss of white water lily in the centers of the sloughs and sawgrass around the edges of sloughs.

Several studies are currently underway to weigh these variables (elevated water levels and nutrient enrichment) in order to determine their relative contribution to the ecological changes which have been observed in Conservation Area No. 2A. A short term study of water draw-down in Conservation Area No. 2 is in progress to determine whether or not such action can provide a remedy to deteriorating marsh conditions.

The water in the marsh of Conservation Area No. 3 is of a pristine condition, being derived primarily from direct rainfall over the area. This Conservation Area has been described by one of the District's chemists as "being covered with distilled water."

A condition of degradation is found in the canal system similar to, but not as severe, as found in Conservation Area No. 1.

The S-9 and S-8 pumping stations are known to contribute water of a lesser quality than that found in the marsh.

Changes in water quality in Conservation Area No. 3 as a result of backpumping S-9 include a sharp reduction in dissolved oxygen, an increase in ammonia and decrease in nitrate. The decrease in dissolved oxygen and increase in ammonia are attributed to water quality conditions in the South New River Canal from which the water is pumped. Concentrations of dissolved oxygen are low in the canal, probably because the canal is replenished mainly from groundwater which has little oxygen. Ammonia tends to be in high concentrations in water with low dissolved oxygen.*

Data from the Miami Canal at pumping station S-8 compared with data from the Miami Canal at Alligator Alley indicates that water quality is vastly improved as it passes through the Conservation Area.

2. Evaluation of the information available with respect to: (a) present water quality in the western portion of C-51, (b) present water quality in the eastern portion of C-51 in relation to urbanization, and (c) present water quality conditions in the conservation areas indicates that:

(1) The potential exists for a degradation of water quality in the western portion of C-51 with time; and

(2) This, in turn, could result in undesirable changes in the environment of the conservation areas.

As indicated in the discussion immediately above with respect to the changes which have been observed in Conservation Area No. 2A, there are two factors which are operative: elevated water levels and nutrient enrichment. The relative contributions of these two factors to the changes

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*Earle, J. E., B. F. McPherson, and H. C. Mattraw. 1973. Water Quality Monitoring and Study of the Everglades Basin, Florida. Progress Report for the Period Ending April, 1973. Prepared by the U. S. Geological Survey in Cooperation with the U. S. Army Corps of Engineers.

observed in Area 2A is at present undetermined. Nevertheless, the nature of the vegetative changes which have been observed strongly indicates that depth and duration of flooding is the dominant factor rather than input water quality.

Assuming, however, that nutrient enrichment plays some part in effecting environmental changes, those changes would be ultimately expressed in such terms as fish and wildlife habitat alteration, environmental "quality" (aesthetics) and water quality for municipal supply (raw water source or groundwater recharge).

On pages 24-26 of this report is was indicated that the combined plan being evaluated herein could not rationally be considered the cause of potential degradation of the water quality in the western reach of C-51. However, the water resources management element of the combined plan would be a causative factor in the potential degradation of water quality (and consequent environmental changes, if any) in the conservation area; this being due, of course, to the backpumping feature of that plan.

As noted on pages 24-26, the combined plan for the C-51 watershed does not address water quality considerations either in terms of the impact on C-51 itself or the impact on the conservation areas.

3. If reasonable water quality control measures within the C-51 watershed are not taken it is quite likely that any consequences of failure to do so would be expressed in terms of nutrient enrichment. It is also quite likely that the brunt of any such adverse impact will continue to be borne by Conservation Area No. 2A.

Under the C-51 water resource management plan the major portion of backpumped inflows will continue to be moved southward through the interior perimeter canal system of Conservation Area No. 1 rather than through the marsh. There may be some small increase, at times, in the volume of water flowing across the Area 1 marsh. This, however, will not result in degradation of either water or environmental quality in the Area 1 marsh system.

Accordingly, Conservation Area No. 2A will continue to receive the poorer quality of water delivered by the Area 1 canal system. This additional volume of water will continue, largely, to be spread over the interior marsh as it is now.

There is a limited potential for some adverse impact in Conservation Area No. 3. The degree of such impact would be dependent (if no water quality control measures are taken) on the extent to which Conservation Area No. 2A could assimilate the additional nutrient loads entering from Area No. 1. Any such impact would be minimal and would be limited to that small portion of the marsh influenced by S-11 discharges, and which goes dry seasonally, and to the interior canal system. It is believed that Area No. 3A will continue to function, as it does now, to improve the quality of water as it moves from north to south through that portion of the system.

On the assumption, as noted above, that poor water quality, in terms of nutrient load has contributed to some limited degree to the affects observed in Conservation Area No. 2A, it can be concluded that the consequences of failure to address quality control in the C-51 watershed would be expressed principally in terms of loss of environmental "quality" and the deleterious effect of such loss on fishery, Wildlife and recreational values. In terms of water supplies for consumptive use water quality deterioration in terms of nutrient enrichment to the degree indicated would not preclude the use of this water for containment of salt water encroachment into the coastal aquifers, for shallow groundwater recharge, or even for raw water supply.

4. In regard to the regulation of water quality in the western portion of C-51 itself, a recommendation has been made on pages 26 and 27 of this report.

It has also been stated herein, on page 9 and elsewhere, that some degree of flexibility exists in the plan in regard to the quantities of water which can be backpumped to the conservation area system. The general range of the options available are indicated on the hydrographs of Figures 13, 14 and 15. Nutrient loads can, of course, be related to water volumes. The range of available water volume options under the plan therefore also reflects nutrient loading ranges. Operational decisions, within system limits, can consequently be made based on water quality considerations as well as quantity considerations.

Accordingly, it is recommended that a water quality monitoring system be incorporated in the plan. It is further recommended that this be a telemetered system to provide continuous data on specific conductance, dissolved oxygen, pH, temperature, nitrate and phosphate. At least two such stations should be provided; one in the L-8 canal north of S.R. #80 and one in C-51, approximately 1/2 mile east of Twenty Mile Bend. An additional station west of S-5A for monitoring S-5A inflows should be considered.

Finally, it is recommended that a study be undertaken immediately to determine time-quality relationships for storm events producing flows in C-51 past S.R. #7 and in the L-8 canal entering Conservation Area No. 1. Such a study will be of assistance in developing operational guidelines for balancing water quality and water quantity considerations to produce maximum beneficial results.

Quality

B. Groundwater

1. An earlier section on groundwater quality within the C-51 watershed itself indicated the factors which can affect water quality. Similar factors affect the quality of the water stored, or in transit, in the shallow aquifers underlying the conservation areas.

Available data indicate a poorer quality of water in terms of total dissolved solids, chlorides, iron and hardness in the aquifer in the areas south of Lake Okeechobee. The pattern of generally poorer quality groundwater from east to west in the C-51 basin apparently continues across Conservation Area No. 1 into the agricultural area south of Lake Okeechobee.

Sparse data indicates that water in the shallow aquifer underlying Conservation Areas 2 and 3 is also somewhat poorer in quality than that in the aquifer below the coastal ridge in Broward and Dade Counties. Again, this is related primarily to higher dissolved solids concentrations and total hardness. The extent of the reduction in quality from east to west is probably not as great in the southern portion of the Everglades basin than in the north.

2. The plan being considered herein will not have the potential for adversely affecting water quality in the shallow aquifers underlying the conservation areas.

WATER RESOURCES
(Lake Worth)

Quantity

A. Surface Water

1. The rise and fall of the sea during the great Ice Age is responsible for the geologic and topographic formation of south Florida. For the purpose of this study it is necessary to describe central Palm Beach County and Lake Worth at the time of statehood just prior to the settlement of the area by the white man.

A series of barrier reefs built from the Anastasia Formation lined the eastern edge of Palm Beach County. Immediately to the west of this barrier was Lake Worth, which was predominantly fresh water. At times of extreme high fresh water or extreme Atlantic high tides and wave actions, the ridge formation was breached and there would exist for a short period of time a natural inlet. These inlets were very unstable and would silt up quickly and revert back to the existing condition. Immediately west of Lake Worth was a sand ridge which completely separated Lake Worth from the interior of Palm Beach County. This ridge was continuous without break between the Hillsborough and Loxahatchee Rivers. This sand barrier between Lake Worth and mainland Palm Beach County came closest to and was thinnest at the extreme north end of Lake Worth, measuring only a few hundred yards in width at that point. Lake Worth, then, as a fresh water body, had a relatively small drainage area bounded on the east side by a ridge which is now occupied by the Town of Palm Beach and on the west by the continuous sand ridge extending the length of Palm Beach County. During extreme high water conditions to the west of the sand ridge, there was seepage through the ground emerging as springs on the western shores of Lake Worth.

The interior of the county was described by the occasional explorer as a wilderness of water, forest, prairie and marsh land. There were four large lakes lying immediately west of the sand ridge which are today much reduced in size and named Mangonia, Clear, Osborne and Ida. The area to the west of these lakes which make up part of the C-51 watershed under consideration in this report, was a belt of poorly drained sandy flat lands, most of which was inundated during wet years and parched during dry years.

A long saw grass slough system beginning around Jupiter proceeded south immediately west of the sand ridge, included the natural lakes already mentioned and then cut to the west into an area which is now occupied by Conservation Area #1. This drainage pattern is obvious on the soils maps of Figure 16. This saw grass slough route was open to small boats from Jupiter south to the narrow sand ridge described earlier at the north end of Lake Worth.

This was generally the condition of Palm Beach County when the first settlers, other than those occupants of the lighthouse at Jupiter, moved to Palm Beach County and built on the ridge which is now the Town of Palm Beach. The first white residents, Mr. Lang and his wife, had migrated to Palm Beach to escape service during the Civil War. Mr. Lang's activities included cutting a narrow trench through the beach barrier ridge permitting the waters of Lake Worth, which stood well above sea level to rush through, cutting an inlet and lowering Lake Worth to sea level. This artificial inlet suffered the same consequences as the natural inlets that had opened up in the past; it quickly silted up and closed. By the early 1870's additional families had moved to Palm Beach County and were settling on the islands of Lake Worth and Hypoluxo; and by the late 1870's, after re-digging the small original inlet of Mr. Lang, a community activity was undertaken by the settlers to dig a deeper, wider, more permanent inlet connecting Lake Worth to the sea. This second attempt was located north of the original inlet and cut through a ridge which stood at about 25 feet above sea level and was protected by an outcrop of rock which had exposed itself on the shore of the Atlantic. This effort proved much more stable than the previous one and remained open for several years.

This effort of inlet construction in 1877 proved to have a very rapid effect on the conversion of Lake Worth from a fresh to a salt water environment. This conversion had mixed blessings. Fishing was great; however, the tidal actions and the lowering of the water in Lake Worth caused shoaling and the build-up of organic muds on the bottom of the lake. This action was to become the first of a series of man-caused alterations to the surface waters of Palm Beach County. Before the turn of the century, the East Coast Canal Company dredges were working on a route connecting Jupiter Inlet through the saw grass route and connecting to the north end of Lake Worth. This canal, now the Intercoastal Waterway, was dug primarily for navigation purposes; however, it had a significant effect on water which had previously flowed from the interior portions of Palm Beach County north to the Jupiter Inlet. This canal was the first breach in the sand ridge and further added to the interior fresh water drainage tributaries to Lake Worth and the build up of organic materials covering the bottom of that lake. In the early 1900's the waterway was completed from the south end of Lake Worth to Biscayne Bay.

Attempts were made at controlling Lake Okeechobee by Disston in the late 1800's. No signifieant work was done, however, until the establishment of the Everglades Drainage District in 1907. The District began work on levee and canal construction to allow farming in the Everglades region around Lake Okeechobee. The District constructed five major drainage canals from Lake Okeechobee to tidewater. They were the St. Lucie, the West Palm Beach (C-51), the Hillsboro, the North New River and Miami Canals. Each of these canals provided a drainage outlet for the waters of the interior plus navigational routes from the east coast to the glades area. The West Palm Beach Canal, as all other canals under the EDD plan, was provided with two water control structures; one at the shore of Lake Okeechobee and the other near the east coast between the connection of fresh and salt water. The West Palm Beach Canal was completed by the EDD in 1925 and functioned as a combination drainage-transportation route to the glades.

The cyclic wet and dry years in the basin were too much for the system to handle. The earliest records available from the EDD operation of the West Palm Beach Canal show an attempt to pull water levels down during the wet season to approximately 3 1/2 feet above mean sea level and hold the canal elevation during the dry season at approximately 8 feet above mean sea level. The net effect of the severe drawdown during the wet season on a canal of this length was the lowering of groundwater levels in the eastern portion of the West Palm Beach Canal. Tailwater readings at the structure at Lake Okeechobee during this same period, seldom receded below 12 1/2 feet mean sea level. This operation lasted approximately 30 years.

During the same period of time that the West Palm Beach Canal was under construction, another significant alteration to the interior of Palm Beach County took place. Part of the natural slough system which fed the Loxahatchee River and the Jupiter Inlet was impounded and diverted east by the creation of the West Palm Beach water catchment area. Flow in this marsh system was diverted east into Clear and Mangonia Lakes to serve as a water supply for the cities of West Palm Beach and Palm Beach.

This is generally the system that prevailed between 1930 and 1949 at the time of the establishment of the Flood Control District when the canals of the EDD were inherited as part of the works of the FCD. The early construction and operation of the West Palm Beach Canal had an obvious affect on the urbanization pattern of Palm Beach County. Prior to the construction of these canals, settlement was primarily on the island of Palm Beach and along the sand ridge that stood high and dry immediately west of Lake Worth. Construction of the drainage system for the interior portion of Palm Beach County provided by the West Palm Beach Canal and the works of the Lake Worth Drainage District allowed urbanization and agriculture to spread west in the area.

Immediately after World War II, the economy of Palm Beach County boomed and additional pressures were being put on surface waters of Palm Beach County, including Lake Worth. In 1950 the only sewage disposal system was one which had been left over by a deactivated military installation at Morrison Field in West Palm Beach. The entire urban development at that period of time was discharging raw sewage directly into the waters of Lake Worth or through septic tanks into the ground waters. In the early 1950's a peak of 10 MGD of raw sewage was being discharged directly into the waters of Lake Worth. During this same period the cost of waterfront real estate had increased significantly, and dredge, fill and bulkhead operations were common around the entire shore of Lake Worth. The cumulative effect of interior drainage, urban runoff and sewage disposal into the waters of Lake Worth reached its peak in the early 1950's.

Between 1950 and this date several significant steps have been taken to improve Lake Worth as a system. The development of urban sewage treatment collection and treatment systems has removed, in part, that threat to the waters of Lake Worth. More recently, the prohibition of dredge and fill, and bulkhead operations around the shore have slowed the pace of that source of degradation.

The most significant change in this pattern was afforded by the establishment of the Conservation Areas, and the resultant diversion of waters from the west half of the West Palm Beach Canal basin through S-5A into Conservation Area I in 1954. The reduction in these flows is shown on page 6 of this report.

Lake Worth has been the subject of a number of studies and the reduction of fresh water discharge into Lake Worth has always been one of the goals in any proposal for remedial action. The water resource management element of the plan being examined herein will have the affect of reducing the average annual volume of fresh water discharge to Lake Worth. The following table lists pertinent data in this regard:

Period	Average Annual Discharge (A.F.)	% Reduction
1940 through 1954	776,000	-
1955 through 1971	462,000	40%
*Minimum Backpumping	390,000	50%
*Maximum Backpumping	96,000	87%

*Based on actual flows for period 1961-1970.

As indicated earlier there is a degree of flexibility provided in the water management plan. The range of options is reflected by the maximum and minimum backpumping discharges in the above table. With minimum backpumping a reduction in present discharge volumes of about 16% can be obtained; with maximum backpumping the reduction in terms of present volumes would approximate 80%.

2. It is obvious from the historical background presented above that the entire social and economic fabric of this portion of Palm Beach County is closely and inextricably linked with the change of Lake Worth from its natural condition as a fresh water body. There is no possibility of returning it to that condition.

A desirable objective, however, is to reverse the past trend of degradation of Lake Worth in terms of what it now is. If that reversal can to some degree be accomplished by reducing fresh water discharges into the lake from C-51, then the plan being examined herein satisfactorily addresses that consideration. It will have no adverse consequences on the hydrology of Lake Worth while at the same time has the potential for beneficial consequences.

Quality

A. Surface Water

1. Lake Worth begins approximately one-half mile north of the Earman River (C-17) and extends south for 20 miles to the Boynton Canal (C-16). The physical structure of the lake has been modified extensively during the past fifty years to increase flow of water into the lake and access to the intracoastal waterway. Canals 16, 17 and 51 were constructed in the early 1920's. An inlet was opened at the north end of Lake Worth in 1877, and a second inlet, at the south end, was constructed during the 1920's. These changes have decreased the stability of the lake ecosystem and have permitted the invasion of marine organisms.

The water quality of Lake Worth has been in a state of decline for many years. The bottom of the lake in many areas is covered with organic sediments, mud, and soft sand, which support little or no life. The water is dark brown in color, carries a heavy load of suspended materials, and is constantly impacted by sewage discharge and runoff from the surrounding communities. In addition to the C-51, C-16 and C-17 canals, West Palm Beach and Boynton Beach have sewage treatment plants that discharge directly into the lake.

Flow contributions from C-51 to Lake Worth have been detailed on page 6 of this report. C-51 water quality information has been given on pages 21 through 31. Currently, discharge from the C-51 canal is about 480,000 acre feet per year, which constitutes the largest source of fresh water in Lake Worth, and the second largest source of pollution. The discharge of degraded water and/or excessive amounts of fresh water from C-51 has been implicated in several fish kills in the Lake Worth area in the past.[1]

The ecology of Lake Worth was investigated in 1969-70 under a research grant from the Environmental Protection Agency. Water samples were taken at stations in the lake and analyzed for various chemical parameters. Some of the results of this investigation have been published.[2]

Water from C-51 comprised 72% of the total fresh water discharge into Lake Worth, as indicated in the following table:

Source	Discharge (CFS)	B.O.D. (mg/l)	(lb/day)
C-17	88.6	3.48	1162
C-51	645.0	1.90	6603
C-16	93.0	2.25	1127
West Palm Beach STP	20.3	61.46	6715
Boynton STP	2.8	15.87	237
Surface Runoff	46.5	9.72	2433
Total	896.2		18777

[1]Berry, James. Palm Beach County Health Department; personal communication.
[2]Draft Report: "Interim Water Quality Management Plan for Palm Beach County", prepared by William M. Bishop, Consulting Engineer, and Area Planning Board of Palm Beach County, February 9, 1973, Vol. 1.

Water from C-51 had a relatively low Biological Oxygen Demand (BOD) level (1.90 mg/l), but because of the large discharge volume, C-51 accounted for 32% of the BOD load in the estuary. Chloride levels (Fig. 1b at the end of this section) were less than 20,000 ppm (normal seawater) for 15 miles of Lake Worth in the vicinity of C-51. Chloride levels approached 20,000 ppm at Boynton and Lake Worth Inlets, and reached a minimum of 8,000 to 10,000 ppm at the C-51 outlet. Discharge from the canal averaged 997 cfs during the August test period and 900 cfs during the December test period.

During the August test period, temperatures in Lake Worth reached a maximum in the vicinity of C-51 (Fig. 1a). Similarly, in December, lake temperatures reached the lowest level near C-51.

Turbidity was higher throughout Lake Worth during the December test period than during the August test period (Fig. 2a). Flushing action at the Boynton and Lake Worth Inlets caused sharp reductions in turbidity. Turbidity was highest at C-51 during August, and 2 miles south of C-51 during December. Dissolved oxygen remained above 4 ppm throughout the lake, but reached a minimum at the discharge point of C-51 (Fig. 2b).

BOD levels (Fig. 2c), generally were lowest at the inlets and highest near each of the major discharge points. C-51 discharge was a major source of nitrogen and carbon, but the primary source of phosphorous was C-17 (Fig. 3). Levels of carbon and nitrogen were considerably higher during August than during December.

A mathematical model has been developed for the Lake Worth Estuary.[3] Based on this model, and assuming a discharge of 852 cfs, 75% of the water from C-51 flows north and 25% flows south. Residence times to remove the fresh water discharge are 8.7 days for water flowing south and 5.26 days for water flowing north.

Backpumping of water from C-51 into Conservation Area No. 1 will reduce the amount of fresh water discharged into Lake Worth, as indicated previously herein. This reduction will increase chloride levels in Lake Worth to values closer to those of seawater. In addition, chloride levels in Lake Worth will be subject to less fluctuation. These changes will favor the influx of marine animals such as bluefish, pompano and snapper; will help establish stable plant and animal communities; and will increase productivity and species diversity.

The large contribution of C-51 to pollution levels (BOD) in Lake Worth is due to the volume of discharge water. Backpumping will reduce the rate of flow in C-51 and reduce the amount of suspended materials carried into

[3] Chiu, Vandekreeke, and Dean. "Residence Time of Water Behind Barrier Islands", University of Florida, Department of Coastal and Oceanographic Engineering, October 1970 (cited in Reference No. 2).

Lake Worth. Most of the nutrients and pollution in C-51 originate from the area east of S. R. #7. With reduced flow, these nutrients will be retained longer in the canal system and can be absorbed by biological or chemical activity. Reduction in flow from C-51 will result in slightly higher BOD levels in the discharge water but will significantly reduce the total BOD, sediment, and nutrient loads discharged into Lake Worth.

Water discharged from C-51 is dark in color from humic acids. Discharged water stratifies in the lake, reduces light penetration, inhibits plant growth, and gives the water an unpleasant appearance. Reduction in discharge from C-51 will improve water clarity, increase light penetration and permit further growth of benthic plant communities. Such plants help to stabilize soft sediments and aid in decomposition of organic materials.

Under the current water management program, large quantities of fresh water are discharged from C-51 at irregular intervals. These discharges can cause rapid and severe changes in salinity, temperature, and oxygen levels, which may produce fish kills. Reduction in flow from C-51 and maintenance of a more constant rate of discharge, would help to stabilize water conditions in Lake Worth and would reduce the incidence of fish mortalities.

Reduced discharge could have some adverse effects. Migratory esturine animals that prefer low salinity water, notably snook, mullet, tarpon, and blue crabs may become less abundant. Discharge of nutrients and organic materials aids in the growth of phytoplankton and zooplankton, which are the food of small fishes. Presently, however, Lake Worth has no extensive sport or commericial fisheries because the waters are badly polluted. Salinity fluctuations and pollution make the waters of Lake Worth unsuitable for the spawning and growth of fish or invertebrates. Bulkheading and filling of the shoreline have destroyed most of the best habitats for development of larval and juvenile animals.

2. Backpumping of water from C-51 into Conservation Area No. 1 will increase the chloride levels of Lake Worth between Boynton and Lake Worth Inlets, and chloride levels will show less fluctuation. The lake will become a more suitable habitat for marine and estuarine animals. Water clarity will improve and help to establish more stable plant and animal communities. Increased salinity and reduced fresh water discharge may affect commercial and sport fisheries for species of estuarine fishes that prefer water of low salinity. Backpumping will significantly reduce the levels of nutrients and pollutants entering Lake Worth and reduce the frequency and extent of fish mortalities. Water that is not backpumped from C-51 should be released into Lake Worth at a slow, constant rate so as to avoid rapid changes in water quality that cause fish mortalities. Reduction in discharge from C-51, combined with a reduction in output from sewage treatment plants, will improve the quality, appearance, and recreational use of Lake Worth.

On balance it seems evident that the net result of the water resource management plan being considered will be beneficial as a result of: (a) raising and probably stabilizing the salinity levels in Lake Worth and, (b) reducing the total load of pollutants entering Lake Worth. This is a qualitative assessment only, although it may be possible to develop a quantitative evaluation with additional data. The degree to which beneficial results will be obtained is dependent upon the operation of the backpumping system within the limits described elsewhere in this report.

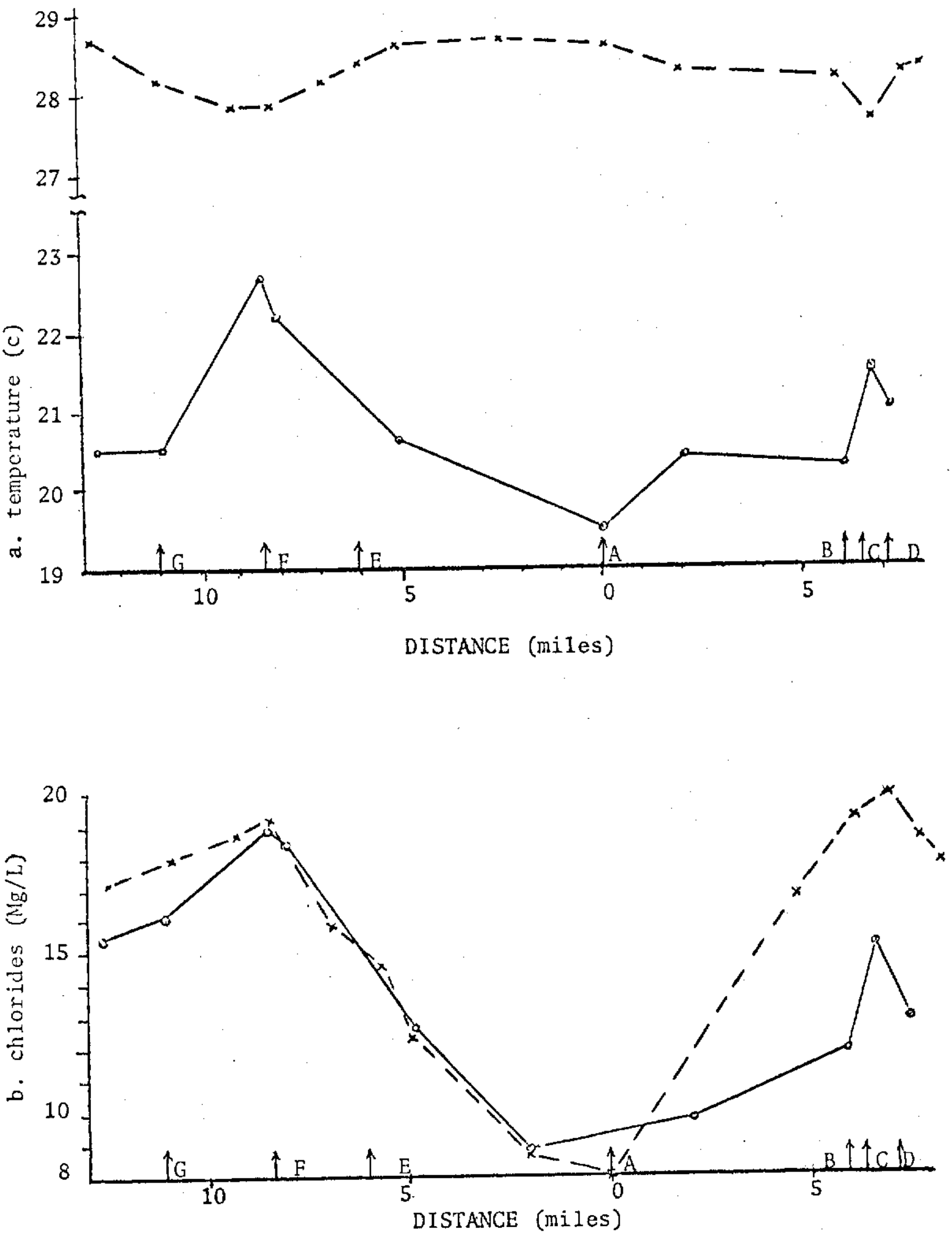


Figure 1. Temperature (a) and chloride levels (b) in Lake Worth, Florida. Each point is the mean of four samples taken in December, 1969 (-0-) and August, 1970 (-x-), at various distances from C-51. Letters represent significant landmarks: A. C-51 Canal. B. Boynton Sewage Outfall. C. Boynton Inlet. D. C-16 Canal. E. West Palm Sewage Outfall. F. C-17 Canal. (data from Reference No. 2)

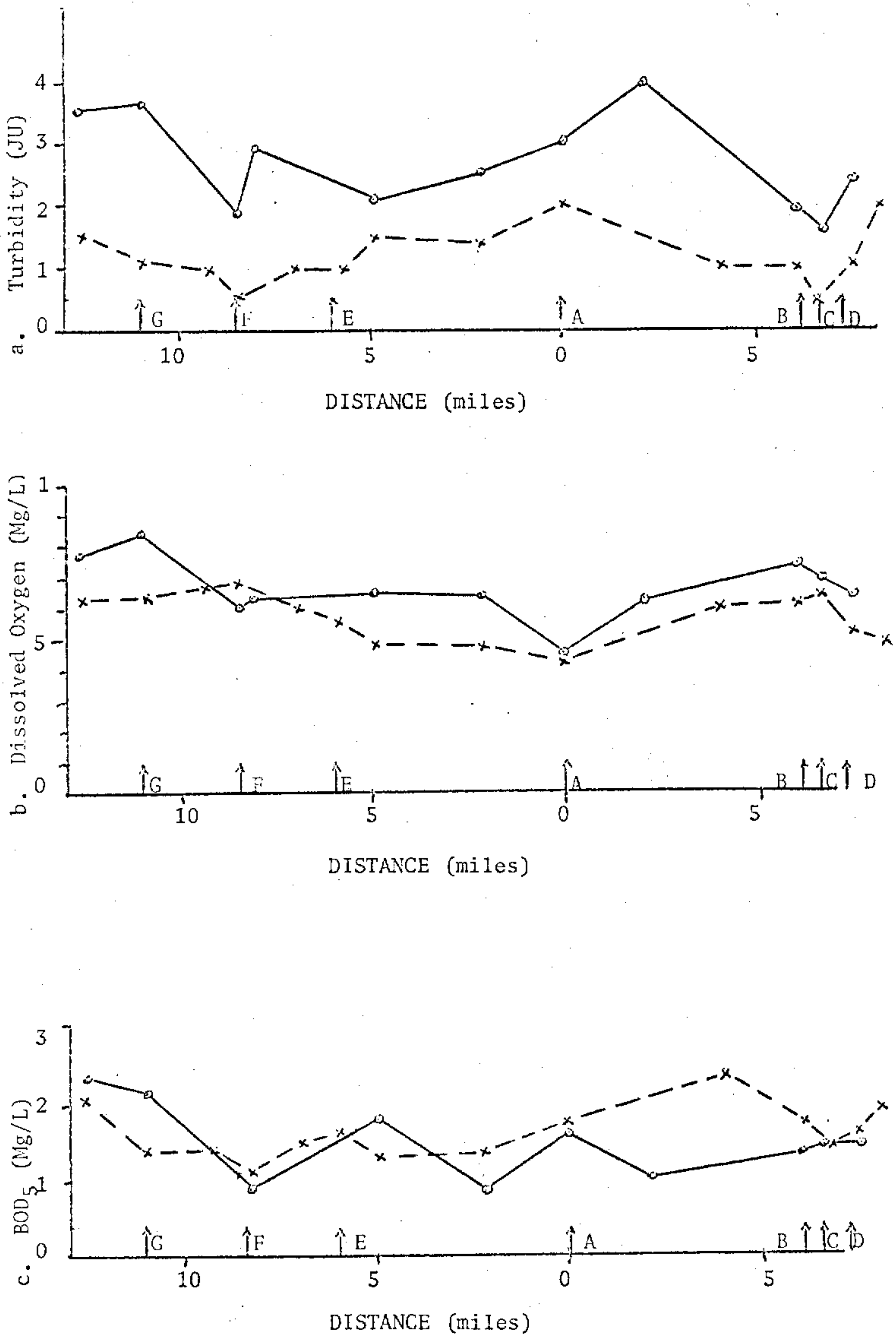


Figure 2. Levels of Turbidity (a), Oxygen (b), and BOD_5 (c) in Lake Worth. For explanation of Symbols, see Figure 1.

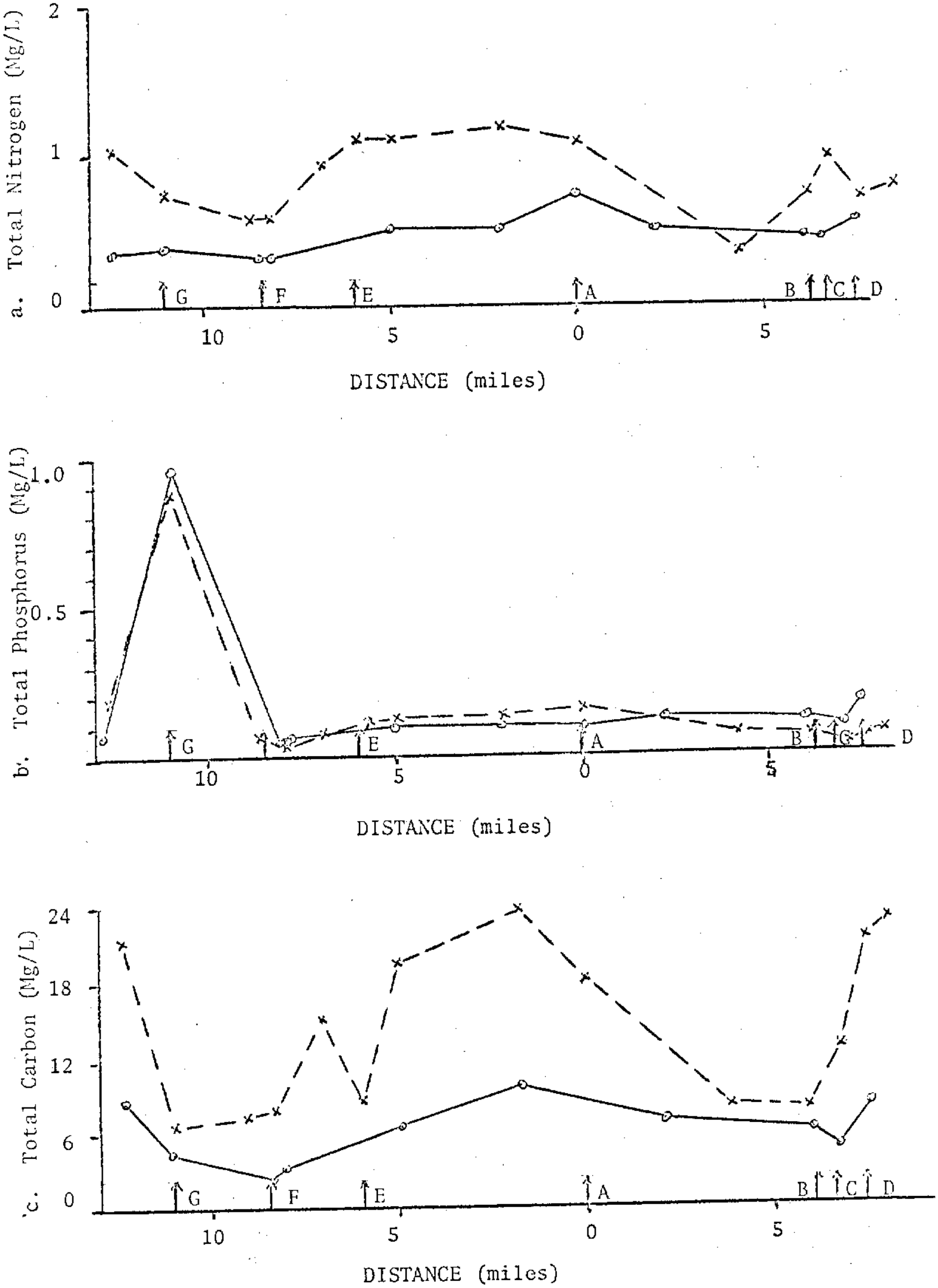


Figure 3. Levels of Nitrogen (a), Phosphorous (b) and Carbon (c) in Lake Worth. For explanation of Symbols, see Figure 1.

LAND RESOURCES

A. Soils & Vegetation

1. The detailed soil survey of Palm Beach County, recently completed by the U. S. Department of Agriculture, Soil Conservation Service, has been generalized into eight categories, depicted on Fig. 16, for the purposes of this study. Data were unavailable for the area east of Congress Avenue and for two areas in the northern half of the watershed. The soils of the watershed as a whole are characteristically wet, due to the flatness of the land and absence of natural drainage systems. Development is possible only with prerequisite drainage of the land.

Organic Soils: The Dania, Everglades, Okeelanta, Pahokee, and Terra Ceia Associations are located along Conservation Area No. 1 levee and in localized pockets throughout the basin. They are rated as "severe" for any type of development because of poor bearing strength and high susceptibility to flooding.

Deep Wet Sands: The Bassinger, Bassinger/Myakka ponded sands, Delray and Pompano Associations are located in the eastern part of the basin. Typified by broad grassy sloughs, they are judged "severe" for development.

Deep Wet Sands with Organic Hardpan: Adamsville Sand (organic subsoil variant), Immokalee, Myakka and Wabasso Associations are the dominant soils of the area west of Palm Beach International Airport south to Greenacres City. They are also found in pockets in the northern part of the basin, and to a lesser degree, in the south. Low bearing strength and poor permeability make them "severe" for development.

Wet Sands over Sandy Loam and Sandy Clay Loam: The Felda, Holopaw, Oldsmar, Pineda and Pinellas Associations are the dominant soils of the basin. They are typified by low flatwoods and grassy slough vegetation. Wetness and flooding make them "severe" for development.

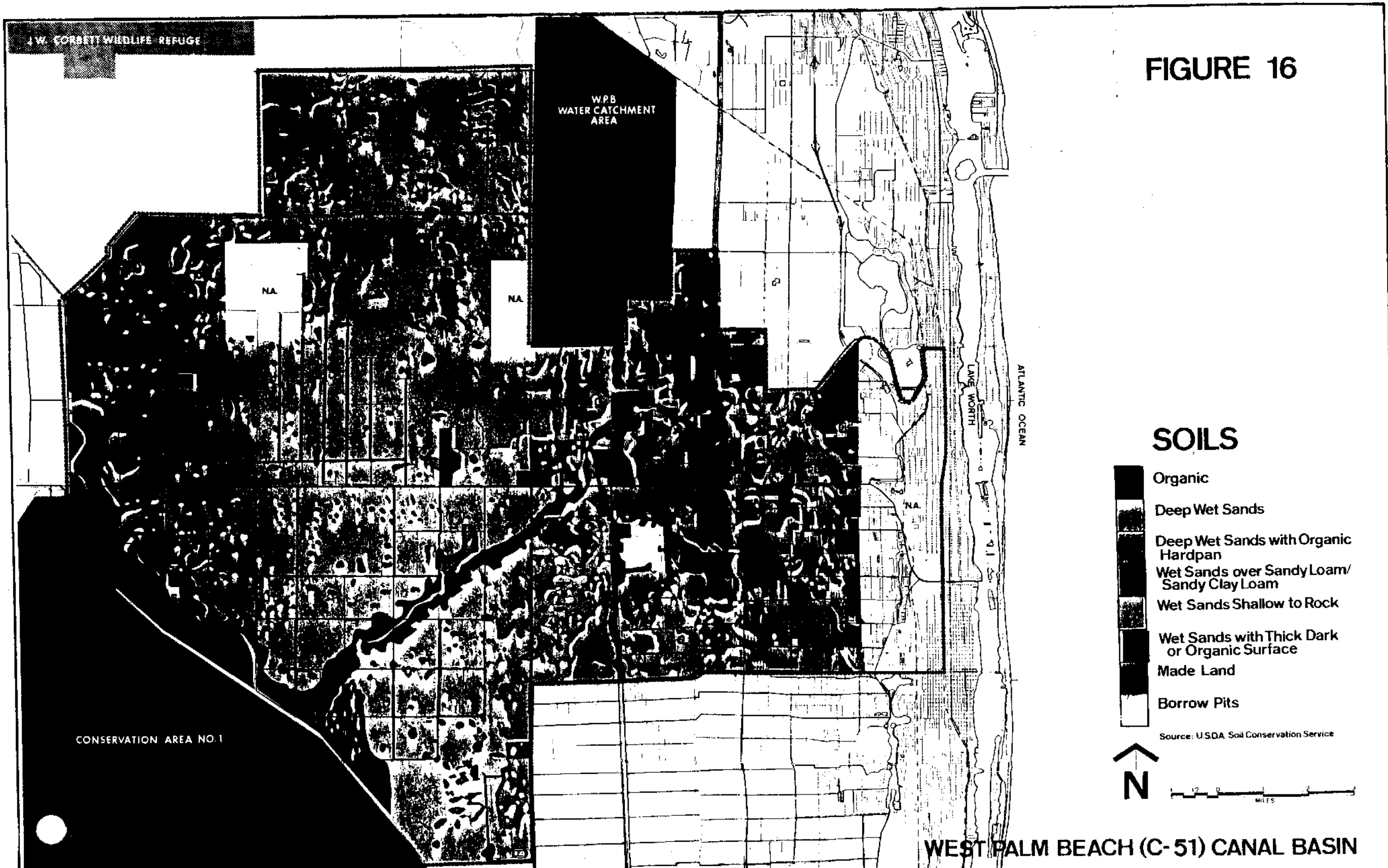
Wet Sands Shallow to Rock: Boca and Hallandale Associations are found interspersed in a belt west of the Turnpike and in the northwest corner of the basin. They are found in low flatwoods areas. Poor permeability makes them "severe" for development.

Wet Sands with Thick, Dark, or Organic Surface: The Anclote, Chobee, Floridana, Glades, Jupiter, Manatee, Placid and Sanibel Associations are located in a slough between the West Palm Beach Catchment Area and Conservation Area No. 1. Prior to man's works the slough connected the Loxahatchee River with the Everglades. Small pockets are also found in the area west of the Turnpike. They are poorly drained and therefore "severe" for development.

Made Land: has been amended by drainage or land fill to allow for development. It is found in the urbanized and urbanizing areas.

Borrow Pits result from shellrock mining and landfill operation. Scattered pits are in areas east and west of the Turnpike.

FIGURE 16



WEST PALM BEACH (C-51) CANAL BASIN

The vegetation in Conservation Area No. 1 can be identified as "typical" Everglades containing dense stands of rushes and sedges interspersed with numerous open water areas, tree islands, and bayheads. The dominant sedges are sawgrass which occurs in extremely rank stands on the western side, and beak-rush which exerts dominance on the wet prairie portions.

There are few large tree islands in Conservation Area No. 1, but the area is abundantly endowed with smaller islands called "bayheads."

The most southern one-fifth of this Conservation Area has become primarily aquatic; that is, it has extensive slough systems dominated by such plants as white water lily, pickerel weed and bladderwort. Spatterdock is also a common component of this community.

The most northerly one-fifth shows the effects of frequent drying and is heavily covered with wax myrtle invading the sawgrass.

The central three-fifths are subjected to the more typical fluctuating water levels of the Everglades and can probably be classified as true, undisturbed Everglades.

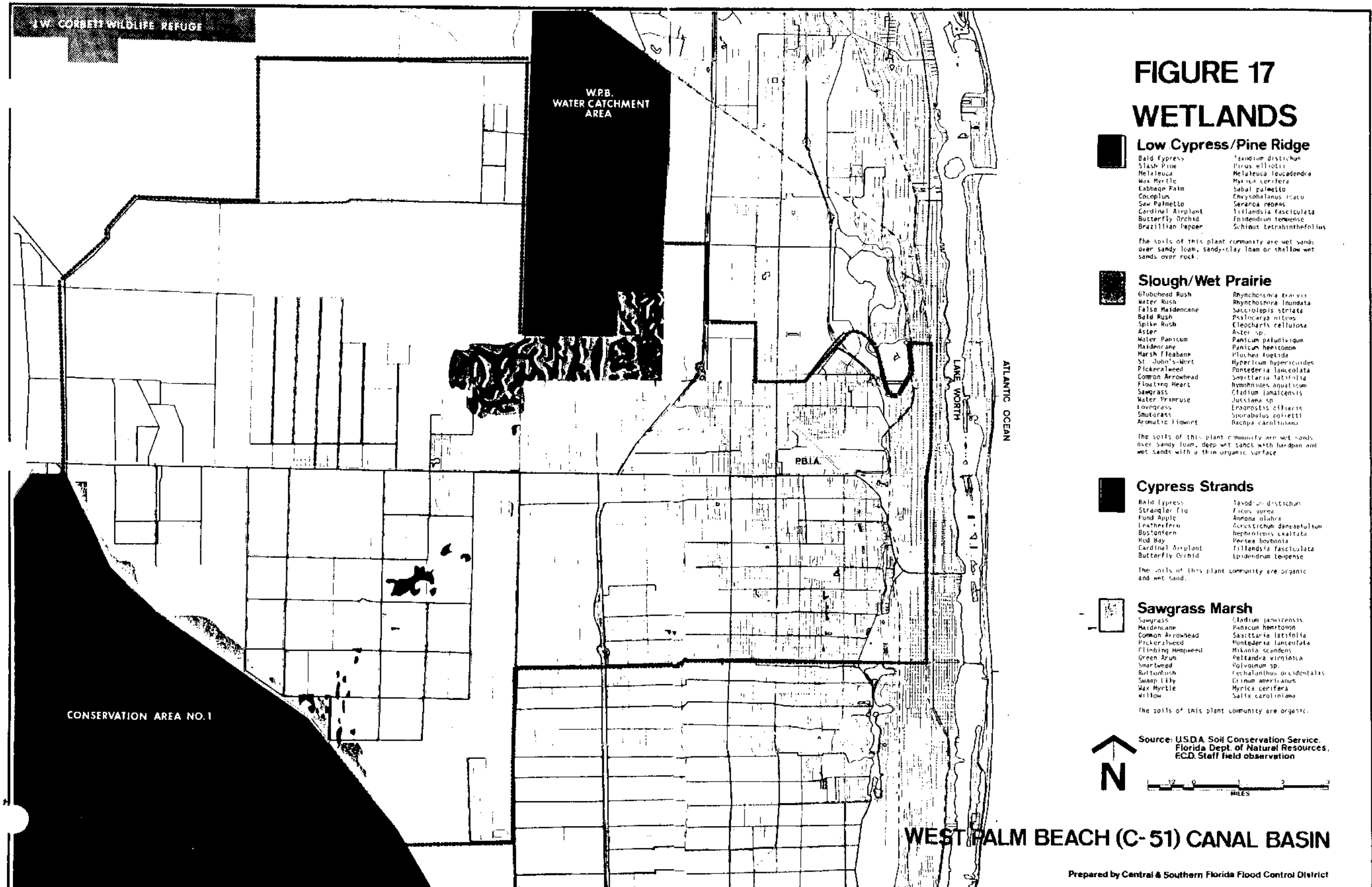
The western side of this section is sawgrass mixed with myrtle-dahoon holly heads blending eastward into a wet prairie-bayhead complex.

This central portion contains vast wet prairies dotted with small bayheads.

The C-51 drainage basin contains two major "wetland" plant communities. A narrow zone of vegetation along the east side of L-40 is representative of the Everglades communities described in Conservation Area No. 1. The southern portion of this community contains islands or "heads" of cypress trees scattered through the sawgrass marsh. There are approximately 2,000 acres within this area and it is shown in yellow on Fig. No. 17. The soils in this area are typically organic Everglades type soils which are inundated most of the year.

The second "wetland" area is located west of the Turnpike and north of Okeechobee Road. It consists of approximately 3,500 acres of ridge and slough topography. The slightly higher ridges contain vegetation similar to that found in low pine flatwoods. The taller trees are pines and cabbage palms with an understory of saw palmetto, coco plum and other typical low sandland plants. The soils on these low ridges are wet sands which are occasionally inundated.

The sloughs contain wet prairie type of plant communities with primarily sedges such as Eleocharis and Rhynchospora. Scattered throughout this slough component of the ridge and slough area are numerous cypress pads. These are nearly circular stands of cypress several hundred feet in diameter. The melaleuca tree is invading threse areas from the east. Figure 17 does not show these areas as undisturbed "wetlands" where this species has become dominant. The soils in these slough areas are wet sands which are inundated for most of the year.


J.W. CORBETT WILDLIFE REFUGE
W.P.B. WATER CATCHMENT AREA
CONSERVATION AREA NO. 1
P.B.I.A.
LAKE WORTH
ATLANTIC OCEAN
FIGURE 17
WETLANDS
Low Cypress/Pine Ridge
Bald Cypress — Taxodium distichum
Slash Pine — Pinus elliotii
Melaleuca — Melaleuca leucadendra
Wax Myrtle — Myrica cerifera
Cabbage Palm — Sabal palmetto
Cocoplum — Chrysobalanus icaco
Saw Palmetto — Serenoa repens
Cardinal Airplant — Tillandsia fasciculata
Butterfly Orchid — Epidendrum tampense
Brazillian Pepper — Schinus terebinthefolius
The soils of this plant community are wet sands over sandy loam, sandy-clay loam or shallow wet sands over rock.
Slough/Wet Prairie
Globehead Rush — Rhynchospora tracyi
Water Rush — Rhynchospora inundata
False Maidencane — Sacciolepis striata
Bald Rush — Psilocarya nitens
Spike Rush — Eleocharis cellulosa
Aster — Aster sp.
Water Panicum — Panicum paludivagum
Maidencane — Panicum hemitomon
Marsh Fleabane — Pluchea foetida
St. John's-Wort — Hypericum hypericoides
Pickeralweed — Pontederia lanceolata
Common Arrowhead — Sagittaria latifolia
Floating Heart — Nymphoides aquaticum
Sawgrass — Cladium jamaicensis
Water Primrose — Jussiaea sp.
Lovegrass — Eragrostis ciliaris
Smutgrass — Sporobolus poiretti
Aromatic Figwort — Bacopa caroliniana
The soils of this plant community are wet sands over sandy loam, deep wet sands with hardpan and wet sands with a thin organic surface
Cypress Strands
Bald Cypress — Taxodium distichum
Strangler Fig — Ficus aurea
Pond Apple — Annona glabra
Leatherfern — Acrostichum danaeafolium
Bostonfern — Nephrolepis exaltata
Red Bay — Persea borbonia
Cardinal Airplant — Tillandsia fasciculata
Butterfly Orchid — Epidendrum tampense
The soils of this plant community are organic and wet sand.
Sawgrass Marsh
Sawgrass — Cladium jamaicensis
Maidencane — Panicum hemitomon
Common Arrowhead — Sagittaria latifolia
Pickeralweed — Pontederia lanceolata
Climbing Hempweed — Mikania scandens
Green Arum — Peltandra virginica
Smartweed — Polygonum sp.
Buttonbush — Cephalanthus occidentalis
Swamp Lily — Crinum americanum
Wax Myrtle — Myrica cerifera
Willow — Salix caroliniana
The soils of this plant community are organic.
Source: U.S.D.A. Soil Conservation Service, Florida Dept. of Natural Resources, F.C.D. Staff field observation
N
1/2 0 1 2 3
MILES
WEST PALM BEACH (C-51) CANAL BASIN
Prepared by Central & Southern Florida Flood Control District

In comparing those areas which have been outlined in this report as wetlands under the Department of Natural Resources definition with the County Land Use Plan we find those areas immediately east of Conservation Area No. 1 are appropriately designated as "Conservation and Preservation Areas." However, there is a substantial area of approximately three square miles immediately south of the West Palm Beach Water Catchment Area which should be covered by the Conservation/Preservation land use classification. The vegetation, soils and relative wetness are similar to the West Palm Beach Water Catchment Area. This area is presently designated as low density residential in the County's Land Use Plan. Were this in public ownership, it would be compatible with and could be designated as part of the Water Catchment Area.

The remaining individual small parcels that could be described as wetlands in the basin can, we believe, be protected from development by the use of the county's PUD section of their zoning ordinance. It should be noted, however, that the PUD section does not require that these lands be set aside in the development. It does not prohibit it, but it does not encourage it either. The most severe danger to these identified wetland areas rests in the fact that they are not covered and/or protected by the subdivision of land or land sales activities in any part of the code other than the PUD section. Development could occur and these wetland areas could be lost without breaking any of the rules and/or regulations established by Palm Beach County.

2. The premise has been established elsewhere in this report that the C-51 watershed will undergo urbanization due to external pressures, the force of which are already being exerted. The purpose of the combined plan being considered is to guide that process within a framework compatible with the natural resource base of the area and region.

The previous description of the surface soil associations of the watershed indicate the limitations of that portion of the natural resource base. Assuming that the area will develop in any event, surface soils drainage, or water control, is required. The water resources management element of the plan satisfactorily addresses this factor. The requisite degree of on-the-land water control will be provided by lowering the high water stages in the primary facility (C-51) while at the same time raising the normal, or optimum, water control elevation in the western portion of the basin, thus preventing over-drainage. In this case the plan provides for a reasonable accommodation between land use and the natural resource base.

In regard to wetlands within the C-51 watershed itself the land use element of the plan addresses satisfactorily a portion of the lands within this category through use of the "C onservation and Preservation" designation. Neither the nearly 3 square mile wetlands area identified above nor the smaller isolated areas fitting this description are addressed by the plan.

3. See the discussion under Section B, "Wildlife", immediately following.

4. It is recommended that the County re-evaluate the land use designation for the 3 square mile area identified herein.

In regard to the smaller areas which fit a wetlands designation, see the discussion under Section B, "Wildlife", immediately following and the recommendation suggested on page 20 of this report.

B. Wildlife

1. The plant communities in Conservation Area No. 1, described in Section A, immediately preceding, support many species of wildlife. Although some wildlife species are closely related to well defined habitat types, it would be most difficult to approach this matter on an ecotone basis. The reason for this is that most species of wildlife utilize different plant communities or habitat for different purposes. For example, many species of birds depend on the wetter communities for feeding and yet nest on the tree islands and willow strands, or even leave the area entirely to roost miles away. Also, in some instances a given ecotone will be used only during certain times of the year or hydroperiod.

The Federal Fish and Wildlife Service at the Loxahatchee Refuge in Conservation Area No. 1 has recorded twenty-two species of mammals in the area. Most of these mammals are found on the tree islands, levees and dryer regions east of the Refuge.

Although white-tail deer are present in the Refuge, this marshland is not good deer habitat. The Fish and Wildlife Service estimates that in 1972 Conservation Area No. 1 had a deer herd of approximately 200 animals.

Racoons are common throughout this entire wetland area. These highly nocturnal animals are usually observed on the tree islands and levees. This species, however, depends on aquatic organisms for much of its diet.

The river otter may well be the most aquatic mammal of the Everglades. This animal is an excellent swimmer and is seldom seen far from the wetland habitat to which it is so well adapted.

Both cottontail and marsh rabbits are common on the levees and higher ground, but the marsh rabbit is the species encountered in the interior marshes.

Several species of rodents are found throughout the area. Most of the rodent species live on the levees. The Florida water rat and the rice rat are the most aquatic oriented of these rodents. Both species occur in the interior marshes.

The most common carnivorous predator of these wetlands is the bobcat. Throughout much of the southeastern United States the bobcat is a swamp dweller; however, this species is not well adapted to life in the interior Everglades marsh and is usually found on the fringes of the marshlands. Bobcats are encountered along the levees where they hunt for rabbits and rodents which comprise the bulk of their diet.

This wetland area contains a varied and plentiful population of birds (208 species). The number and diversity at any given time is largely dependent upon the water conditions and the season.

All of the common wading birds (Egrets, Herons, Ibis, etc.) frequent these marshes. The largest concentrations of wading bird species occur on falling water levels. As the marshes dry, the aquatic organisms upon which these birds feed are concentrated and create ideal feeding conditions.

The waterfowl population tends to vary throughout the year, due to the influx of migratory birds. Last winter during the peak of the waterfowl season the Fish & Wildlife Service estimated that the bulk of the waterfowl population was composed of the following species: Ringneck ducks (5,000), Bluewing Teal (4,000), Fulvous Tree Ducks (2,000), and Florida Mallards (1,500). Coots and Gallinules also utilize the area in considerable numbers.

Over one hundred species of passerine birds have been recorded for the Refuge and the immediate surrounding area.

Thirty species of reptiles have been recorded in Conservation Area No. 1. The list includes six species of turtles, six species of lizards, seventeen snake species and one species of alligator. In addition, twelve species of amphibians are represented. Ten of these amphibian species are toads and frogs.

Although on the rare and endangered species list, over 10,000 alligators presently reside in the Refuge.

The Everglade Kite, a rare and endangered species, also utilizes the marshes of Conservation Area No. 1. In March and April of 1972, upwards to twenty-two were observed in the Refuge; however, these birds tend to move into and out of the Refuge, as they do in Conservation Area No. 2.

Other endangered species which have been sighted in the Refuge include the Bald Eagle, Osprey, Peregrine Falcon, Great White Heron, and the Florida Panther.

The only hunting allowed in Conservation Area No. 1 is for waterfowl during the open season. Approximately 25% of the Refuge is open for this purpose. In 1972 an estimated 2,500 hunters used the area for this purpose.

Conservation Area No. 1 supports a typical Everglades marsh fishery. All of the common species of fresh water fishes found in south Florida are present in this wetland area. Depending on water levels, the sport fishing can be spectacular at times. The best fishing occurs during periods of falling water levels. This sport fishing is basically a centrarchid fishery (Largemouth Bass, Bluegill, Shellcracker, and Stumpknocker). Over 190,000 fishermen visited Conservation Area No. 1 in 1972.

A total of 305,066 visitors frequented the Refuge in 1972. In addition to the figures already mentioned for hunting and fishing use, Refuge personnel have provided the following data on other recreational activities.

Wildlife Observation	42,900
Photography	27,941
Picnicking	27,993
Boating	37,576
I & E Tours Conducted by the Refuge	6,019

The C-51 watershed, itself, contains two wetland areas as described under Section A, immediately preceding. The plant communities and the common wildlife species found in the Loxahatchee Refuge are also represented in these wetlands.

From a fish and wildlife standpoint, there are some major differences between these small wetland areas and the Refuge. The most obvious of the differences are in the alligator population, the sport fishery and the numbers of migratory waterfowl.

Although alligators occur in the wetlands outside of the Refuge, their number has been reduced by illegal hide hunting. The fact that Conservation Area No. 1 is closed to night use is largely responsible for the size of the alligator population there (one alligator per 15 acres).

Most of the common fresh water fishes of south Florida are found in the wetlands of the C-51 watershed. However, these wetlands do not provide the spectacular sport fishing common to Conservation Area No. 1. The reason for this is that Conservation Area No. 1 has a canal system which supplies temporary habitat for the fishery during periods of falling and low water. Not only is the fish population concentrated in the Area 1 canals during low water but, in addition, sport fishery becomes available to the public.

The large numbers of migratory waterfowl that use the Refuge probably do so because of the extensive marshes (147,000 acres) and the protection provided by the Fish & Wildlife Service. The two wetlands remaining in the C-51 Basin are small (2,000 and 3,500 acres) and they are most likely as not as attractive to the birds as the large protected marshes of the Refuge.

It should be noted here that, although outside the immediate study area, both the Corbett Wildlife Management Area and the West Palm Beach Water Catchment Area abut the C-51 watershed boundary. These areas together support substantial wildlife and fishery values.

2. The potential impact of the water resources management element of the plan on the conservation areas has been discussed in previous sections of this report. The impact on wildlife is intimately related to those quantity and quality changes which have the potential of altering the environment over time.

In the C-51 watershed itself, small size wetlands areas have been identified. As noted elsewhere herein the combined plan being considered does not address itself specifically to maintenance and protection of these areas for wildlife habitat.

3. In regard to the identified wetlands areas in the C-51 watershed our examination indicates that they have some value as wildlife habitat. In view of the extensive wildlife habitat being maintained and preserved in the immediate vicinity (Conservation Area No. 1, Corbett Area, the Catchment Area, and the preservation areas of the Land Use Plan) some question can be raised as to the necessity for preservation of these areas; the effect of failure to do so, in this view, could be considered inconsequential. In the long run the justification for their preservation may well rest on aesthetic considerations and preservation of some of the amenities related to natural vistas.

4. It is our finding that sufficient justification exists to make the effort to preserve these areas. These areas should not be subject to potential destruction and the means appears to be available for incorporation of these areas into the "open space" requirements of the County's ordinance. The recommendation in regard to preservation and maintenance of these areas is contained on page 20 of this report.

C. Allocation as to Use

1. The Palm Beach County Master Land Use Plan of Figure 23 was the result of a comprehensive study by the Palm Beach Planning, Building and Zoning Department. The effort of the staff planners in the development of that program included all of the inventory information on soils, vegetation, municipal boundaries, public facilities and utilities, transportation, etc. A comprehensive effort of monumental proportions was handled in approximately one year, culminating with the adoption of the Land Use Plan by the Board of County Commissioners on December 6, 1972. The plan itself is supported by a package of codes and ordinances, including zoning, subdivision, building, electrical, plumbing, etc. Existing land use is shown on Figure No. 20.

It is assumed, for the purpose of this study, that the enforcement of all the appropriate codes and ordinances with respect to the guidelines established by the county's plan would make a compatible system of land use with the drainage facilities offered by the C-51 water resources management plan.

The Land Use Plan is a statement of policy adopted by the Board of County Commissioners to guide logical growth and development of the county. It is not a document which establishes firm hard rules and regulations for development. The plan is a flexible guide for growth to be implemented by the appropriate codes and ordinances enacted and enforced by the Board of County Commissioners. Further, it is not a zoning map; the adoption of this land use plan did not rezone properties. The plan does not affect or direct the policy statement of the ten municipalities involved in the basin. Each municipality is empowered to develop plans of their own and to create, enact, and enforce appropriate zoning and subdivision codes and ordinances which may be in direct conflict with the intent of the County's master land use plan.

This section of the report will discuss those conflicts which exist in the plan itself or may come about by actions of other political jurisdictions or other actions of property holders within the basin.

It is difficult to relate land use categories, zoning and runoff rates. We have had to generalize the zoning districts of the 11 different jurisdictions to make the comparisons. Dwelling unit figures will be compared on straight subdivision standards. PUD's allowed by the county would have a beneficial result in the implementation of this plan. An example of this fact is Wellington. This development, designed in conformity with the Land Use Plan, preserved a valued wetland and up to this point in development has been able to meet existing runoff constraints to C-51.

The conflicts identified will be stated in terms of dwelling units and are categorized as follows:

Municipalities: Of the 174 sq. mi. under study in this report, 18.7 sq. mi. are under the jurisdiction of the ten municipalities in the watershed.

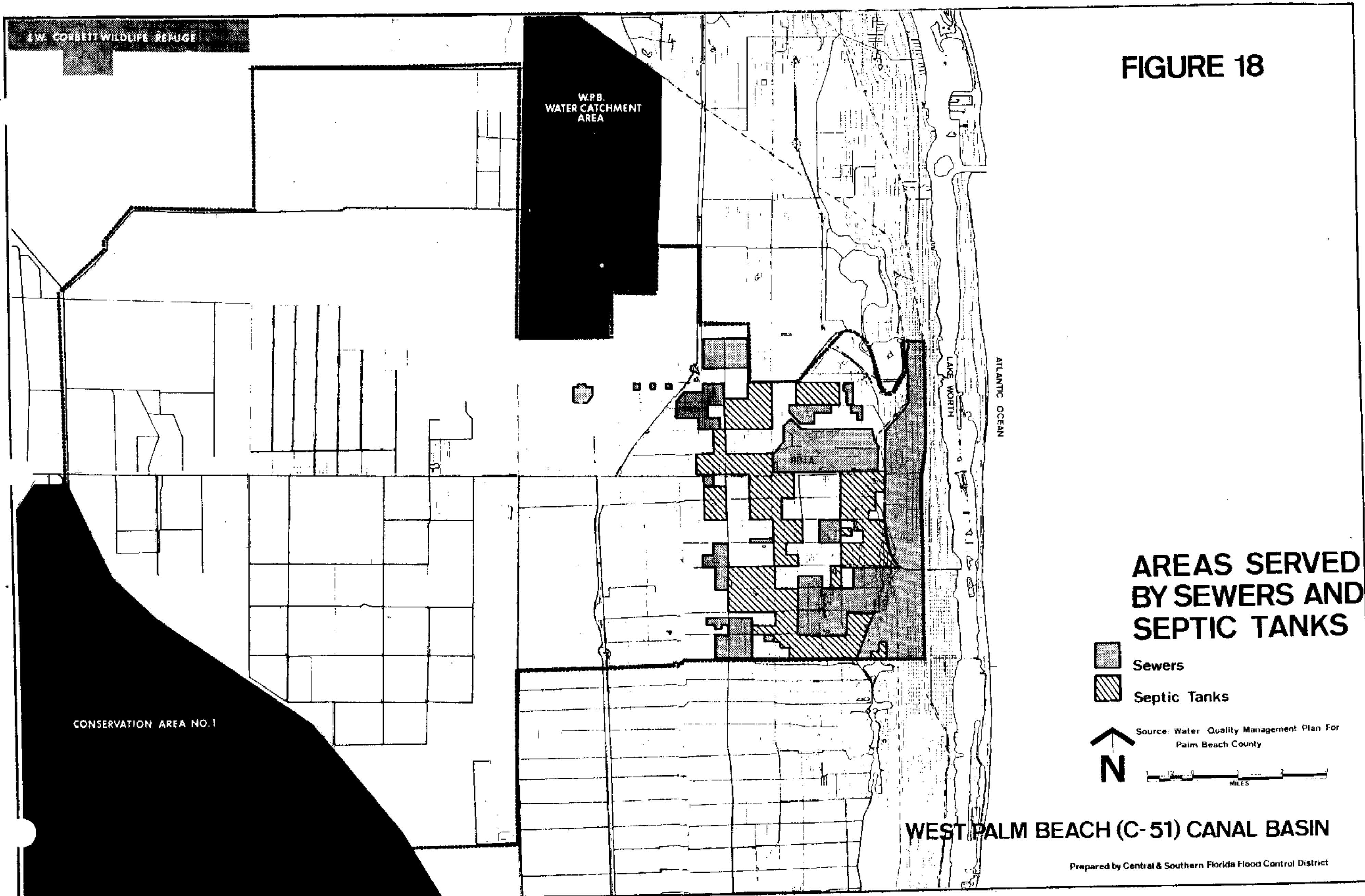


FIGURE 18
AREAS SERVED BY SEWERS AND SEPTIC TANKS
Sewers
Septic Tanks
Source: Water Quality Management Plan For Palm Beach County
N
MILES
WEST PALM BEACH (C-51) CANAL BASIN
Prepared by Central & Southern Florida Flood Control District
J.W. CORBETT WILDLIFE REFUGE
W.P.B. WATER CATCHMENT AREA
CONSERVATION AREA NO. 1
LAKE WORTH
ATLANTIC OCEAN

FIGURE 19

FLOODED AREA, 1947 WITH 1960 DRAINAGE FACILITIES

Depth (Feet)	Average Duration (Days)
0-1.5	15
1.5-2.0	30
1.5-2.0	45
2.0-3.0	120
3.0-4.0	180
4.0-5.0	180

Source: U.S. Corps of Engineers

N

MILES

WEST PALM BEACH (C-51) CANAL BASIN

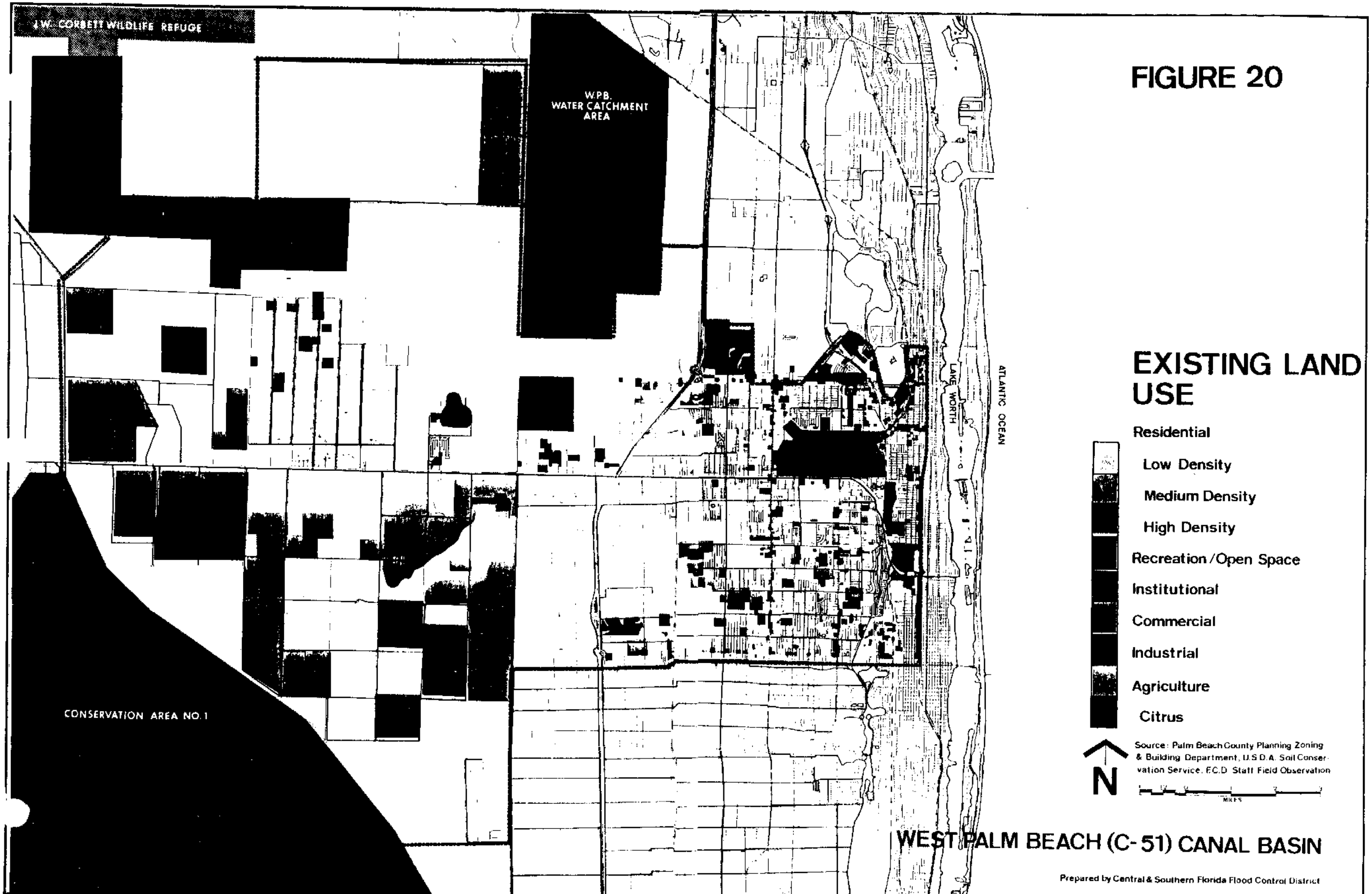


FIGURE 20

EXISTING LAND USE

As mentioned before, the County's Land Use Plan does not have an affect on the activities of the municipalities. The existing conflict between the plan and the zoning of the municipalities is illustrated in Table 6, at the end of this section. The County's Land Use Plan would provide for 45,221 dwelling units in these areas of the county whereas, in reality the zoning ordinances of those municipalities provide 78,359 dwelling units. Jurisdictional boundaries are shown on Figure No. 21.

Another very real problem from this same multi-jurisdictional authority revolves around the fact that strong codes and ordinances being developed by one unit of government tend to encourage an adjoining unit of government to drop its restrictions and by annexation take in those areas, thus allowing development to a much higher degree. A case in point is the recent annexation movements by the City of Greenacres with regard to developments involving construction using a higher density than authorized by the County's Land Use Plan. These pressures will continue as long as there is an unbalanced policy by those governing officials and an unequal enforcement of the appropriate rules and regulations for development.

Prior Zoning: Another conflict stems from Palm Beach County's prior zoning ordinance. The zoning densities and other land commitments which had been made in the basin prior to the adoption of the plan are still in existence. These conflicts are also shown on Table 6. Conversion of existing zoning to a zoning compatible with the Land Use Plan can only be initiated by either the owners of the property or the Board of County Commissioners. It has been the general experience that owners of property, with very few exceptions, will not request a zoning classification which will reduce the intensity to which they can use their land. And where local jurisdictions (in this case the Board of County Commissioners) have made efforts to rezone an individual's land to a lower density, these matters have generally ended in long, laborious court suits and ultimate failure on the part of the governmental jurisdiction to make such a down-graded zoning stick. Present zoning is shown on Figure 22.

It should be noted that there is a significant conflict in the C-51 watershed between the intensity of use based on prior zoning and/or other development commitments and that intensity of use that is projected by the plan. In these unincorporated areas the Land Use Plan would project 237,735 dwelling units, whereas in reality, existing zoning and/or other commitments would allow 279,539 dwelling units. In this category, the most notable exception to the County's Land Use Plan is that in the area of land sales activity around the Village of Royal Palm Beach. Figure 3 indicates those lands which have been committed to one acre tracts in a gridiron type of subdivision on 22 sq. mi., out of 28 sq. mi. which are in the C-51 basin. The land use classification on the Palm Beach County plan indicates this entire land sales area is in a Residential Estate category, which would allow one dwelling unit per 2 1/2 acres in a standard layout. The effect of this single acre subdivision is to more than double the potential density of the area.

It is also significant to note that the control, and continuance, of this practice in this area of Palm Beach County was addressed in the original zoning code adopted by the Board of County Commissioners on February 2, 1973 by two sections of that ordinance dealing with non-conforming

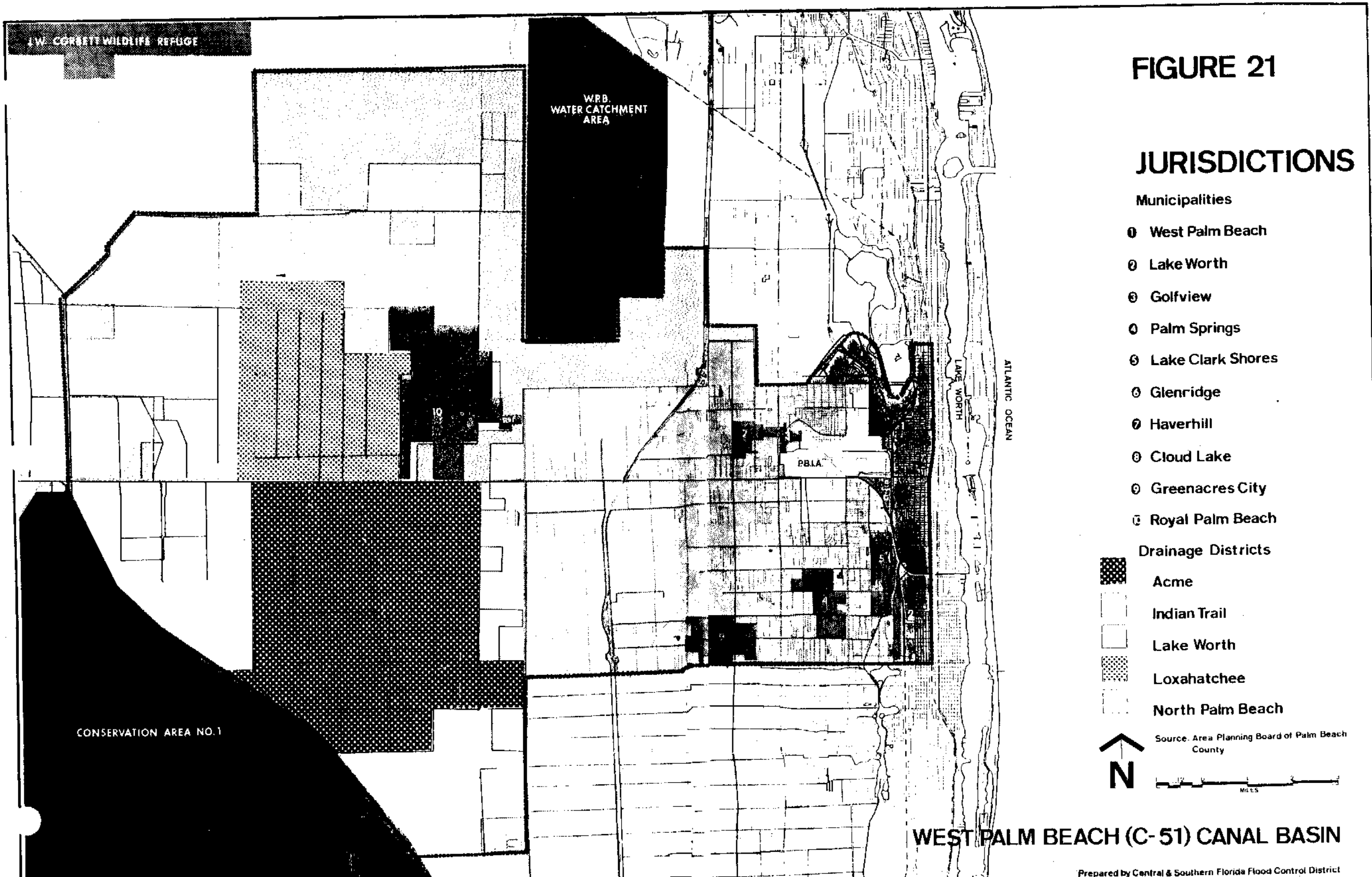
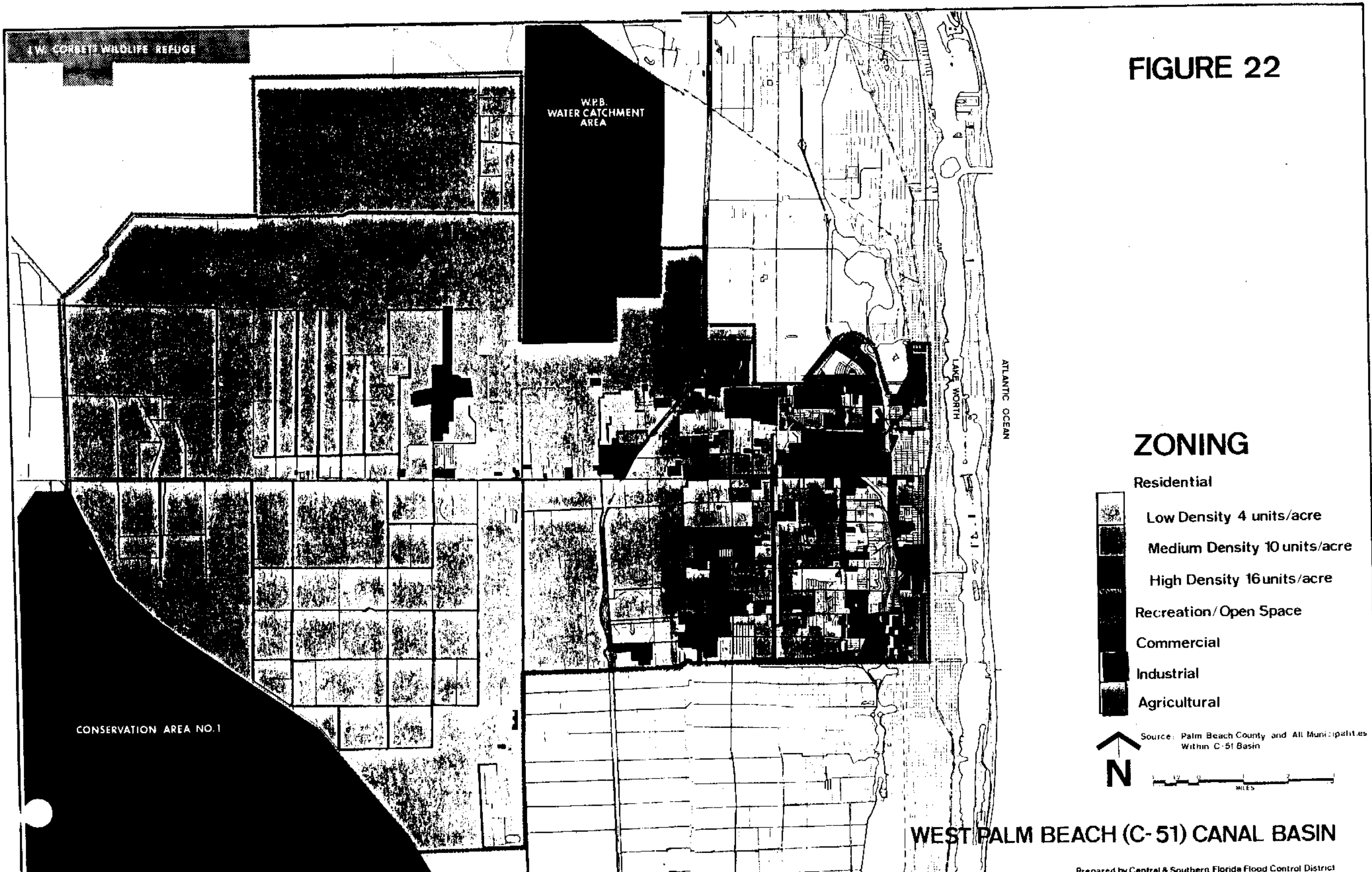


FIGURE 21

WEST PALM BEACH (C-51) CANAL BASIN

Prepared by Central & Southern Florida Flood Control District



J.W. CORBETT WILDLIFE REFUGE
W.P.B. WATER CATCHMENT AREA
CONSERVATION AREA NO.1
LAKE WORTH
ATLANTIC OCEAN
FIGURE 22
ZONING
Residential
Low Density 4 units/acre
Medium Density 10 units/acre
High Density 16 units/acre
Recreation/Open Space
Commercial
Industrial
Agricultural
Source: Palm Beach County and All Municipalities Within C-51 Basin
N
MILES
WEST PALM BEACH (C-51) CANAL BASIN
Prepared by Central & Southern Florida Flood Control District

lots. Both of these sections have been amended in July 1973. The original and amended sections of the ordinance are included as Appendix A at the back of this section.

The effect of these amendments is not fully known. In the area of land sales all lots drawn and dated prior to July 28 are grandfathered. It is possible that other proposed subdivision plans drawn but not filed will turn up, committing additional lands in this basin. The most serious result of these amendments is in allowing areas yet unsold to be divided into substandard lots and thereby precluding, through the vehicle of the code, the establishment of lakes and flooding areas by re-design of those remaining sections of land.

Land in the C-51 basin is developing as fast as in any area in south Florida. Existing land use controls will allow an ultimate population of 1,002,144 in the watershed. It is unlikely that any additional restrictions will be initiated at a local level to curtail this trend. Urban growth of this type is costly, fragmentation of service delivery systems plus increasing stress on transportation links, water supply, drainage, etc., usually end in duplications and expensive governmental outlays.

Land values in the area have increased to a point that holding speculation is short term, at best. As land values continue to rise the pressure for increased intensity of use will occur. It is reasonable to assume that revisions to the land use in both the cities and county may add to the projected densities in the near future.

The land sales area around the Village of Royal Palm Beach is a most perplexing problem. It is unlikely that these one acre tracts will develop on a wholesale basis. The trend is likely to be the expansion of the type of development in the Village of Royal Palm Beach with those buyers of the one (1) acre sales contracts trading for an urban lot, apartment, or condominium. If this trend proves to be true the intensity of use could far exceed any projections made to date.

2. The conflicts listed in Table 6 is a statement of "saturation" development. This kind of comparison is useful, but is often misunderstood as being a projection of things to come. In reality these numbers are never reached. Changes in the market, transportation modes, service deliveries, government, taxation, and school districts will play a more significant role in the development of the area than the Land Use Plan or any zoning regulations. However, if these calculations are used to produce a development curve in relationship to the ultimate population of the county some reasonable predictions can be made. Such predictions are shown on Figure 25. Areas of conflict are shown on Figure 24.

A most important and enlightening finding in the preparation of this table of conflicts is that we are now able to estimate the net effect of the establishment of an Area of Critical State Concern in the C-51 basin. 90% of the area east and 60% of the area west of the Turnpike is committed

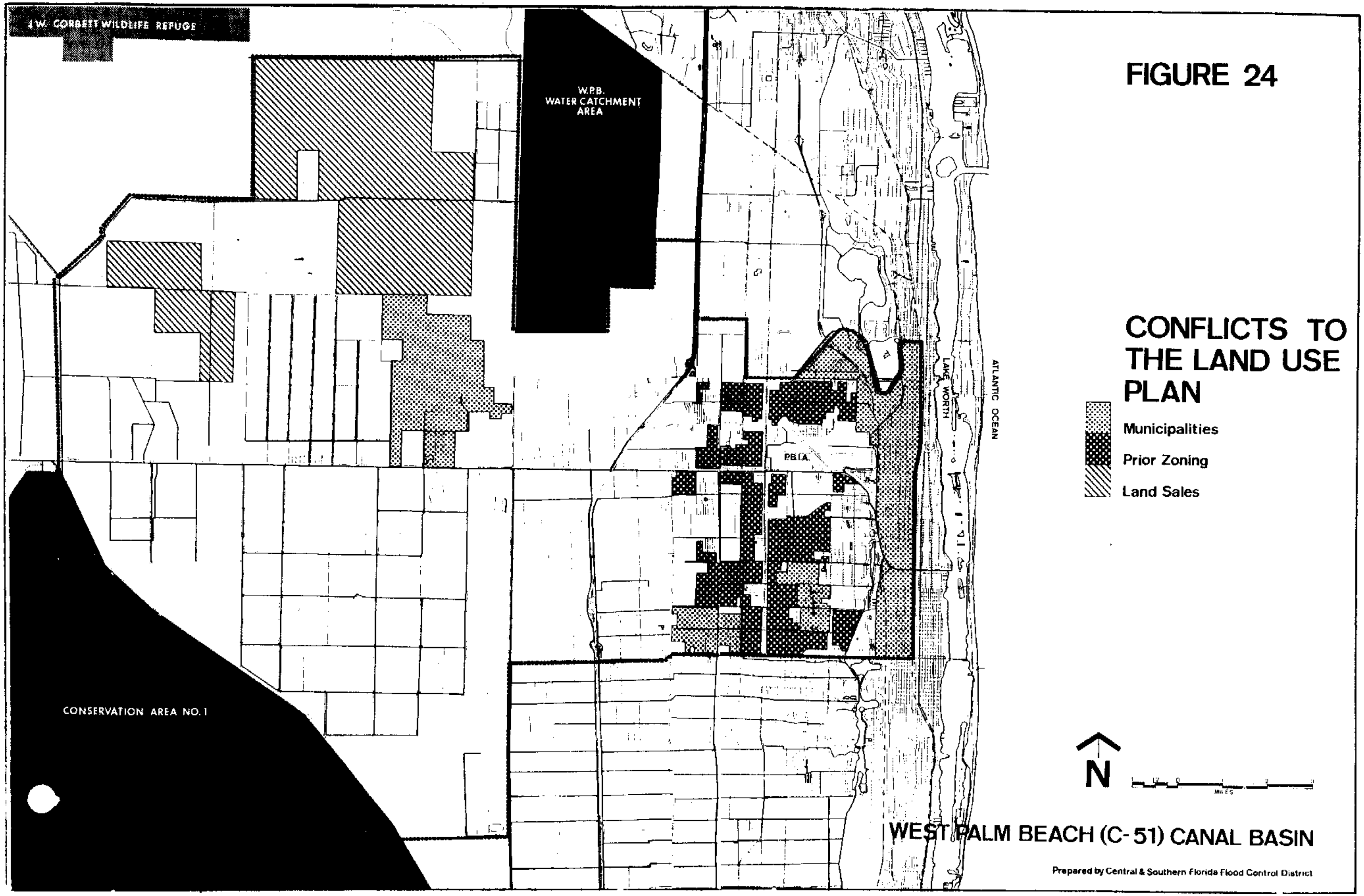


FIGURE 24
CONFLICTS TO THE LAND USE PLAN
Municipalities
Prior Zoning
Land Sales
J.W. CORBETT WILDLIFE REFUGE
W.P.B. WATER CATCHMENT AREA
P.B.I.A.
LAKE WORTH
ATLANTIC OCEAN
CONSERVATION AREA NO. 1
N
MILES
WEST PALM BEACH (C-51) CANAL BASIN
Prepared by Central & Southern Florida Flood Control District

to a development pattern or type which would exempt it from the full force of the police power as reflected in land use controls. Reductions in the intensity of land use could probably be made in some areas; however, such reductions would have an insignificant effect on the potential "saturation" impact.

Another significant finding is that the most serious problem with respect to the generation of conflicts in terms of land use is in the "land sales" area; that is, the Village of Royal Palm Beach - Indian Trail Ranch area. Previous sections of this report also identified this area as having the potential of generating the most serious problems in regard to surface water quantity (pgs. 10 and 11) and groundwater quantity (page 14). In the light of the recommendations made on pages 26 and 27 with respect to surface water quality and the exemption of this area from provisions for surface water detention areas (page 11), this same area can be identified as a potential source of surface water quality problems.

The identification of this area as a potential source of certain problems both with respect to land use and with respect to water resources is, of course, not coincidental. It simply is a reflection of the basic premise of the State's environmental land and water management legislation.

The combined plan being evaluated herein does not address the land use problems of the land sales area. The water resources element of the plan does not, because it can not (see discussion on pages 24 and 25). The land use element of the plan does not because it was constrained to recognize the limitations of the police powers with regard to land sales areas. It is necessary to make a clear distinction here; neither element of the plan is the cause of whatever potential problems are inherent in the continued development of the area in question.

3. Failure to acknowledge and address the specific potential problem identified above, and in previous sections of this report, with respect to land sales area can be serious. It can result in the failure to implement a water resources management plan needed to provide flood protection for already developed areas, groundwater management for an entire watershed, conservation of fresh water, and orderly development of an area already receiving population stress.

4. It is difficult to suggest an approach which might be taken for resolution of the potential problems. As indicated above the "Area of Critical State Concern" designation approach may well not be practicable or productive. A possible course of action is by agreement and/or through the use of police powers and regulatory powers derived from other sources. This type of approach was suggested in the recommendations and observations made on pages 12, 15, 18, and 27 of this report.

A specific recommendation is that, either by agreement or through legislation, the municipalities in the C-51 watershed be placed under the provisions of the County's Land Use Plan.

Table 6

Conflicts resulting from non-applicability of Palm Beach County Land Use Plan

	Area in (Acres)	1972 Dwelling Units	Zoned and Committed Dwelling Units	Palm Beach Co. Land Use Plan Dwelling Units
West Palm Beach	3,627	6,420	17,139	12,750
Lake Worth	909	1,643	11,254	5,143
Royal Palm Beach	3,958	502	32,610	15,832
Haverhill	294	323	1,176	1,176
Cloud Lake	38	58	152	152
Greenacres	960	762	8,704	3,840
Glenridge	128	89	512	512
Lake Clarke Shores	700	787	2,800	2,800
Palm Springs	704	1,533	3,812	2,816
Golfview	640	52	200	200
Municipal; sub-total	11,958	12,169	78,359	45,221
Unincorporated; sub-total	99,402	19,875	279,539	237,735
C-51 Basin				
East of Turnpike	28,544	31,103	191,424	141,964
West of Turnpike	82,816	941	166,474	140,992
C-51 Basin; Total	111,360	32,044	357,898	282,956

LAND SALES AREA

	Palm Beach County Land Use Plan	Grandfathered
North of M Canal	2944 D. U.	6720 D. U.
South of M Canal	2432 D. U.	7360 D. U.
Total	5376 D. U.	14080 D. U.

POPULATION OF C-51 BASIN

Palm Beach County Land Use Plan	792,277
Zoned and Committed	1,002,144

APPENDIX A

200.2 (Original) February 2, 1973

"NONCONFORMING LOTS: A single lot, tract or parcel of land shown on either a recorded or unrecorded map, plat, drawing or survey under the ownership of a single person, firm, partnership, association, corporation, joint venture, estate, trust, joint tenancy, tenancy by the entireties or other combination of persons acting as a unit where such map, plat, drawing or survey was in existence at the time of the adoption of or amendment to this ordinance, even though such lot fails to meet the requirements for area or width or depth, but provided that yard dimensions and setbacks of the lot shall conform to the property development regulations for the district in which such lot is located."

200.2 (Amended) July 28, 1973

"NON-CONFORMING LOTS: A single lot, tract or parcel of land of record or the subject of an agreement for deed or other instruments of conveyance properly executed prior to the effective date of this Code, or shown on either a recorded or unrecorded map, plat, drawing or survey under the ownership of a single person, firm, partnership, association, corporation, joint venture, estate, trust, joint tenancy, tenancy by the entireties or other combination of persons acting as a unit where such map, plat, drawing or survey was in existence at the time of the adoption of this Ordinance, even though such lot fails to meet the requirements for area, width or depth, but provided that minimum yard dimensions and setbacks of the lot shall conform to the property regulations for non-conforming lots as hereinafter set forth."

404.3 (Original) February 2, 1973

"NONCONFORMING LOTS: If any district in which single family or duplex dwellings are permitted, notwithstanding limitations imposed by other provisions of this Code, a single family or duplex residence and customary accessory buildings may be erected on a single lot, tract or parcel of land shown on either a recorded or unrecorded map, plat, drawing or survey, which tract, lot, or parcel was at the time of the preparation of such map, plat, drawing or survey, under the ownership of a single person, firm, partnership, association, corporation, joint venture, estate, trust, joint tenancy, tenancy by the entireties or other combinations of persons acting as a unit where such map, plat, drawing or survey was in existence at the effective date of the adoption or amendment of this Code; provided further, that at least thirty (30) percent of the parcels, tracts or lots shown on an unrecorded map, plat, drawing or survey were subject to deeds, agreement for deeds, installment land sales contracts, contracts for sale and purchase or other instruments of conveyance properly executed prior to the effective date of the adoption or amendment to this Code and where the land encompassed by said unrecorded map, plat, drawing or survey was either registered with the Department of Business Regulation, Division of Florida Land Sales, prior to the effective date of the adoption or amendment to this Code, or said unrecorded map, plat, drawing or survey was certified by a land surveyor or engineer duly licensed by the State of Florida, prior to the effective date of the adoption or amendment of this Code.

Such lot must be in separate legal or equitable ownership and not of continuous frontage with other lots in the same ownership. This provision shall apply even though such lot fails to meet the requirements for area or width or both, that are generally applicable in the district, provided that yard dimensions and setback requirements of the lot shall conform to the property development regulations for the district in which such lot is located.

If two (2) or more lots or combinations of lots and portions of lot and portions of lots with continuous frontage in single ownership at the time of the passage of or amendment to this Code and if all or part of the lot does not meet the requirements for lot width and areas established by this Code, the lands involved shall be considered to be an undivided parcel for the purposes of this Code. No portion of said parcel shall be used which does not meet lot width and area requirements established by this Code, nor shall any dividion of the parcel be made which leaves remaining any lot with width or area below the requirement stated in this Code."

404.3 (Amended) July 28, 1973

"NON-CONFORMING LOTS. A single family residence and customary accessory buildings may be erected on a single lot, tract or parcel of land, notwithstanding limitations imposed by other provisions of this Code, if:

1. The erection of such a single family residence was permissible prior to the adoption of this Code; and

2. A. The single lot, tract or parcel of land was of record or was the subject of an agreement for deed or other instrument of conveyance properly executed prior to the effective date of the adoption of this Code; or

B. The single lot, tract or parcel of land was shown on a recorded map, plat, drawing or survey prior to the adoption of this Code; or

C. The single lot, tract or parcel of land was shown on an unrecorded map, plat, drawing or survey, which was either registered with the Department of Business Regulation, Division of Florida Land Sales, prior to the effective date of the adoption of this Code or was certified by a land surveyor or engineer duly licensed by the State of Florida, prior to the effective date of the adoption of this Code; and

3. The single lot, tract or parcel of land shall meet the minimum property development regulations that are generally applicable in the district, except, however, the single lot, tract or parcel of land need not meet the minimum lot area and dimensions, minimum yard setback requirements, maximum lot coverage and maximum total floor area, but shall conform to the following minimum regulations:

A. Minimum Yard Setback Requirements

Front	30% of Depth
Side (Corner)	20% of Depth
Side (Interior)	15% of Depth
Rear	20% of Depth

B. Maximum Lot Coverage - 40% of Total Lot Area

C. Maximum Total Floor Area - - - -"

SOCIAL - ECONOMIC

A. POPULATION

The degree of growth in the C-51 basin is the variable which determines increased social costs to the existing taxpayers. The following table lists the approximate necessary financing for varying populations:

Per Capita Amounts of Selected City Finance Items by
Population-Size Groups
Fiscal Year 1969

Item	1,000,000 or more	500,000 999,000	300,000 499,999	200,000 299,999	100,000 199,999	50,000 99,000	Less than 50,000
General Expenditures, total	411	300	215	192	198	185	120
Education	85	50	41	26	37	36	12
Highways	20	21	18	21	19	19	19
Public Welfare	88	25	7	6	7	7	1
Hospitals	35	17	7	2	10	6	5
Health	12	8	3	2	3	2	1
Police protection	44	32	23	21	20	19	14
Fire protection	18	19	16	16	17	16	8
Sewerage	7	13	15	11	9	11	11
Sanitation other than sewerage	15	11	9	9	8	7	5
Parks and recreation	12	17	15	11	11	10	6
Housing & urban renewal	23	15	7	13	12	9	2
Libraries	5	4	4	4	4	3	2
Financial administration	5	5	4	4	3	3	3
General control	9	8	5	5	5	5	5
General public buildings	6	4	2	6	4	4	3
Interest on general debt	15	10	10	10	7	7	5
All other	47	36	30	25	20	21	19
Gross debt outstanding, total	678	399	404	401	307	270	225
Long-Term	602	356	361	353	268	238	215
Full faith and credit	400	253	219	199	168	144	92
Utility debt only	153	30	32	22	16	16	16
Nonguaranteed	202	103	142	153	100	95	121
Utility debt only	67	51	66	83	61	55	63
Short term	76	43	43	49	49	31	10

Source: Department of Commerce, Bureau of the Census.

In the case of C-51 population estimates, the total general expenditure, using the Palm Beach County Land Use Plan would require approximately $237,683,100*. On the other hand, as the area is developing with existing commitments and previously noted conflicts, this projected expenditure figure increases to approximately $411,881,184.* Of course these figures are offset somewhat by the increased

*Figures do not include Total Gross Debt Outstanding

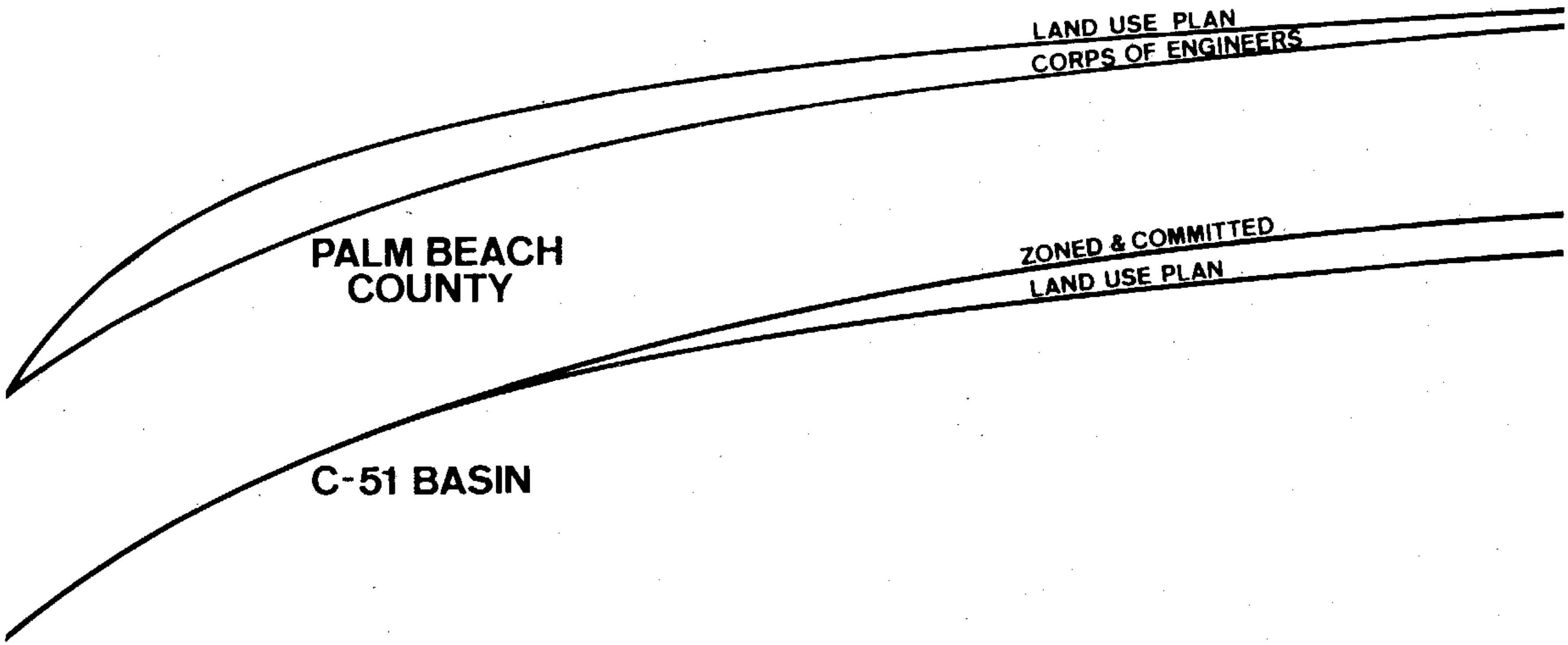


FIGURE 25

POPULATION PROJECTIONS

property tax base and, if upheld, Palm Beach County's proposed impact fee per dwelling unit. However, with this scale of growth the theory that bigger is cheaper is unfounded. The region, when viewed as a service area, with the projected growth will be operating at diseconomies of scale. Numerous studies and existing examples verify this conclusion.

Accepting the above, economic rationale would dictate that the C-51 basin should not develop. This, however, is not a realizable alternative. The implications of using exclusionary zoning have been ruled illegal by the courts. In National Land & Investment Co. vs Kohn, the court stated:

> "The question posed is whether the township can stand in the way of the natural forces which send our growing population into hitherto undeveloped areas in search of a comfortable place to live. We have concluded not. A zoning ordinance whose primary purpose is to prevent the entrance of newcomers in order to avoid future burdens, economic or otherwise, upon the administration of public services and facilities cannot be held valid."

The courts have, however, recognized zoning as a viable means of achieving orderly and compatible growth. Within this context, physiographic determinism can offer an objective method towards rational development. The theory of planning growth based upon the capability of natural processes was the formula used in the Palm Beach County Land Use Plan. In planning for optimum size or population, it stands to reason that at that point at which the increase of an additional person equals the marginal cost of securing services, the C-51 basin will then have achieved a saturation point. The finite natural resources in the area represent a tangible account above which point additional public costs make growth uneconomical and incompatible.

If the Land Use Plan is not followed and the growth is dependent upon the market system, the natural resources will be abused as a result of encouraging intensive use. The laissez faire market system will produce increased revenues but not value, as evidenced by the table above, with rising costs fixed incrementally to growth.

With excessive growth not only will the natural resources be stressed and the regional economy overburdened, but due to the existing flood-prone conditions of the basin, the public safety is also at stake. Flood protection is a component of the natural processes considered in the Palm Beach County Land Use Plan. Without government intervention in the form of zoning and land use controls, the area will develop to optimize market revenue conditions but the costs will be increased social costs, stressed natural resources and jeopardizing public safety.

The plan being considered herein provides the land use and water resource management framework needed for minimizing social costs, providing for development reasonably compatible with the natural resource base, and protecting the public safety and welfare. It is believed this is a valid statement despite the conflicts identified earlier herein with respect to land use.

B. FLOOD PROTECTION

The major consideration in the Congressional authorization of the water resources management plan for the C-51 watershed is the flood damage prevention benefits which will be realized. This authorization is consistent with long standing Federal policy in regard to national responsibility for provision of those measures and/or assistance necessary to minimize flood damages and the social disruptions and economic losses consequent to flooding occurrences.

A new national approach in regard to flood protection has been recommended by the National Water Commission in its recent report. The thrust of that recommendation, if reflected in national policy, will be to place a greater share of the burden of cost of flood protection measures on those who will directly benefit. There is no implication therein that structural measures are not applicable to the very real flood protection problem; the suggested new approach deals basically with the question of relative cost burden.

The water resources element of the combined plan being reviewed herein clearly is in conformity with existing national policy, since it has been authorized for construction at the Federal level. It will be useful, however, to examine the combined plan, which includes both structural facilities and institutional measures of land use regulation, in the context of what may eventually become a national policy approach.

The map "Flooded Area, 1947 with 1960 Drainage Facilities", shows the areas which are susceptible to flooding of the type which has been experienced in the recent historical past. Data presented elsewhere herein have indicated past flood stages and flood stage durations. The critical flooding hazard area is the already rather heavily urbanized area east of the Turnpike.

Examination of the runoff data presented in an earlier section shows that to reasonably eliminate the flood hazard in this area, runoff rates from the watershed west of the Turnpike would have to be reduced to values <u>less</u> than those which that area generated 13-14 years ago; that is, to approximately 1/2" per day. In effect, another large water retention area, or areas, would be required west of the Turnpike or west of S.R. #7 to accomplish reduction in the flood hazard to developed areas to the east.

If the reasonable assumption is made that an appropriate function of government, at whatever level, is to seek the means to reduce the flood hazard in developed areas, it appears that this problem in the eastern portion of the C-51 watershed must be positively addressed. It is clear that institutional control measures alone, in the western portion of the watershed, are insufficient to accomplish a flood hazard reduction objective in the eastern urbanized areas. Because of the large land areas required (25% or more of the total land area west of the Turnpike) and on which positive runoff control would be necessary, it is more than likely that any institutional controls specifying these requirements would be considered confiscatory.

Some combination of structural measures and institutional controls is a logical framework, therefore, for achieving a flood hazard reduction objective in the eastern portion of the basin. This reduction can only be accomplished by lowering flood stages in C-51 itself; this is the function of the structural element of the plan. The function of the institutional element of the plan is to preserve the integrity of the structural function.

A well conceived institutional element will serve the purpose of placing a greater share of the cost burden on those who will benefit, or on a general category of beneficiaries; i.e., the users of the complete system. Such a distribution of costs, as noted earlier in this section, is an objective of the new national policy approach suggested by the National Water Commission.

The combined plan being reviewed requires runoff retention for several reasons as discussed in previous sections. Some lands in the western portion of the basin will have to be reserved for, and other lands periodically committed to, flood runoff retention. Because of the structural measures which reduce C-51 flood stage, the amounts of land so reserved and committed do not represent an onerous burden on private property rights. Moreover, the costs for such reservation and commitment are borne by the ultimate consumer; i.e., the homeowner in the watershed. Required flood water retention is obtained not at public cost, but at a cost borne in the public sector; by the user of the system. Flood hazard reduction is obtained not at complete public cost (as might be the case with a C-51 plan designed for a 4"/day runoff removal rate) but at a combined public-private cost.

The direct and immediate beneficiaries of the combined water resources management-land use plan for the watershed can be identified by reference to the flooded area map (Figure 19). This area is that which was flooded in 1947 and would be flooded again with a recurrence of that event. Flood durations would range from 15 to 120 days with a storm having a 30 year frequency of occurrence. A population of about 44,000 is presently resident in the area, with approximately 15,700 dwelling units.

Admittedly, the direct and immediate beneficiaries (the urban residents east of the Turnpike) are not bearing a "user's cost" burden. However, considering the entire watershed as a unit, and all residents of the watershed (present and future) as users, this general category of beneficiaries will be bearing a share of the total system cost.

It can be demonstrated, then, that a combined water resources management - land use plan of the general type being reviewed, is consistent in flood damage prevention terms with both present national policy and what may well become future national policy. It may be consistent as well with the not yet clearly articulated State policy concerning such questions.

It is necessary to indicate here a particular circumstance relating to flood protection the existence of which must be acknowledged. The Soil Conservation Service has completed a Work Plan for the Loxahatchee Drainage District, involving flood protection and improved water control in that district. That plan is entirely consistent with the C-51 water resources management plan. However, further progress on implementing the Loxahatchee Drainage District plan, which was completed several years ago, is being held in abeyance. The Soil Conservation Service will not proceed without the approval of the Flood Control District. The Flood Control District will not, and can not grant approval unless the C-51 water resource management plan is approved for construction.

C. WATER SUPPLIES

This is a regional consideration and not strictly a local one. However, there are local implications which must be noted before passing on to regional concerns.

As pointed out in the Interim Water Quality Management Plan for Palm Beach County, the West Palm Beach Metropolitan Area is the "hottest housing market in the country." It states that in fact, it is "the hottest in U. S. history." The rate of growth for this area has been projected to be 450% of the national average and 15% higher than the Disney World impacted Orlando area. This trend can only be expected to continue since the factors creating the situation are still very much at work. South Florida is still the haven of sunshine and warmth for the retiree in the eastern half of the United States. This group is usually able to afford on a single commitment basis the high real estate prices and therefore is not easily deterred from keeping a great deal of development pressure on the lands of the C-51 basin, as well as on the remainder of south Florida.

The shallow aquifer in Palm Beach County is not near the limit, at present, of what it can safely produce to meet the water needs of an increasing population. Local stresses may occur, but on an overall basis there is no apparent immediate threat of "running out of water." The rough computation outlined on page 17 of this report indicates this. It must, however, be borne in mind that there will be increasing problems in terms of water quality as the groundwater west of the coastal ridge is developed, as noted on page 32 of this report.

The important point to be made is that the development pressures cited in the Interim Water Quality Management Plan for Palm Beach County must be acknowledged. Prudent planning should take this into account, as well as the possible groundwater quality problems, and consider the possible, if not probable, need for development of additional surface water supplies for use within Palm Beach County. The volumes of water being drained easterly in C-51 annually are a loss in terms of serving a beneficial use. They represent a partially recoverable resource which can be conserved; a portion of which, in turn, can be placed to beneficial use within Palm Beach County.

This potential need within Palm Beach County may be considered by some as being somewhat remote in time. In regional terms one is dealing with a more immediate problem. One example may suffice.

A critical situation with respect to lowered groundwater levels has existed for years in south Dade County. This condition has been documented in several reports prepared by the U. S. Geological Survey. It results from the generally low land elevations and the high rates of evapotranspiration loss from the groundwater table. This condition results even with moderately deficient rainfall. Under more severe droughts groundwater levels along the coast and in a portion of Everglades National Park are depressed below sea level.

The "Water Resources Plan", an addition to the Central and Southern Florida Project authorized by the Congress in 1968, included provisions for delivery of water to south Dade County and the lower portion of Everglades National Park to sustain groundwater levels and protect the Biscayne Aquifer. In a monetary authorization bill in 1970 the Congress mandated that construction be started on this delivery system within five years. Contracts will be let during the current fiscal year.

But this is only the "plumbing system." The availability of water to meet these needs is another question. A detailed study made by the District in cooperation with the U. S. Geological Survey indicated that during a critical once in ten year frequency drought a sustained flow at the rate of at least 1000 cfs. would be needed for approximately 5 months to maintain adequate groundwater levels in that area and to protect against saline encroachment.

The volume of water required is substantial. Water recovered from the C-51 watershed by backpumping would, in part, be available to meet this requirement and, more surely, the lesser requirements under less severe drought conditions.

This is not an isolated example, although it is undoubtedly one which involves the largest volumes of water. The need presently exists to transfer water from surface storage areas (the conservation areas and Lake Okeechobee) to the Broward and Dade County coasts to protect municipal water supplies during extremely deficient rainfall periods. Deerfield Beach, Pompano Beach, Fort Lauderdale and Miami are numbered among those municipalities which rely to varying degrees on the ability of the regional water management system to deliver water to their well fields during drought periods such as 1970-71. Again, the regional benefits of the recovery and storage of water generated on the C-51 watershed is apparent in these cases.

D. COSTS

1. Public: This section simply tabulates for this record the estimated cost of implementing the water resources element of the plan. Costs are based on 1972 price levels.

	Federal	Non-Federal	Total
Initial Cost	$12,248,000	$5,590,000	$17,838,000
Annual Cost	432,000	348,300	780,700

Initial Federal costs consist entirely of a contribution to construction costs. Non-Federal initial costs consist of a share of construction costs ($1,674,000) and all lands and relocations costs ($3,916,000). The former represents the total State contribution from the General Revenue Fund. The latter costs are funded from the District-wide ad valorem tax.

Of the $348,300 non-Federal annual cost, $161,000 is operation and maintenance cost. This cost, again, is funded from the ad valorem District tax.

Proportional Federal, State and District contributions to initial cost are:

Federal	69%
State	9%
District	22%
	100%

It is of more than passing interest to examine these annual costs in terms of the amount of water which can be recovered and has the potential of being put to beneficial use. In the "Water Resources Plan" cited in a previous section of this report, a value of $30 per acre foot was placed on water developed and stored by the Central and Southern Florida Project. It can be assumed this value is sanctioned by the Congress since it adopted that plan and authorized its construction. The maximum and minimum average annual amounts of water which can be recovered and stored by the C-51 water resource management plan are 366,000 acre feet and 72,000 acre feet respectively. Annual costs of the C-51 plan are $780,700. Costs per acre foot, then, would range from about $10.80 to about $2.10. These costs are to be compared with the value of $30.00/acre foot.

2. Private: This section will give an indication in general terms only of flood damage costs in the private sector which will be incurred as a consequence of failure to implement the water resources management portion of the C-51 watershed plan. It is illustrative and only representative of a "typical" pattern of residential development.

The flooded area map indicates that with a recurrence of the 1947 flood a substantial area west of Military Trail, both north and south of C-51, would be flooded. The major portion of this area would be flooded to depths up to 1.5 ft. and for a 15 day duration. Using the damage-depth and damage-duration curves presented in the Corps of Engineers report, the damage per dwelling unit in this area would be on the order of $1300. At four dwelling units per acre (single family residences) damages in this area would be at the rate of about $5,000 per acre.

SUMMARY OF RECOMMENDATIONS

1. That subdivision regulations be modified, as necessary, to require the design of internal, on-the-land drainage systems to be such as to positively limit peak runoff rates to the values established by the Flood Control District.

2. That agreement be reached between the Flood Control District and the governmental agencies having jurisdiction over subdivision approval as to the method to be used for runoff calculations, and that internal drainage system design and calculations be certified by registered professional engineers and be approved by both the local agency having jurisdiction and the Flood Control District.

3. That the Lake Worth Drainage District and the Flood Control District agree as to the size and method of operation of structures to be installed in the equalizing canals at the C-51 drainage divide; to be installed at Lake Worth Drainage District cost.

4. That a complete report by a registered professional engineer be furnished the Flood Control District by the Village of Royal Palm Beach - Indian Trail Ranch on the design and functioning of that internal drainage system.

5. That the Village of Royal Palm Beach - Indian Trail Ranch agree to provide those facilities and/or to modify its internal drainage system to the extent necessary to ensure, to the satisfaction of the Flood Control District, that the design performance of C-51 will not be impaired by the functioning of the Village of Royal Palm Beach - Indian Trail Ranch system.

6. Require the installation of interior water level control structures within the Village of Royal Palm Beach - Indian Trail Ranch drainage system unless it can be demonstrated to the satisfaction of the Flood Control District that lack of such controls will not materially affect groundwater loss.

7. Require the installation in this area, by the Village of Royal Palm Beach - Indian Trail Ranch interests, of a groundwater level monitoring network adequate to provide the data base for shallow groundwater management in the area.

8. Develop criteria, on an ecological basis, for defining environmentally desirable areas and require that such areas remain in their existing state under development plans which are subject to local governmental approval.

9. Incorporate in subdivision regulations requirements that construction of storm drainage facilities be designed in such a way as to minimize water quality degradation.

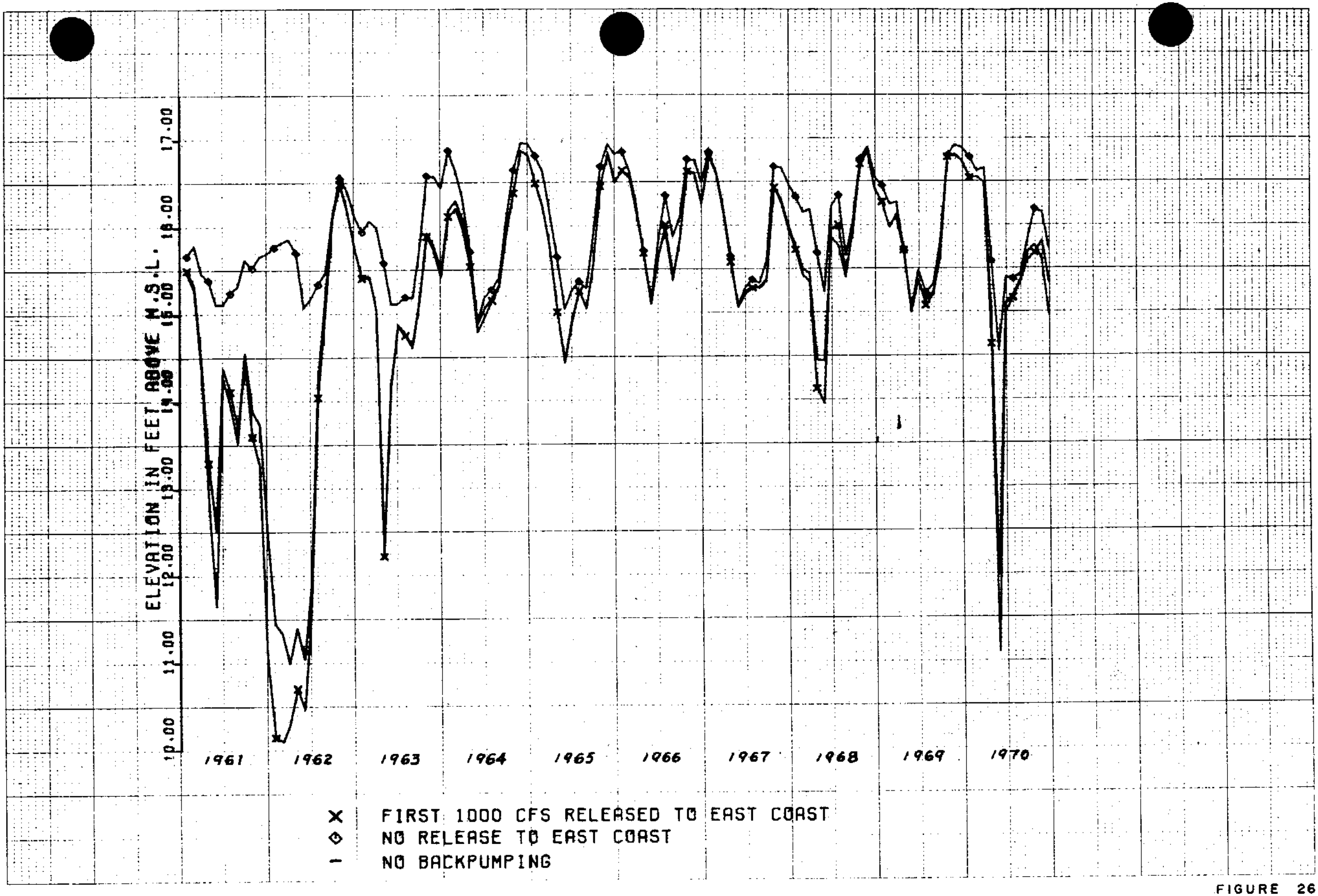
10. Provide the Flood Control District with the authority necessary to withhold the issuance of storm runoff permits from those developments which do not incorporate on-site storm water management techniques for control of storm runoff water quality.

11. Incorporation of a telemetered water quality monitoring system in the plan, including a minimum of two stations; one in the L-8 canal north of S.R. #80 and one in C-51 about 1/2 mile east of Twenty-Mile Bend.

12. Immediate collection of water quality data in C-51 and L-8 canal related to storm events, to be used in developing operational guidelines for backpumping based on water quality considerations.

13. Reconsideration and expansion of the use of the "Conservation and Preservation" designation for lands in the C-51 watershed.

14. Either by agreement or by legislation place the municipalities in the C-51 watershed under the provisions of the County's Land Use Plan.



ELEVATION IN FEET ABOVE M.S.L.
17.00
16.00
15.00
14.00
13.00
12.00
11.00
10.00
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
X FIRST 1000 CFS RELEASED TO EAST COAST
◇ NO RELEASE TO EAST COAST
— NO BACKPUMPING

FIGURE 26

STAGE IN CO RVATION AREA NO. 2 (GAGE S-

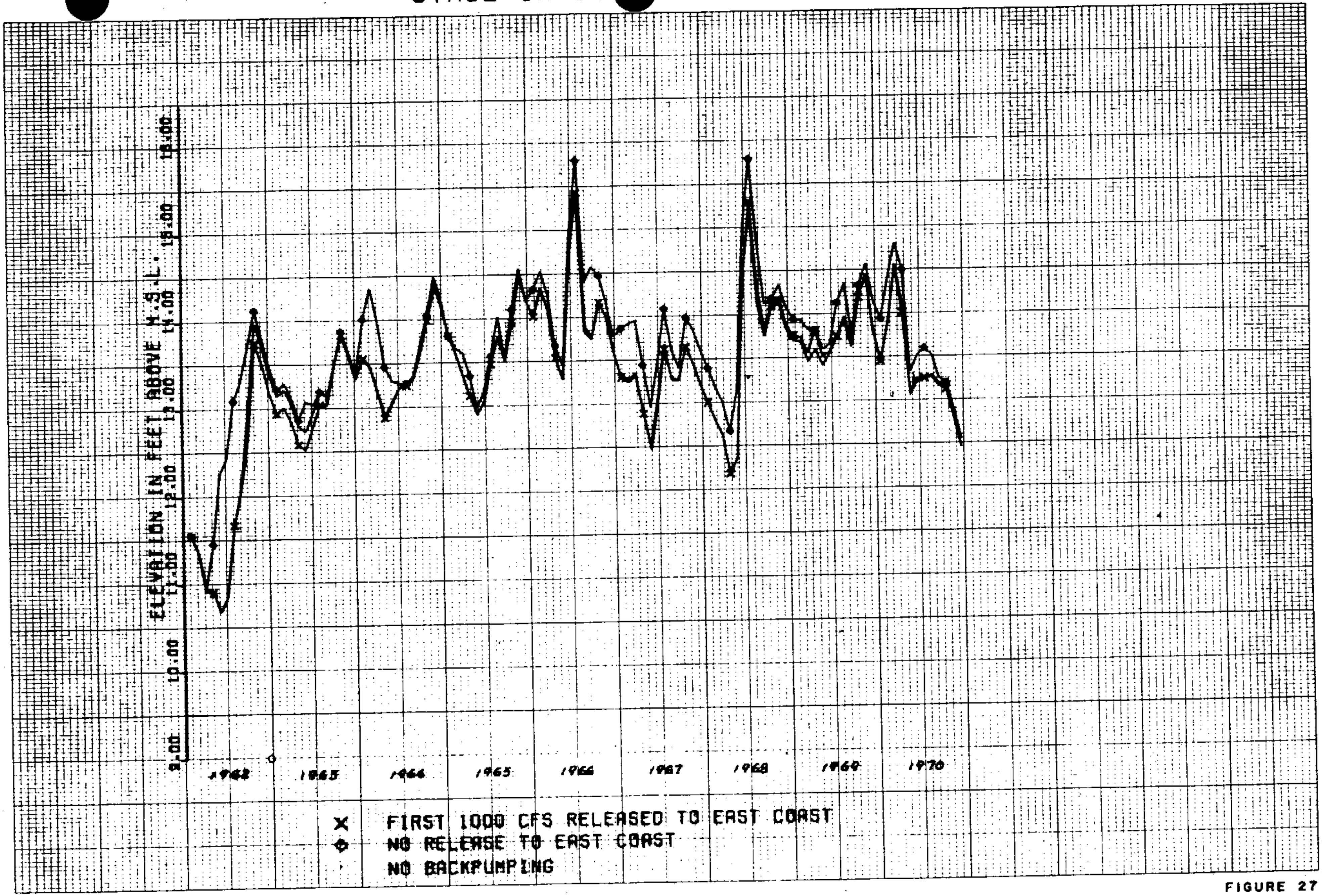


FIGURE 27

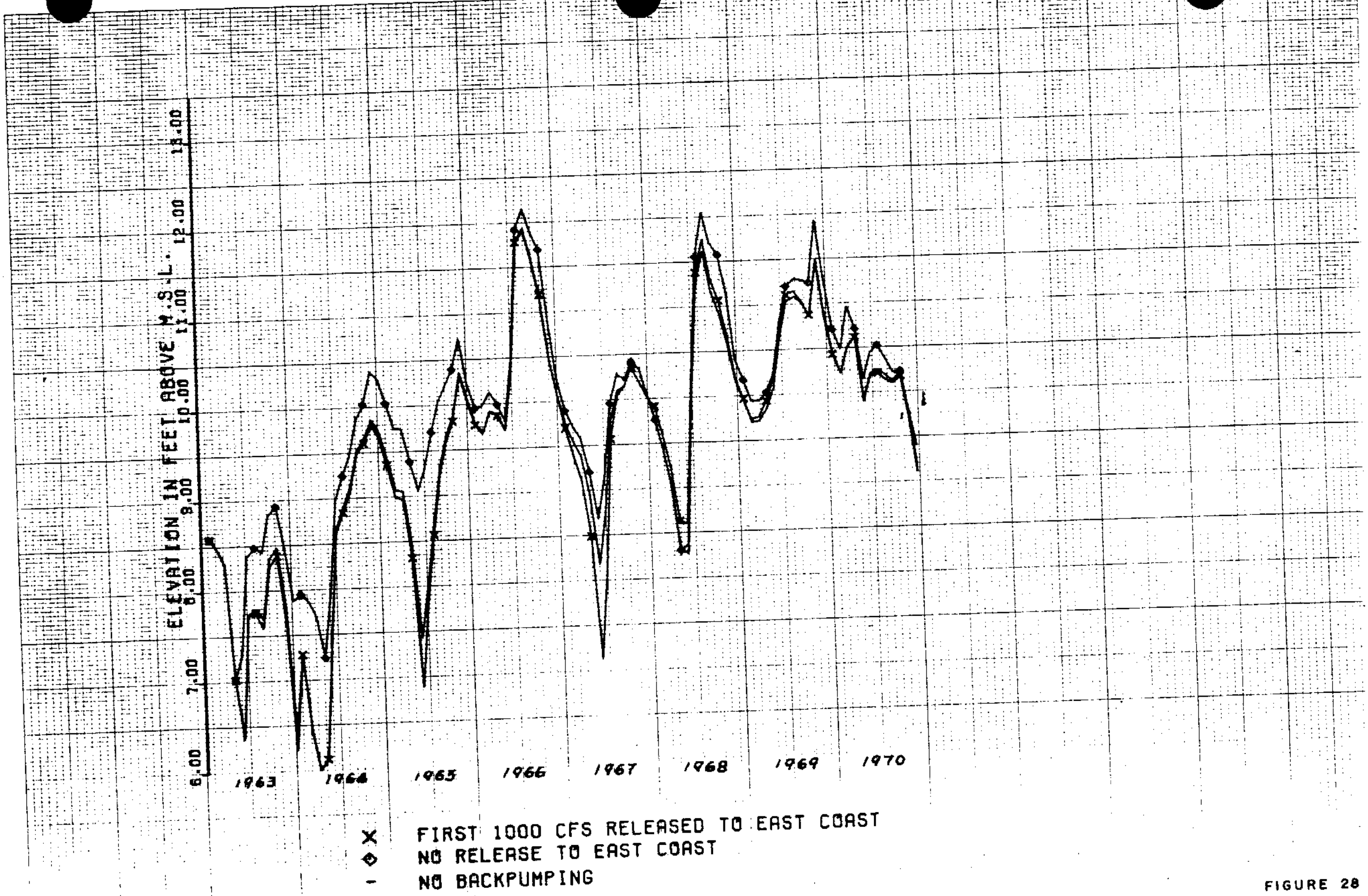
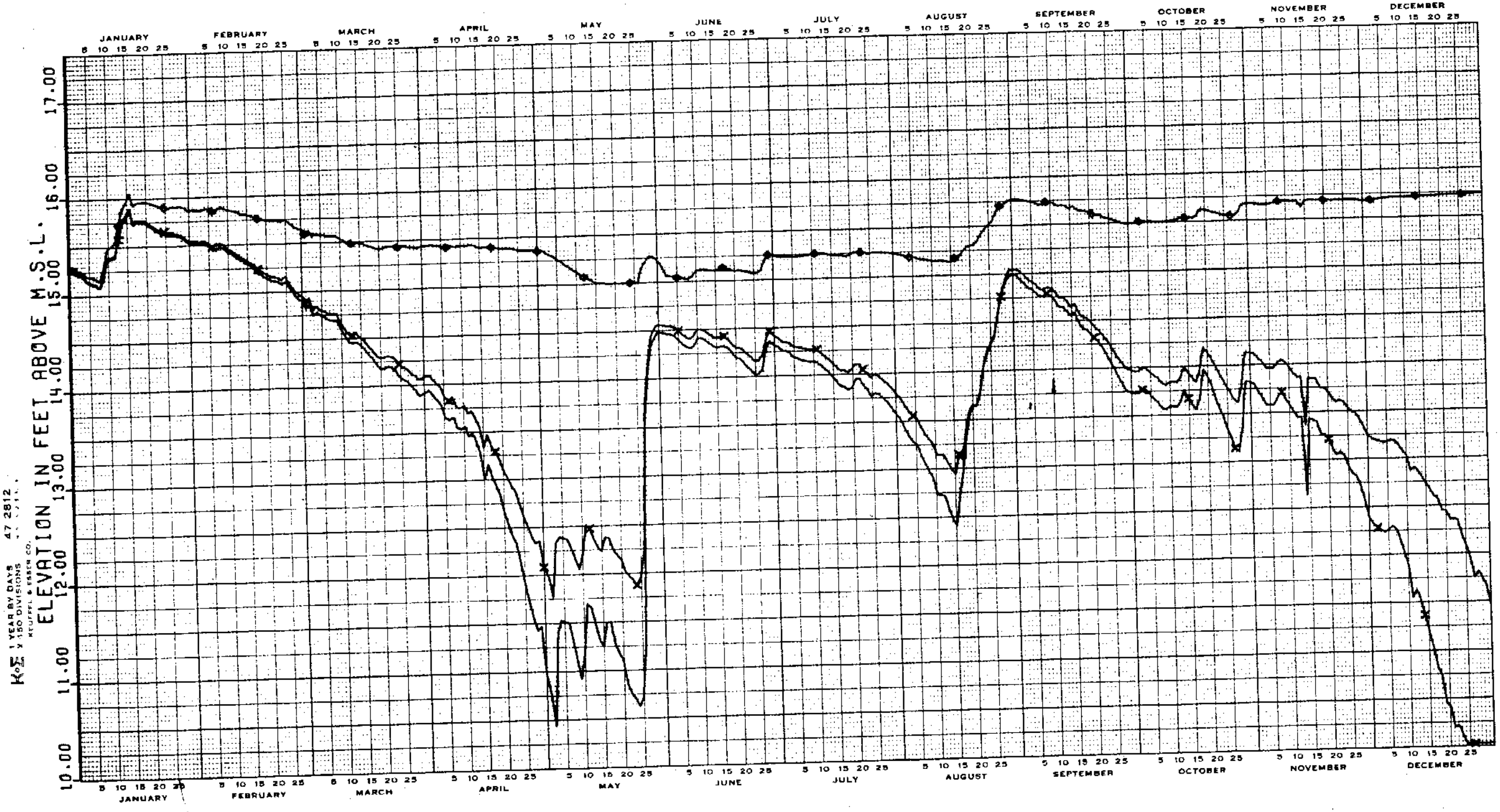

ELEVATION IN FEET ABOVE M.S.L.
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
1963
1964
1965
1966
1967
1968
1969
1970
X FIRST 1000 CFS RELEASED TO EAST COAST
◇ NO RELEASE TO EAST COAST
- NO BACKPUMPING

FIGURE 28

STAGE IN CONSERVATION AREA NO. 1

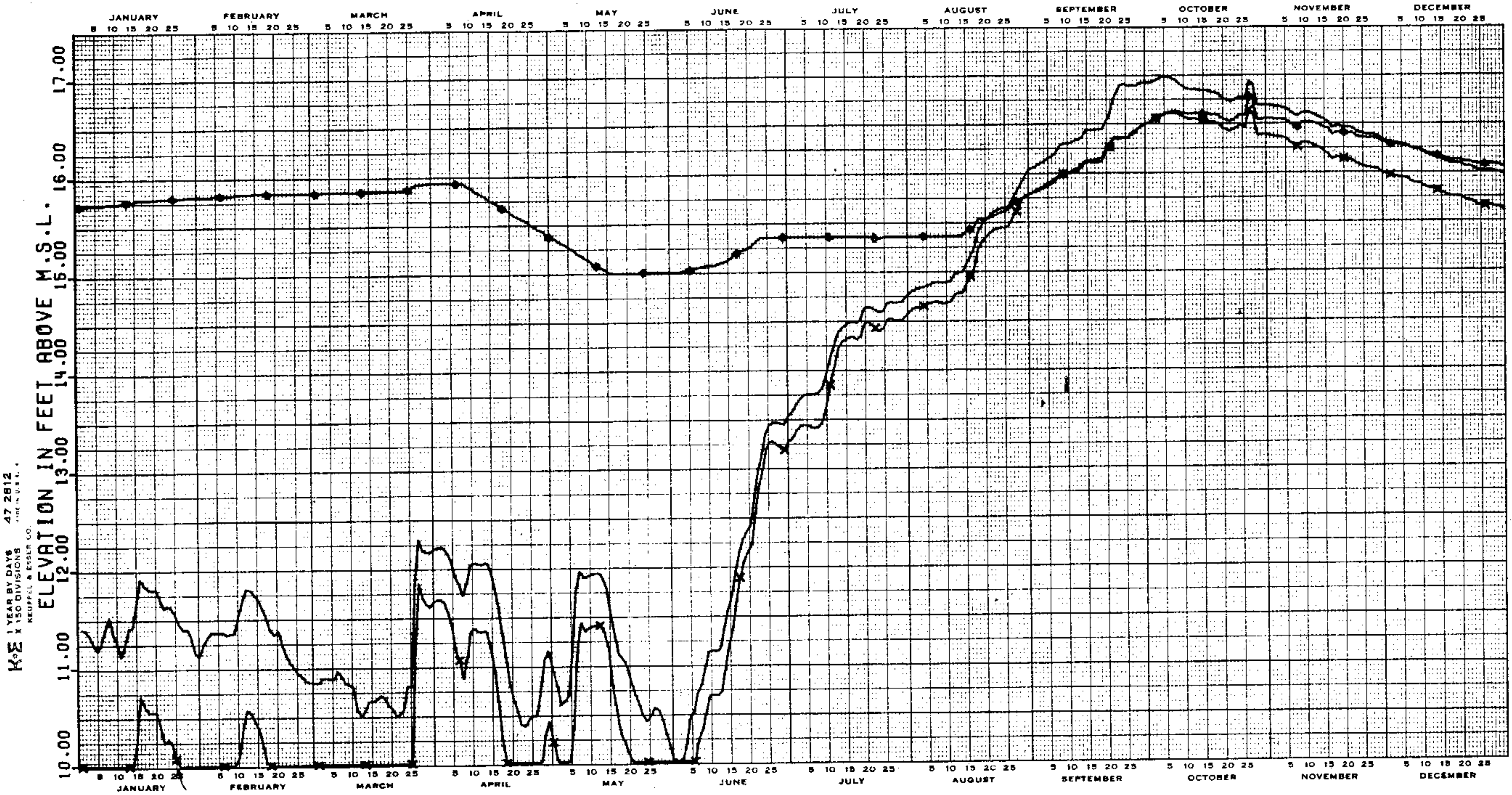
YE 1961



× FIRST 1000 CFS RELEASED TO EAST COAST
◇ NO RELEASE TO EAST COAST
— HISTORICAL STAGE

FIGURE 29A

YE 1962



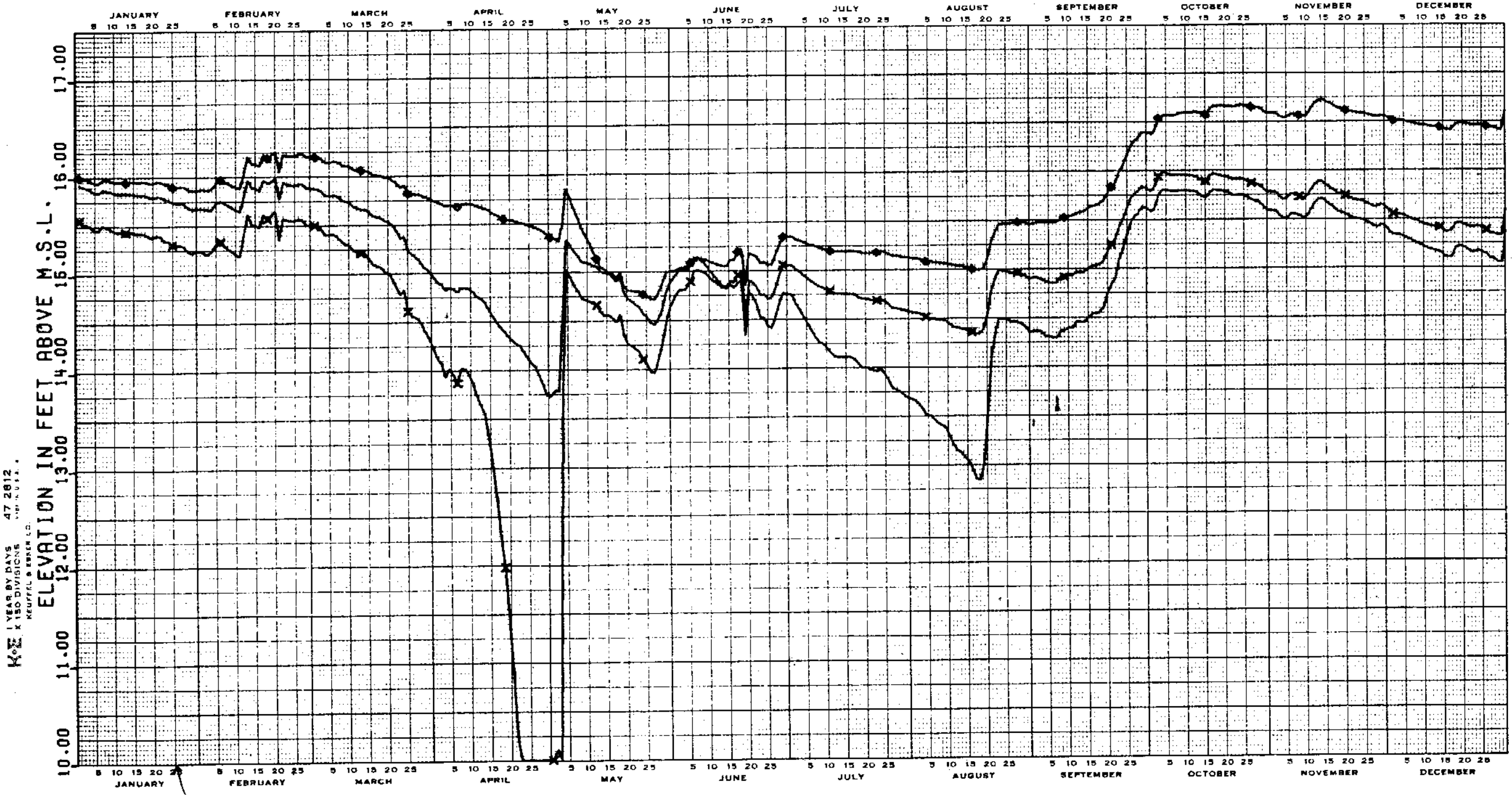
× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

— HISTORICAL STAGE

FIGURE 29B

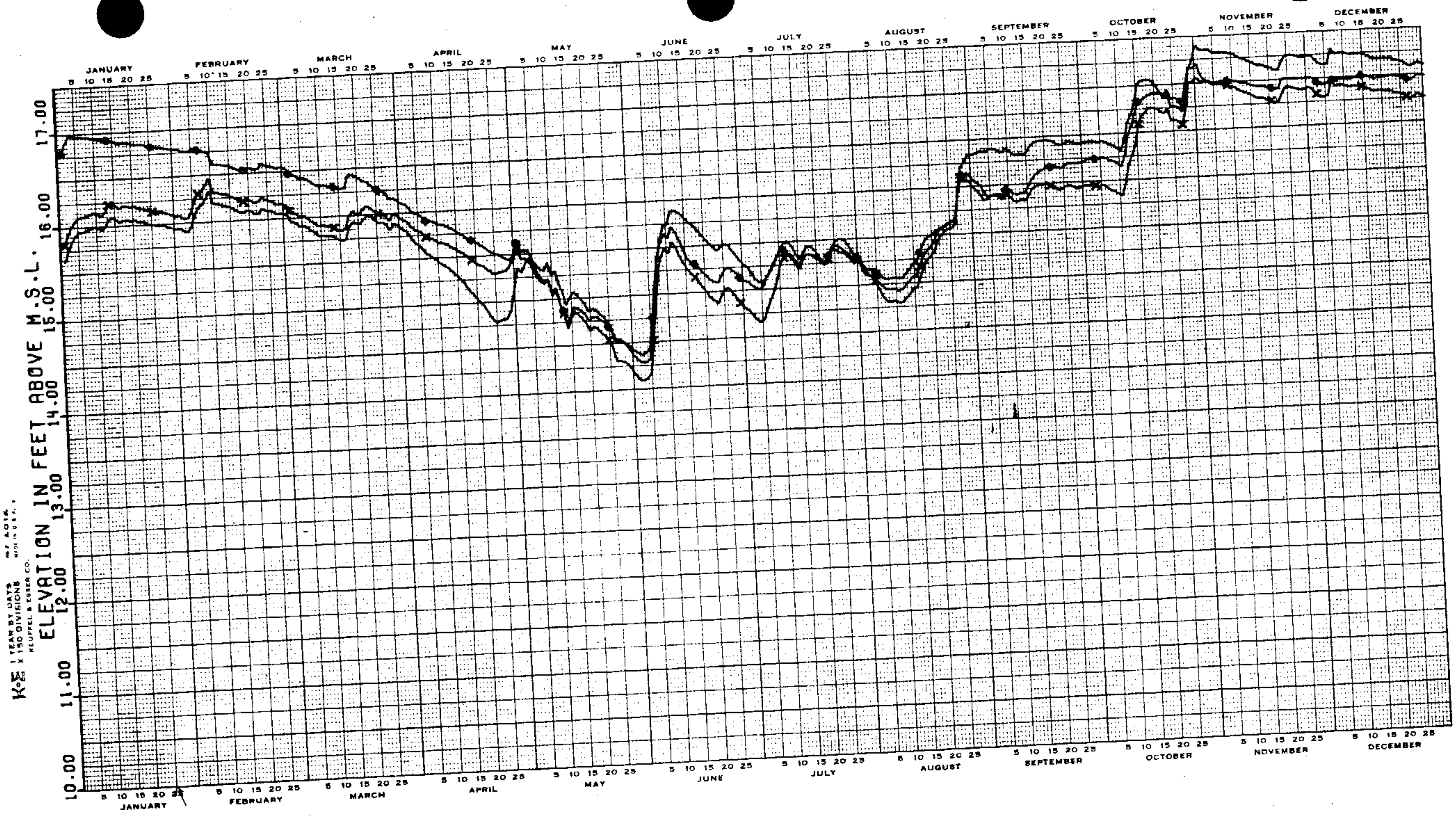
YE 1965



× FIRST 1000 CFS RELEASED TO EAST COAST
◊ NO RELEASE TO EAST COAST
— HISTORICAL STAGE

FIGURE 29C

YEA 1964



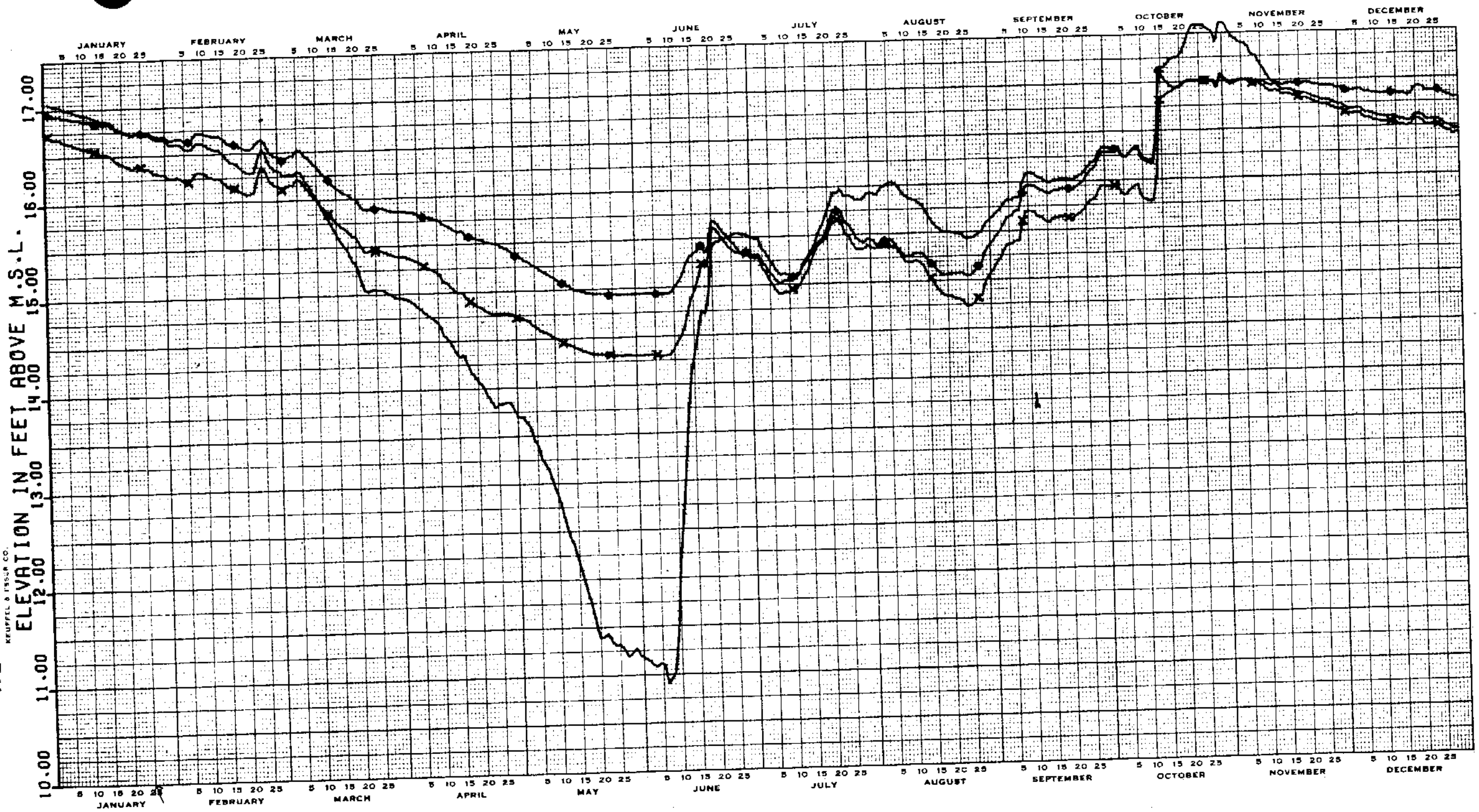
× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

— HISTORICAL STAGE

FIGURE 29D

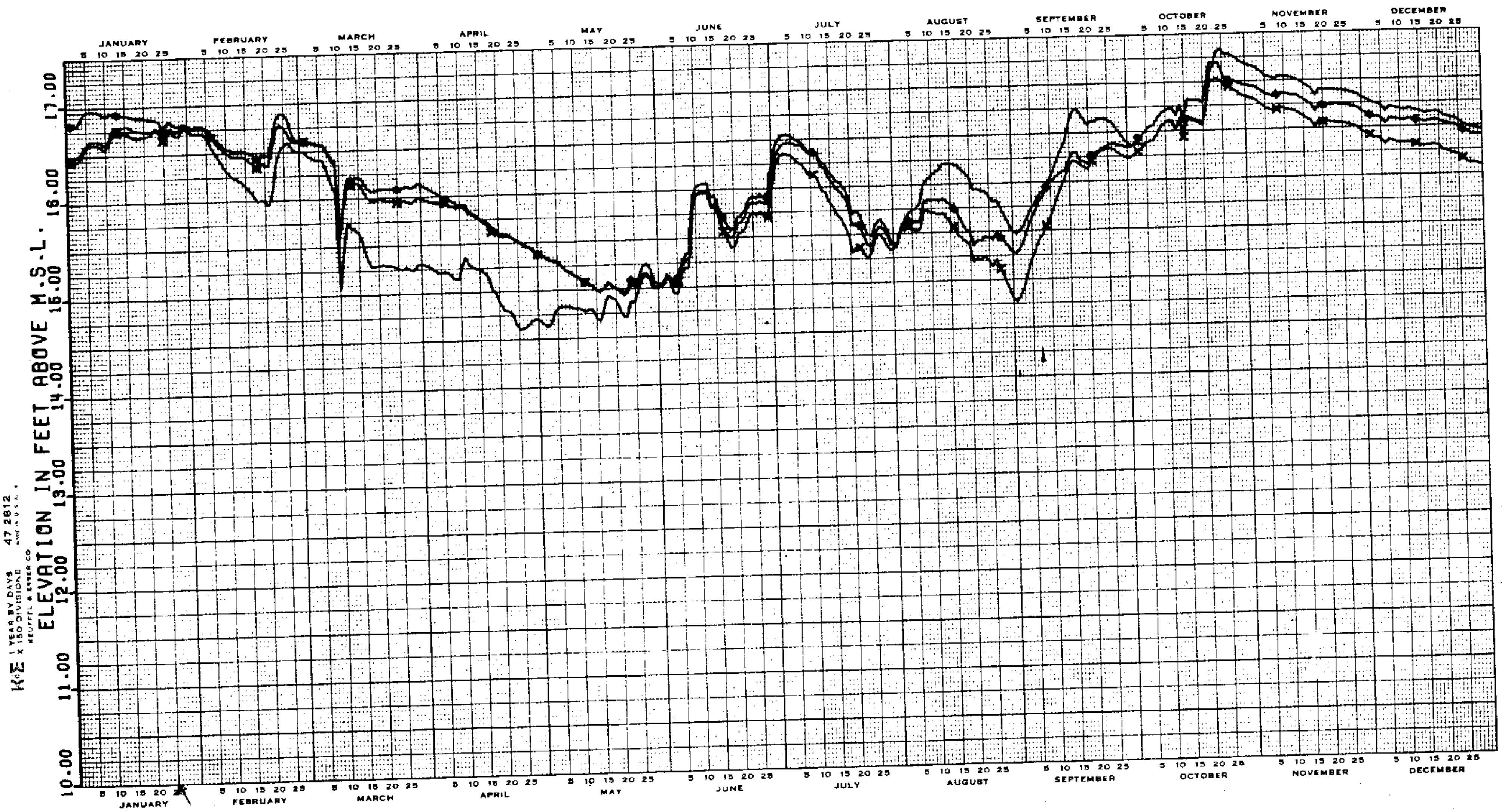
YEAR 1965



× FIRST 1000 CFS RELEASED TO EAST COAST
◇ NO RELEASE TO EAST COAST
— HISTORICAL STAGE

FIGURE 29E

STAGE IN CONSERVATION AREA NO. 1 (GAGE 1-8)
YEAR 1966

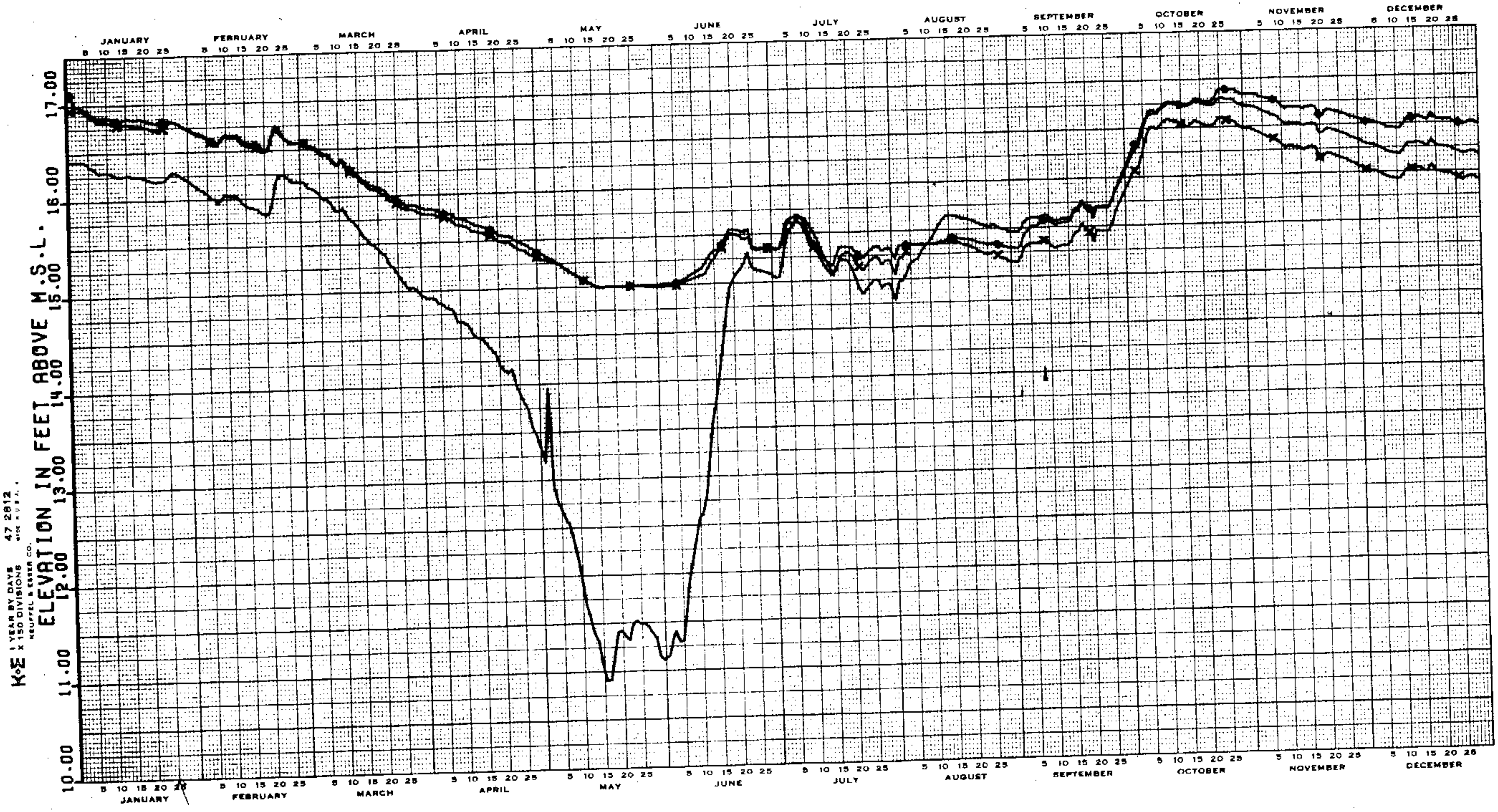


× FIRST 1000 CFS RELEASED TO EAST COAST
◇ NO RELEASE TO EAST COAST
— HISTORICAL STAGE

FIGURE 29F

STAGE IN CONSERVATI[illegible] AREA NO. 1 (GAGE 1-8)

YE[illegible] 1967

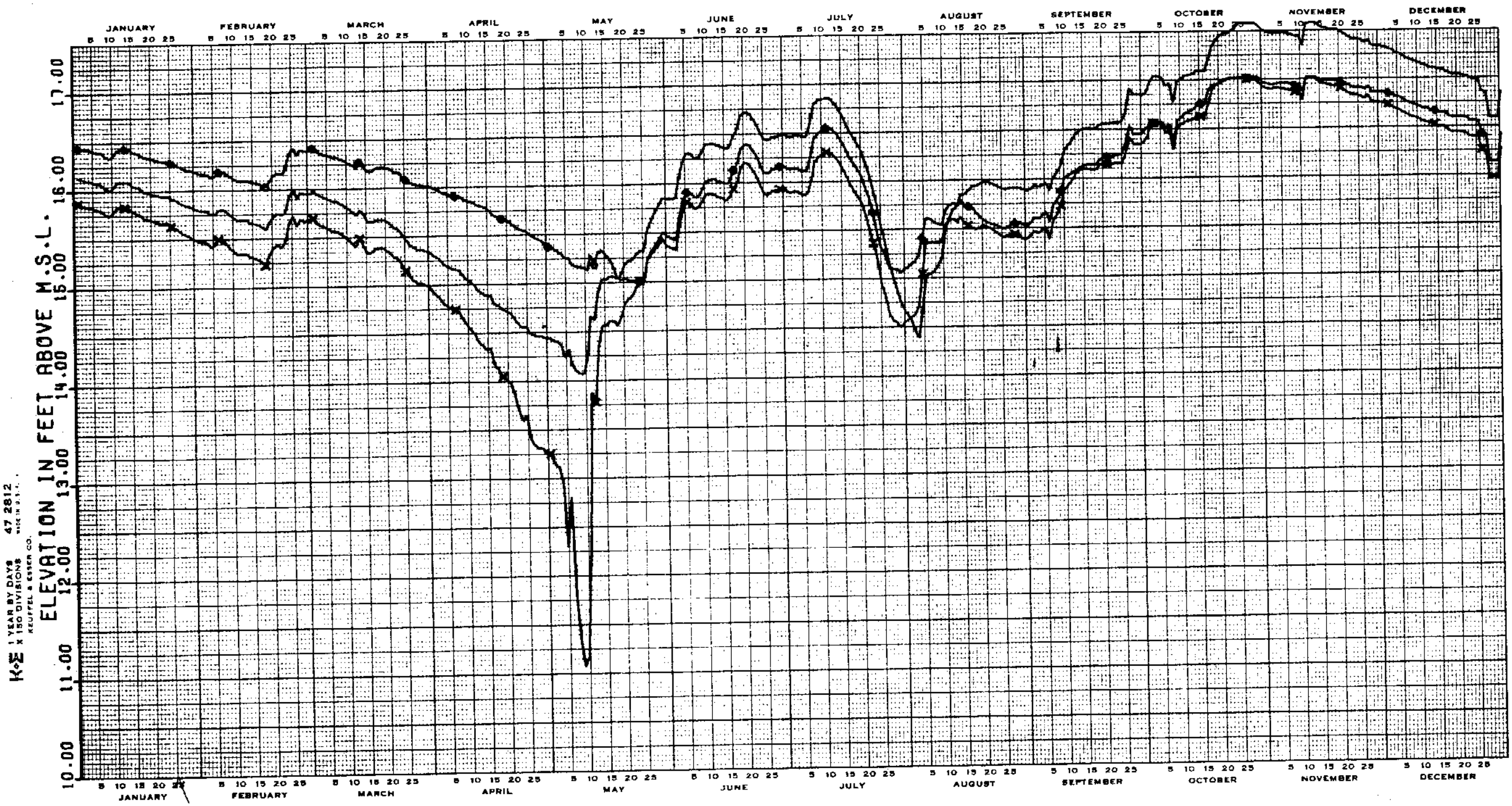


× FIRST 1000 CFS RELEASED TO EAST COAST
◇ NO RELEASE TO EAST COAST
— HISTORICAL STAGE

FIGURE 29G

STAGE IN CONSERVATI AREA NO. 1 (GAGE 1-8)

YEAR 1968

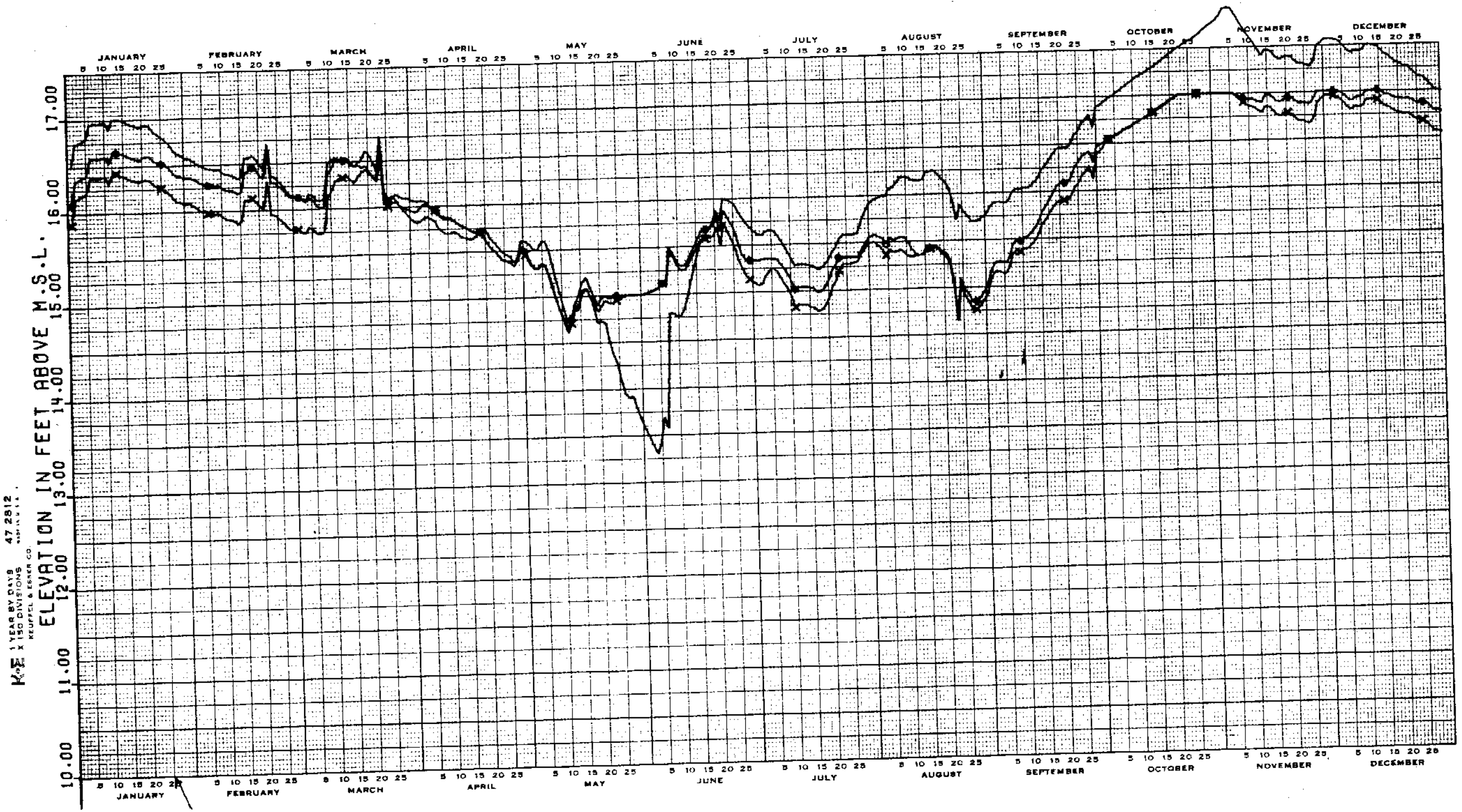


× FIRST 1000 CFS RELEASED TO EAST COAST
◇ NO RELEASE TO EAST COAST
— HISTORICAL STAGE

FIGURE 29H

STAGE IN CONSERVATI[...] AREA NO. 1 (GAGE 1-8)

YEAR 1969



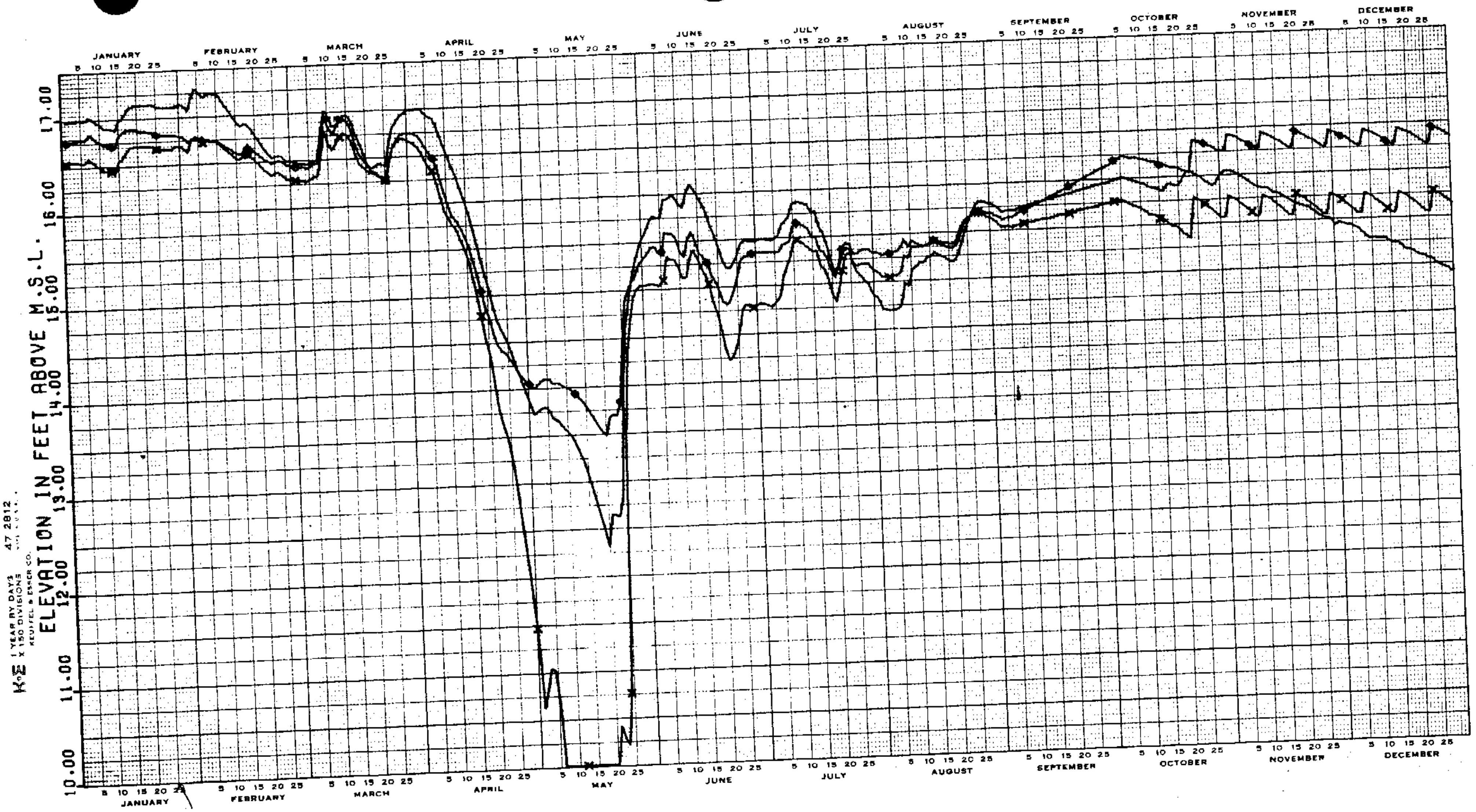
× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

— HISTORICAL STAGE

FIGURE 291

YE 1970



× FIRST 1000 CFS RELEASED TO EAST COAST

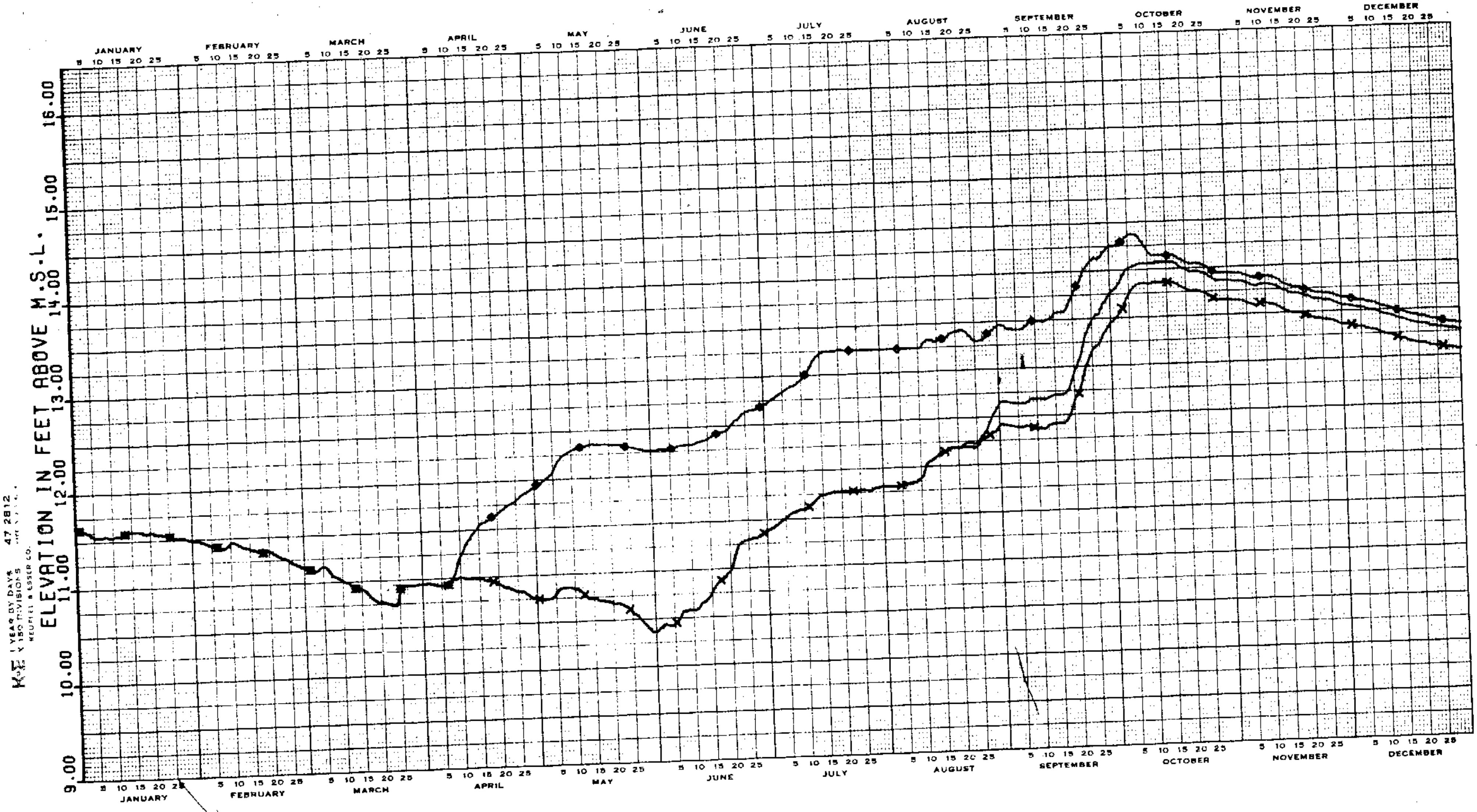
◊ NO RELEASE TO EAST COAST

— HISTORICAL STAGE

FIGURE 29J

STAGE IN CONSERVATION AREA NO. 2 (GAGE 3-30)

YEAR 1962



× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

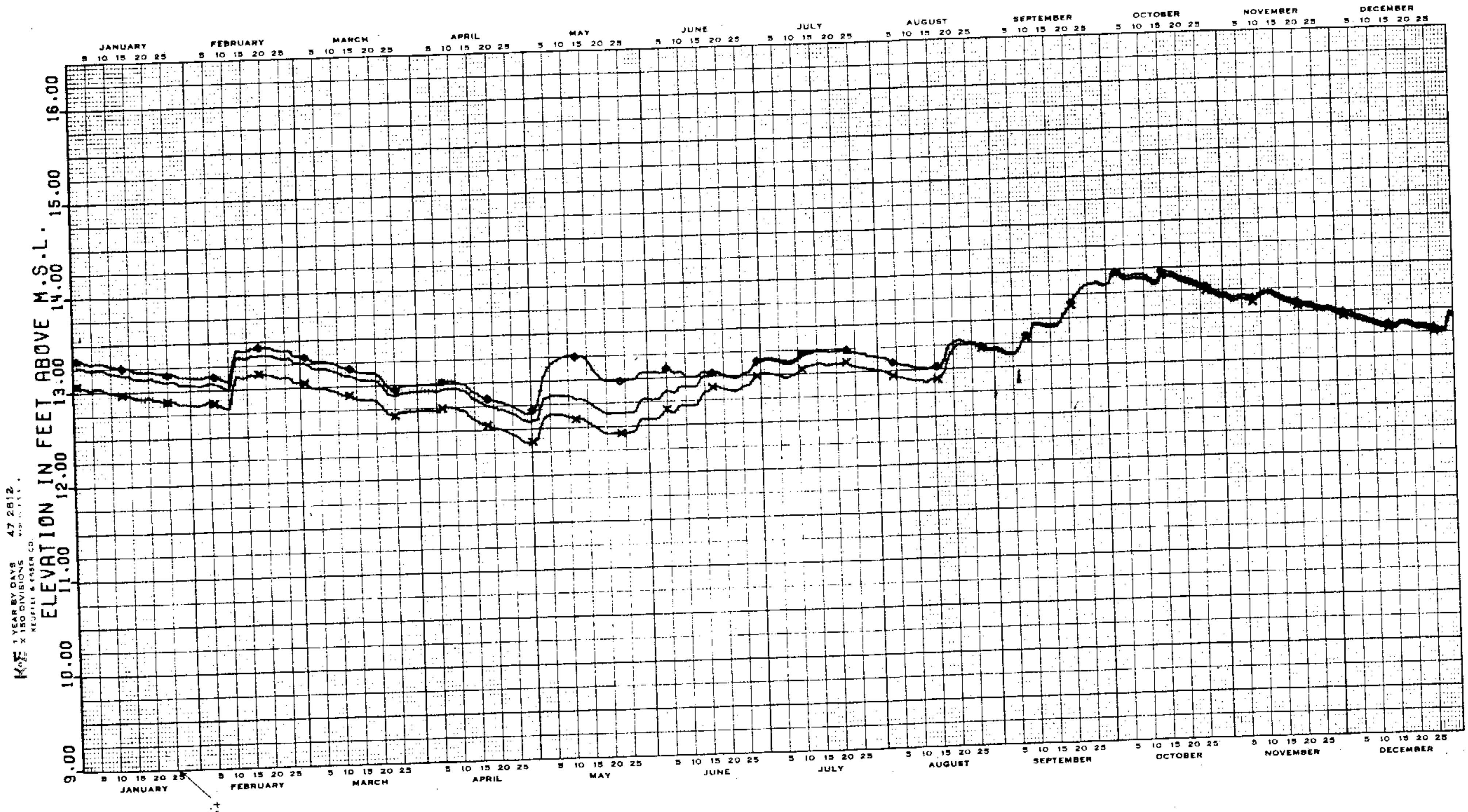
· NO BACKPUMPING

30 A

FIGURE 30A

STAGE IN CONSERVATI[illegible]

YE[illegible] 1963



× FIRST 1000 CFS RELEASED TO EAST COAST

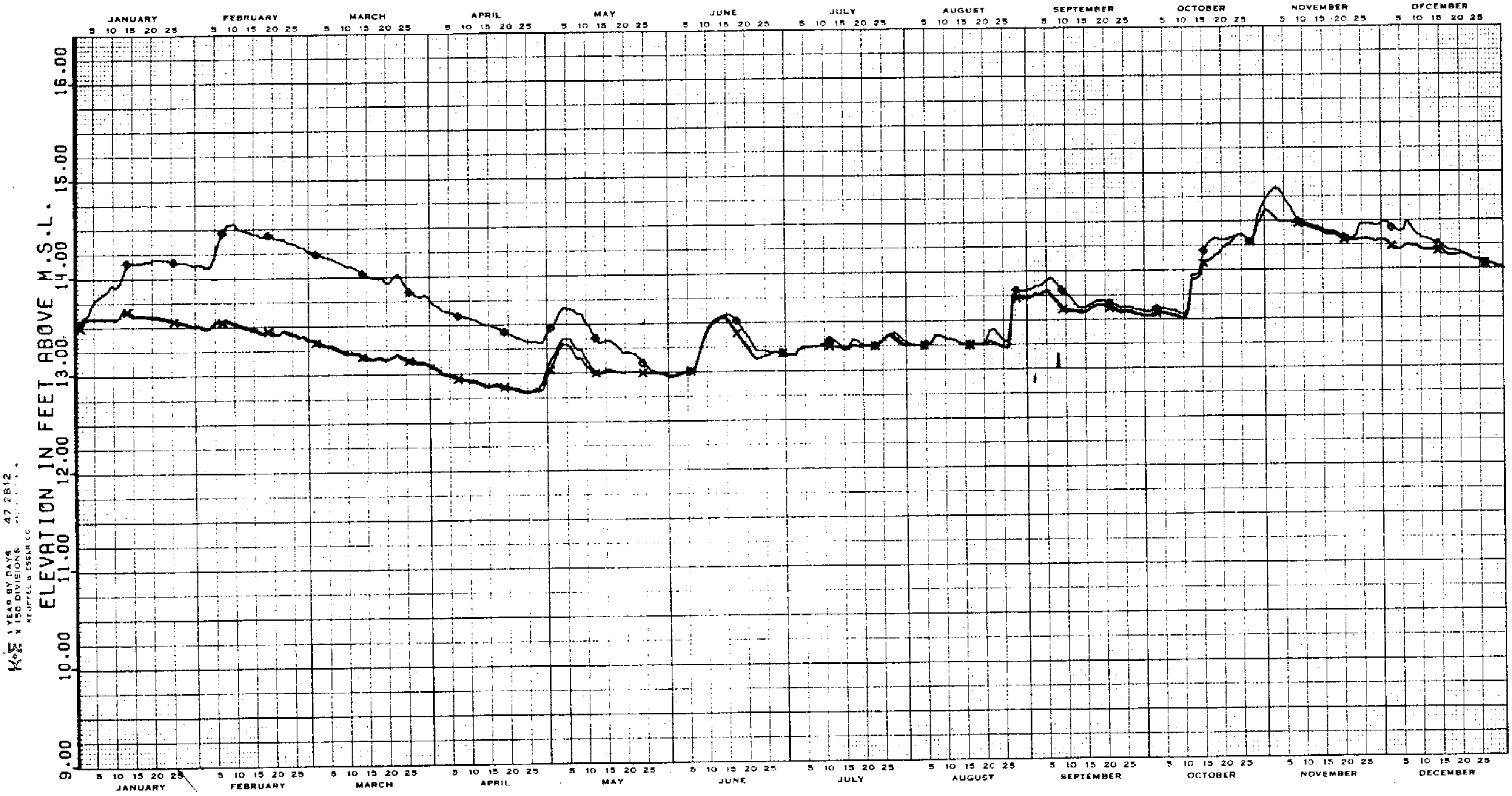
◇ NO RELEASE TO EAST COAST

NO BACKPUMPING

FIGURE 30B

STAGE IN CONSERVATI[ON] AREA NO. 2 (CASE 3-30)

YEAR 1964



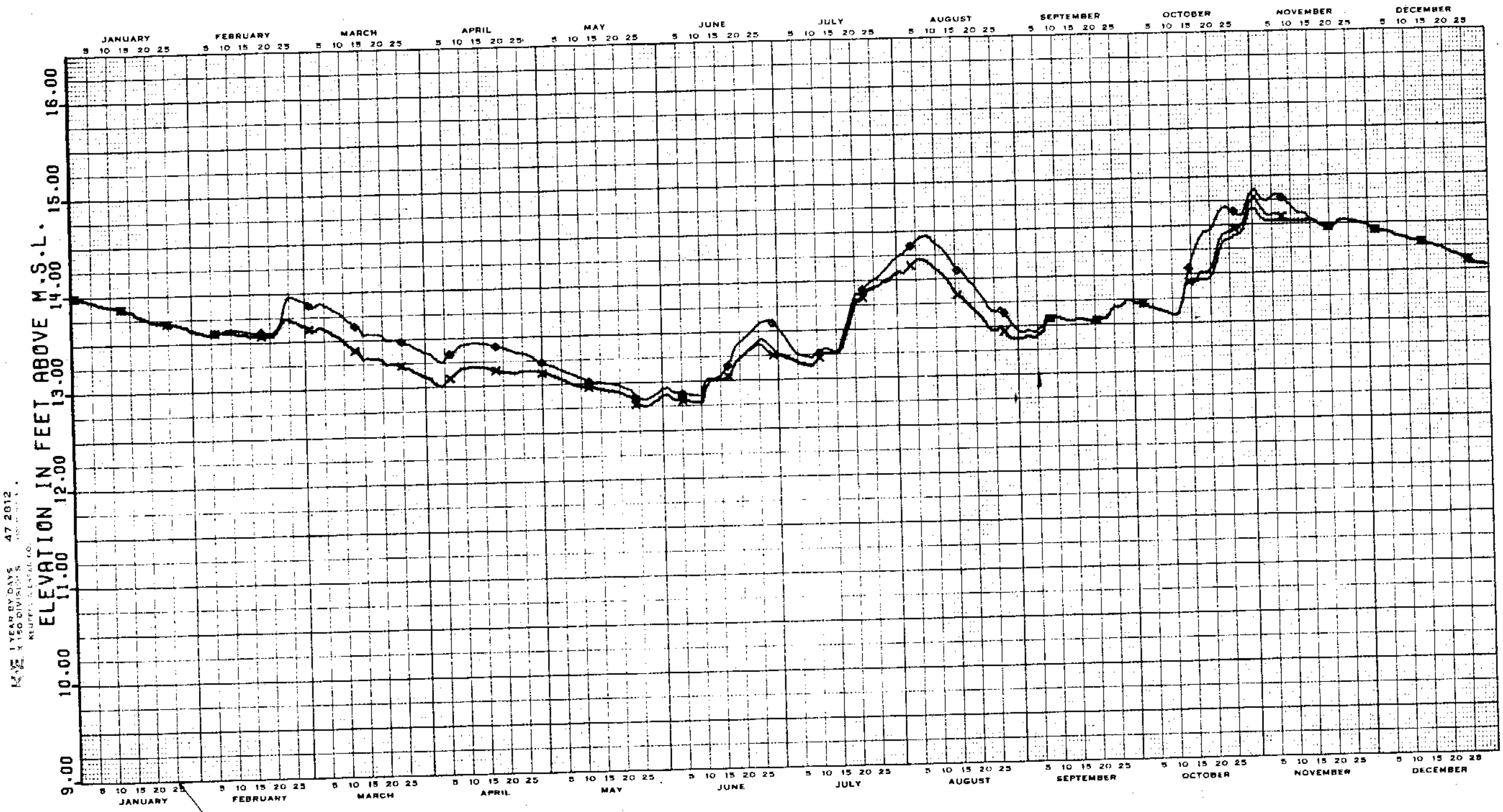
× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

NO BACKPUMPING

FIGURE 30C

YEAR 1965



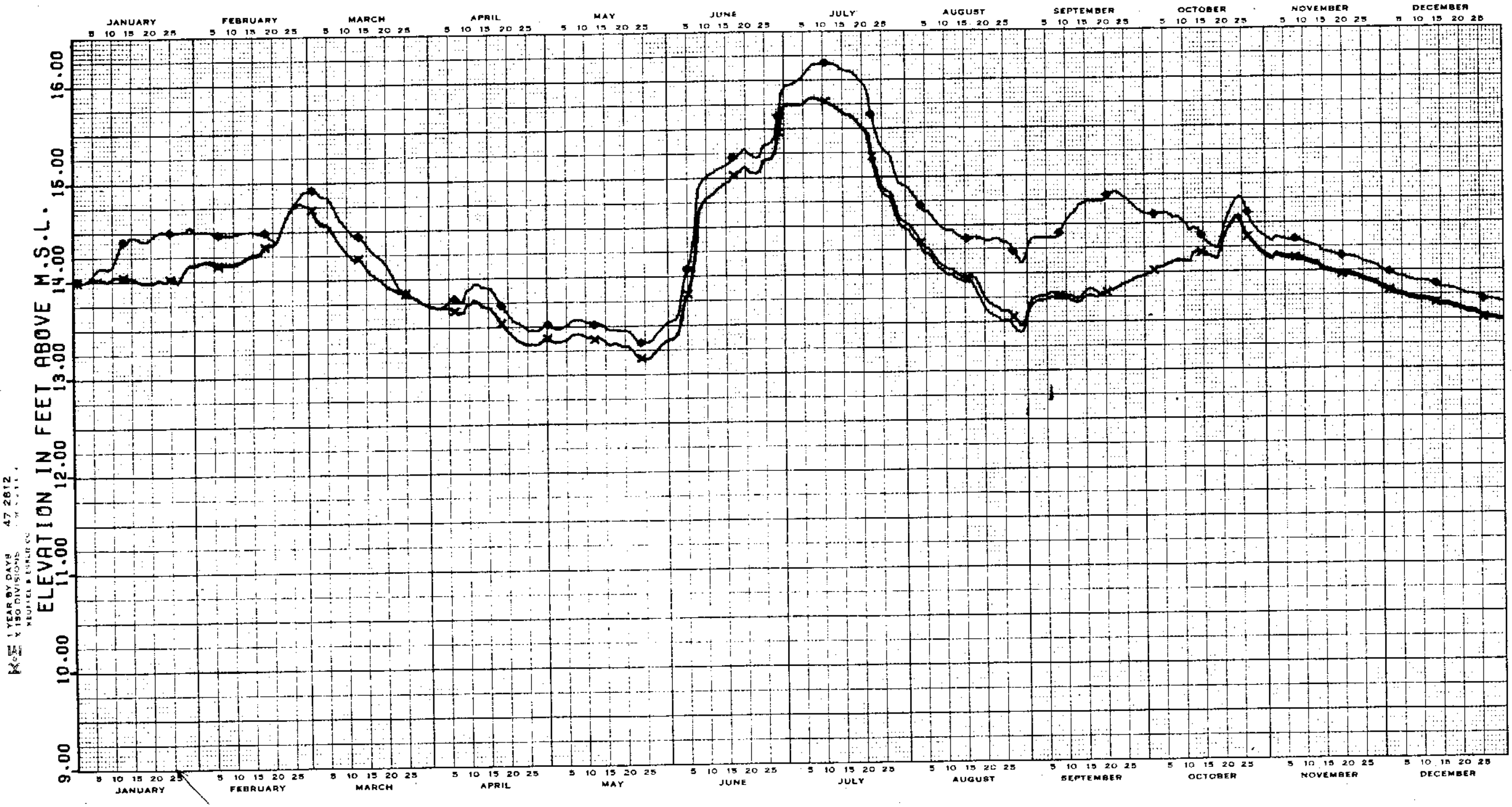
× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

NO BACKPUMPING

FIGURE 30D

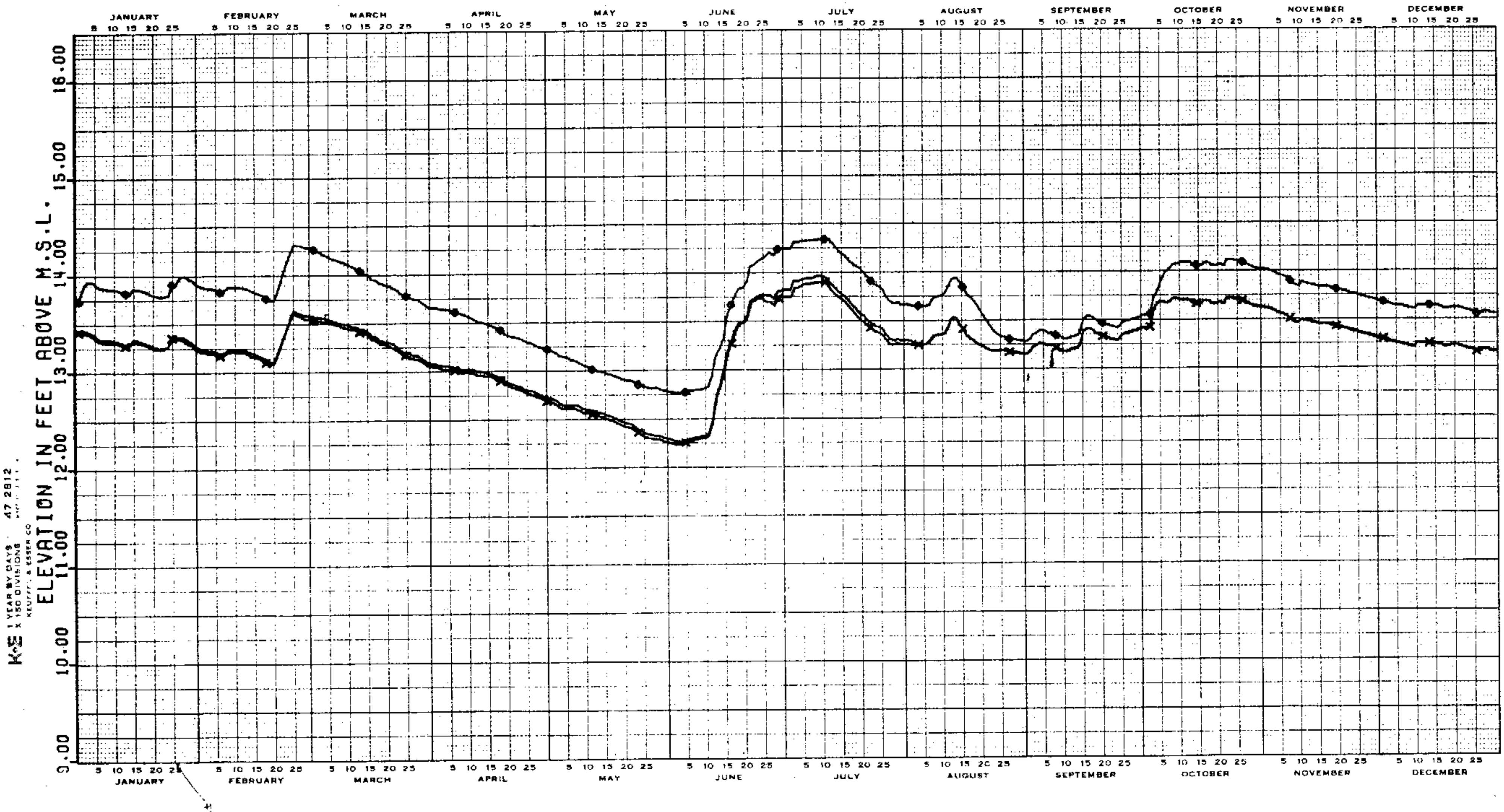
YE 1966



× FIRST 1000 CFS RELEASED TO EAST COAST
◇ NO RELEASE TO EAST COAST
NO BACKPUMPING

FIGURE 30E

YEAR 1967

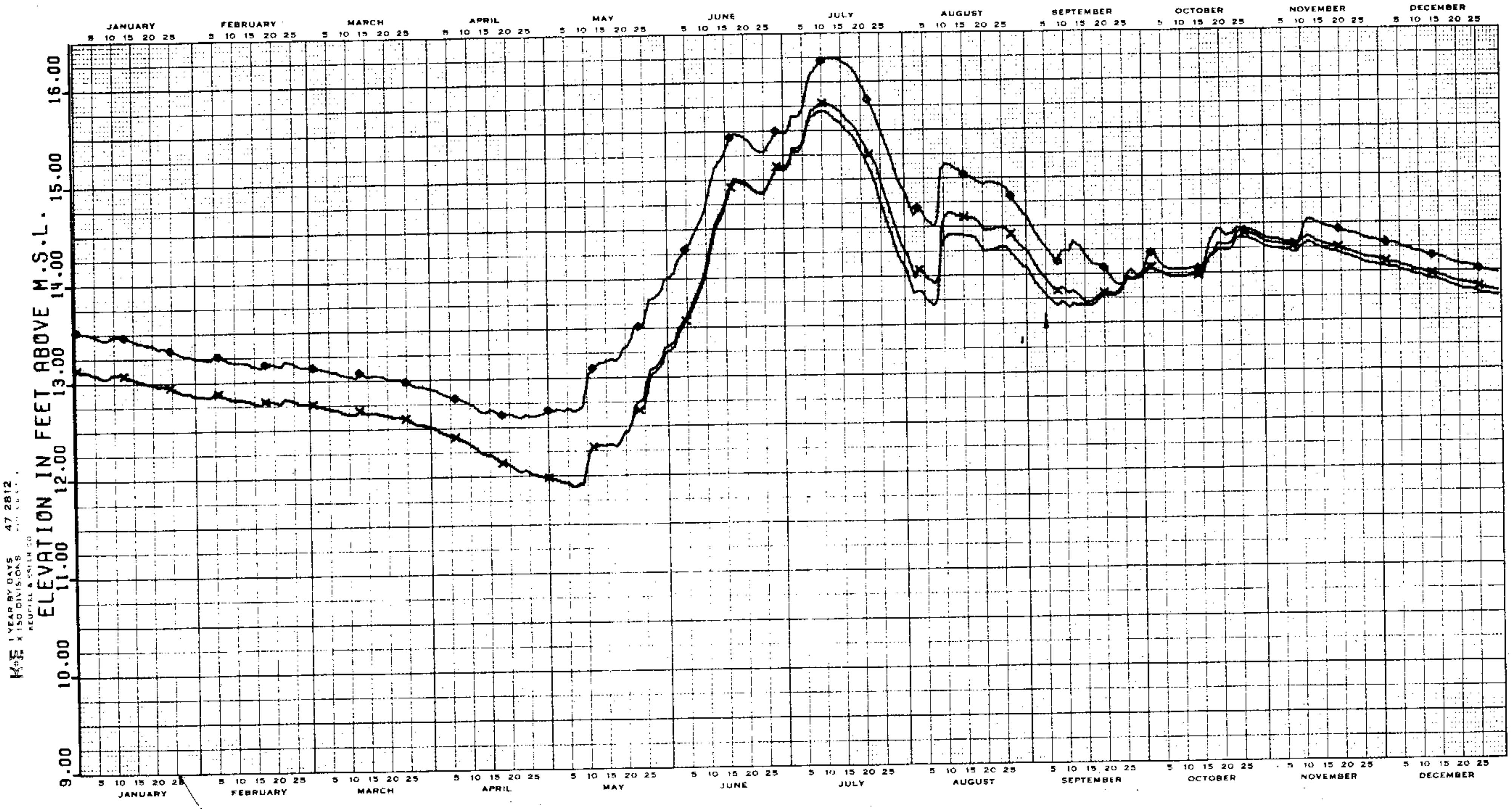


× FIRST 1000 CFS RELEASED TO EAST COAST
◇ NO RELEASE TO EAST COAST
NO BACKPUMPING

FIGURE 30F

STAGE IN CONSERVATION AREA NO. 2 (GAGE S-38)

YEAR 1968



× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

NO BACKPUMPING

FIGURE 30Ø

YEAR 1969

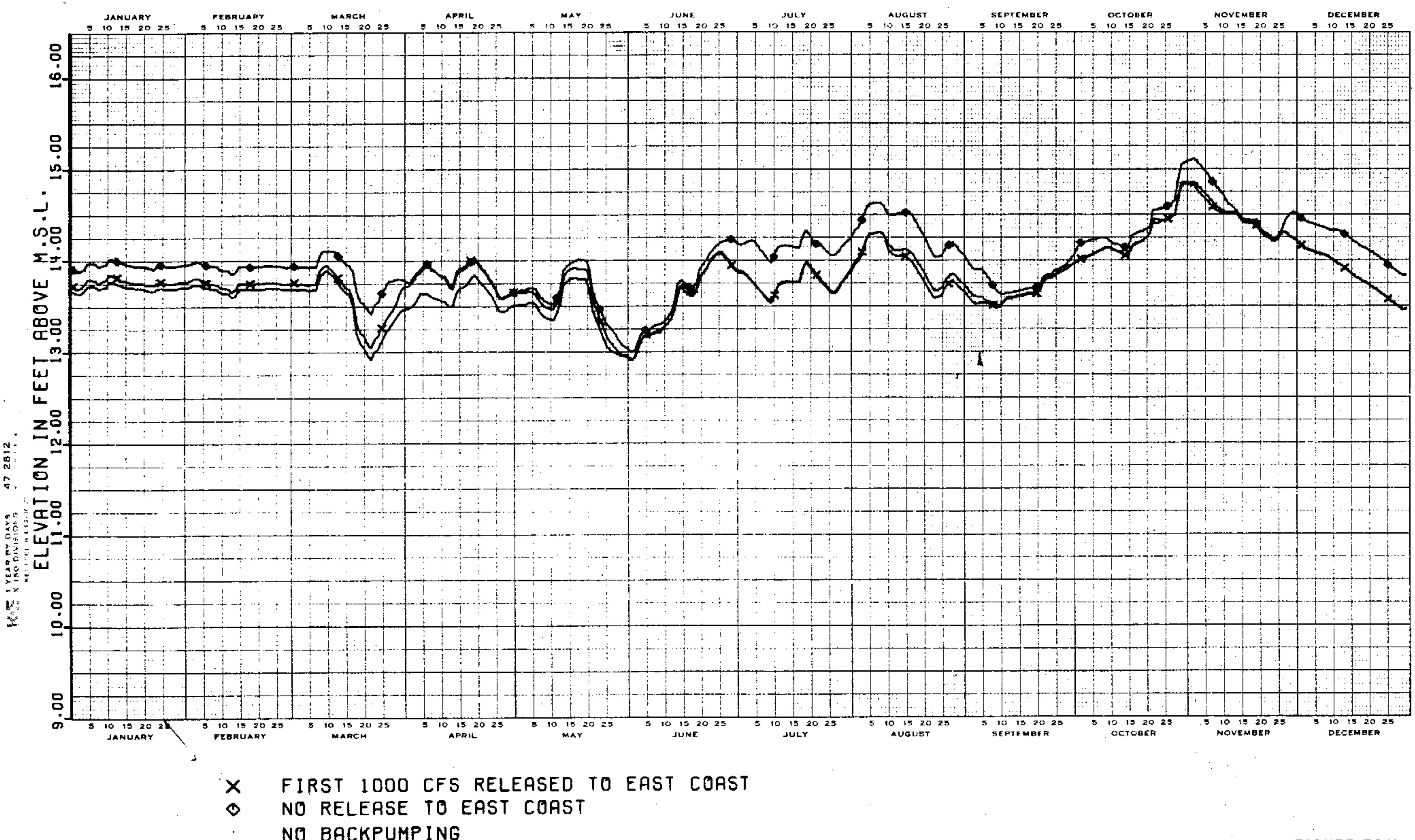
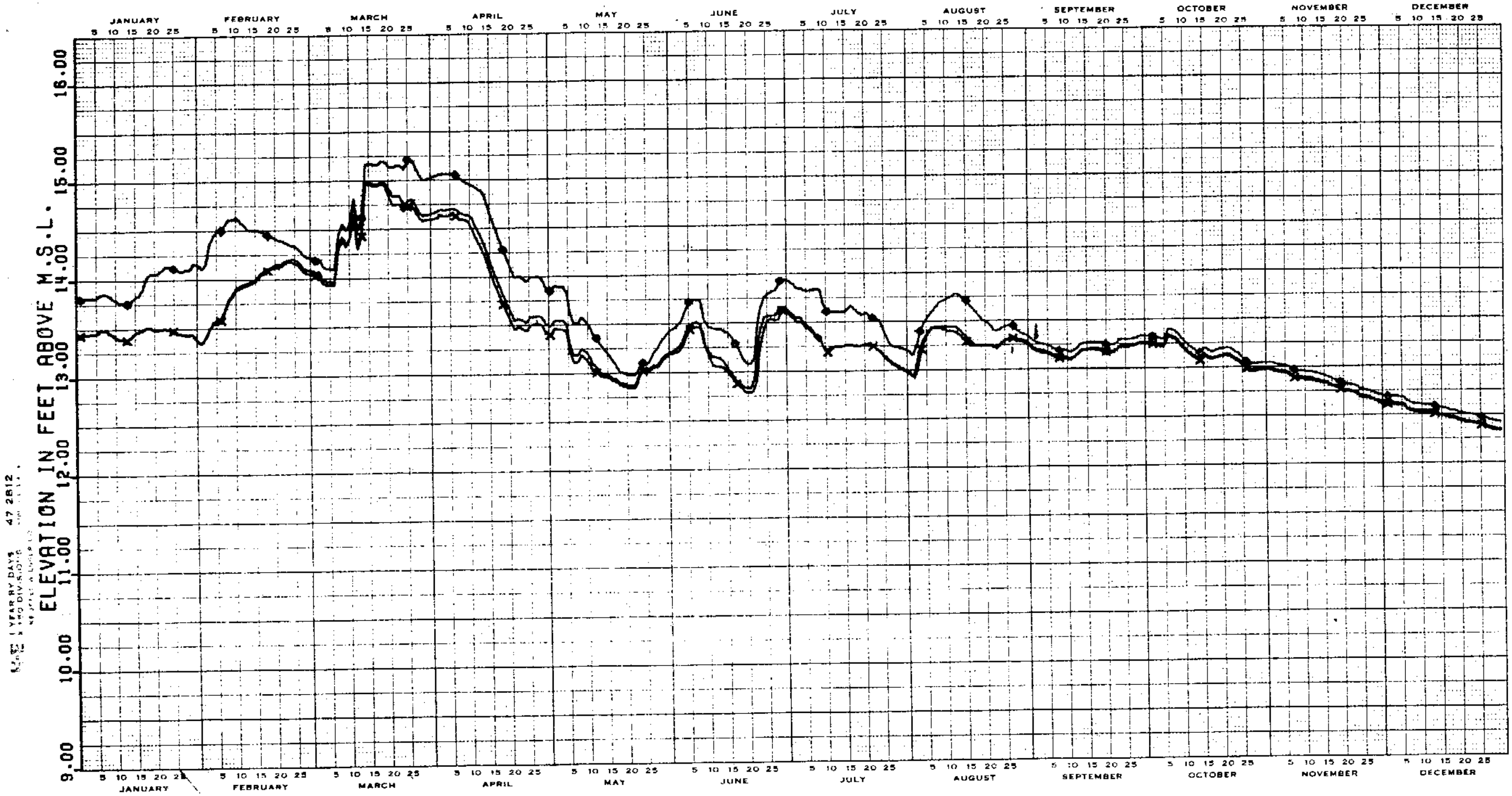


FIGURE 30H

STAGE IN CONSERVATION AREA NO. 2 (GAGE S-38)

YEAR 1970



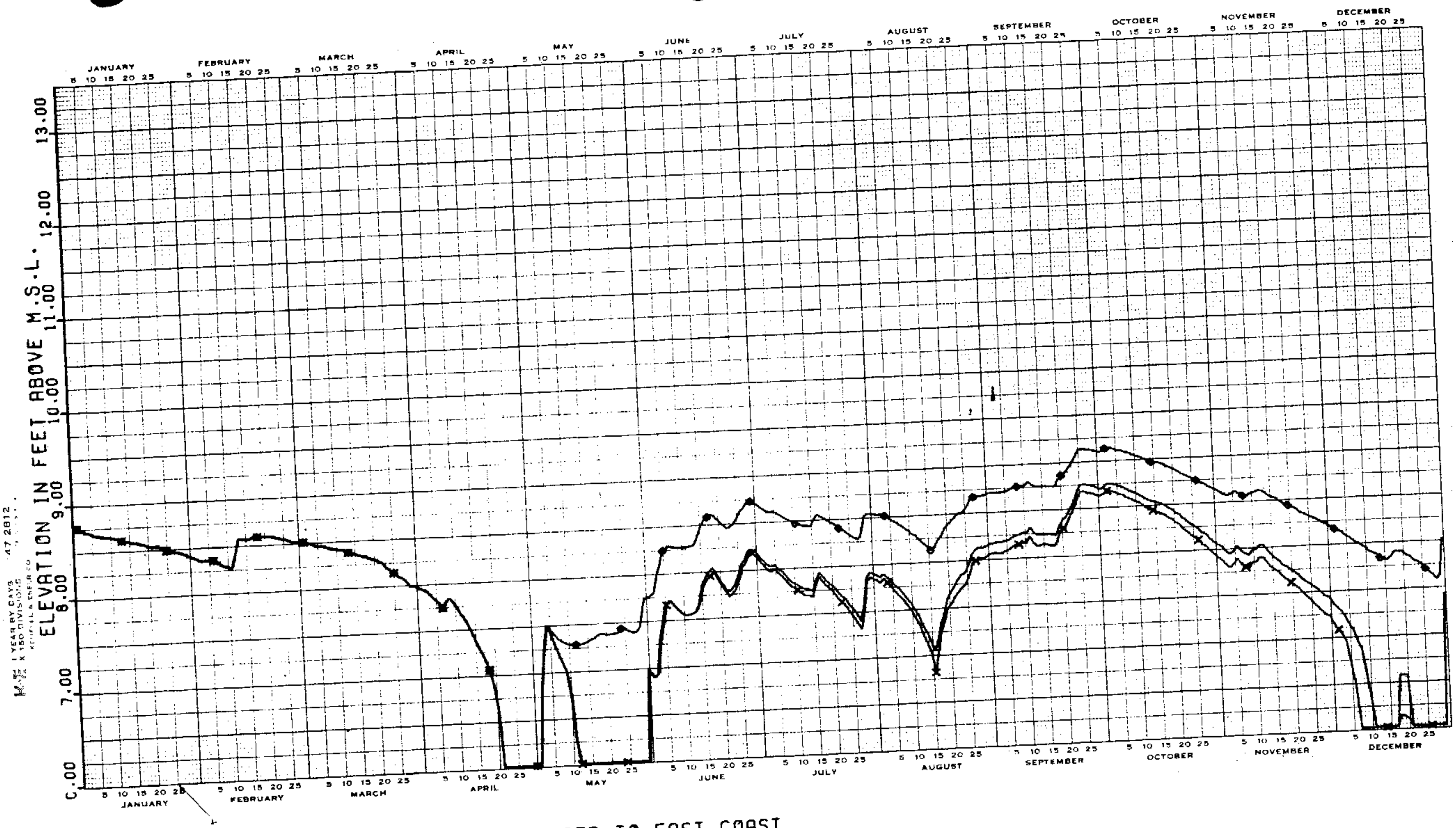
× FIRST 1000 CFS RELEASED TO EAST COAST

◊ NO RELEASE TO EAST COAST

· NO BACKPUMPING

FIGURE 30I

YE 1963



× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

NO BACKPUMPING

FIGURE 31A

STAGE IN CONSERVATION AREA NO. 3 (IND. GAGE)
YEAR 1964

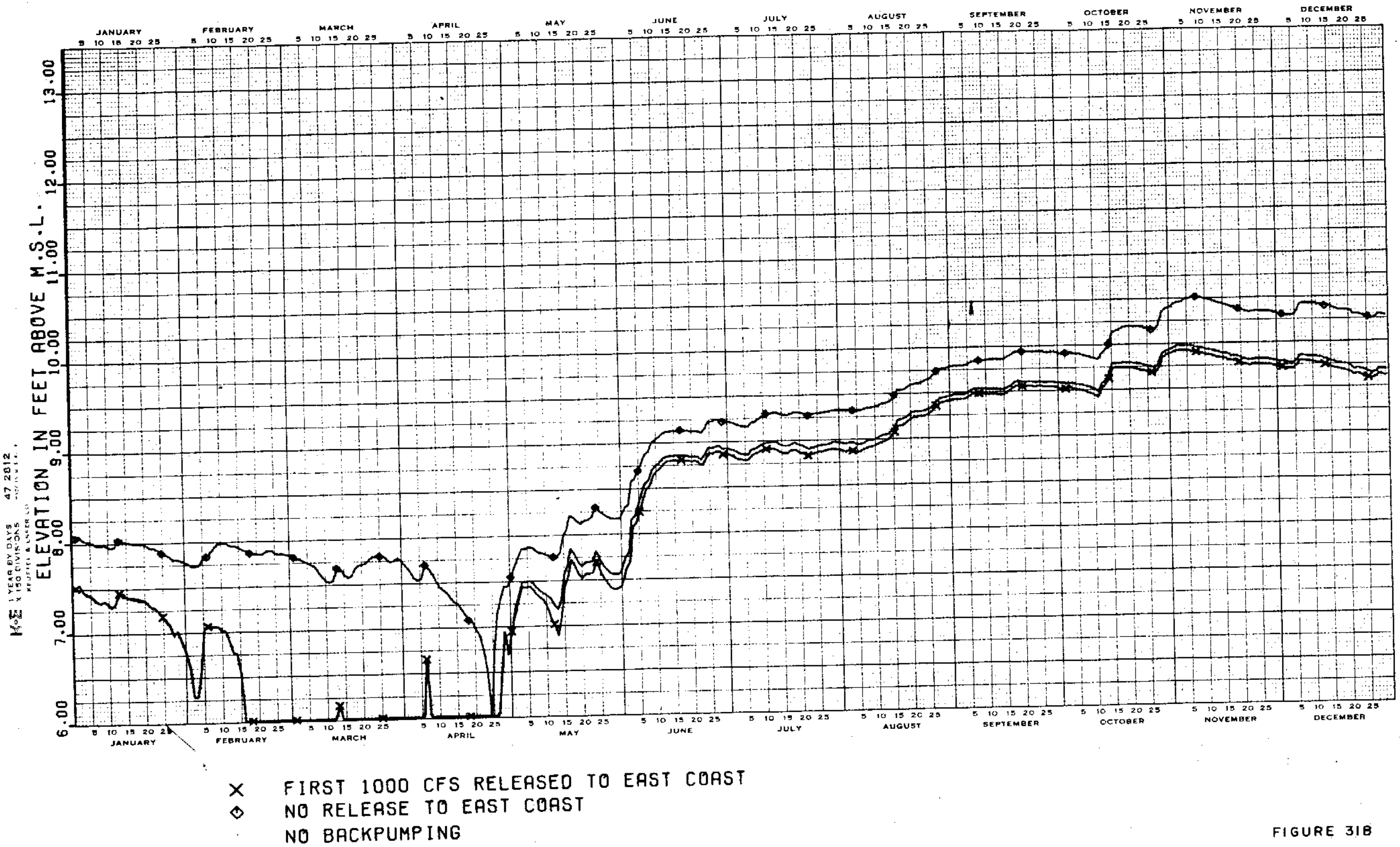
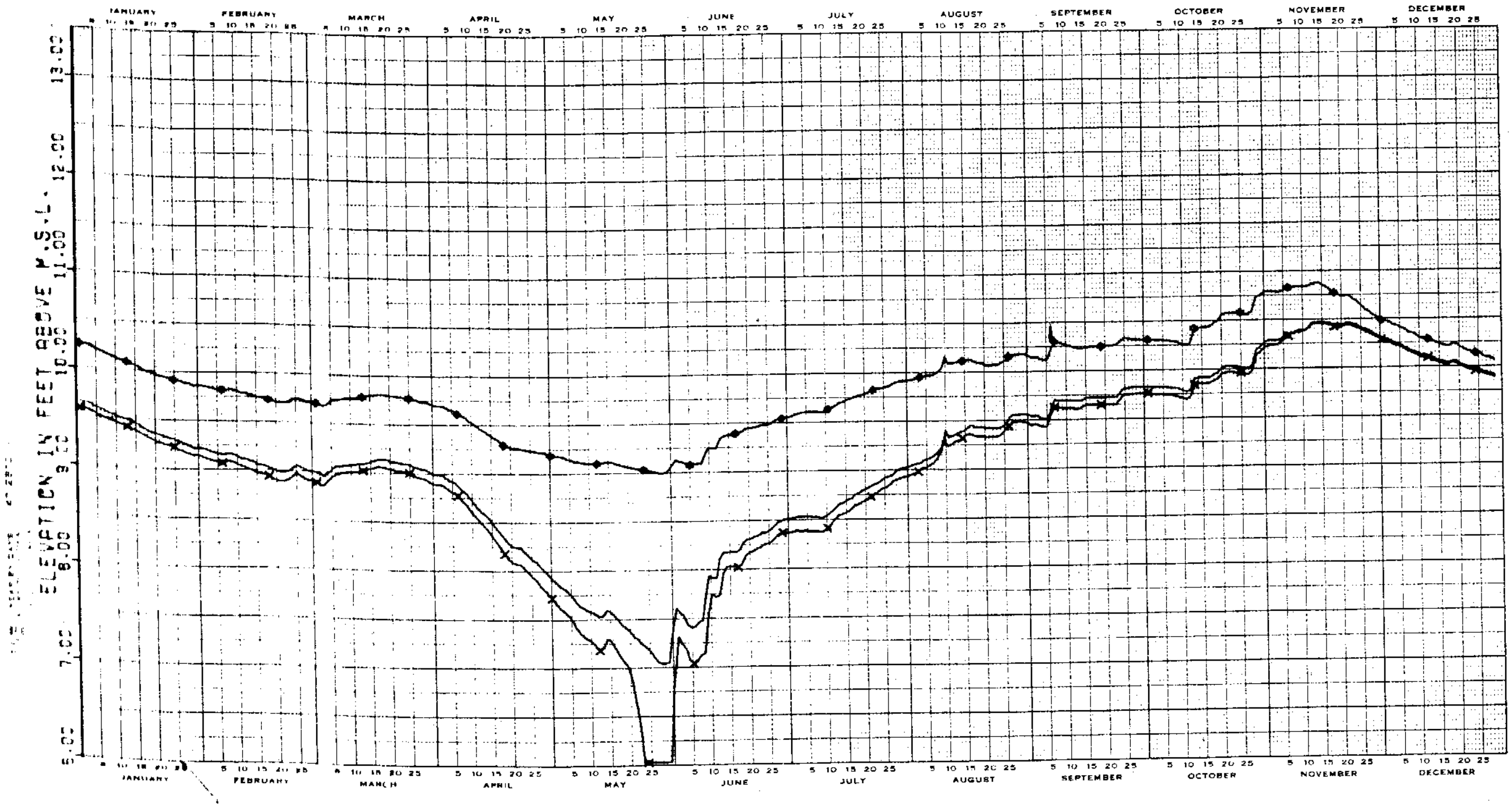


FIGURE 318

STAGE IN CONSERVATION AREA NO. 3 (IND. GAGE)

YEAR 1965



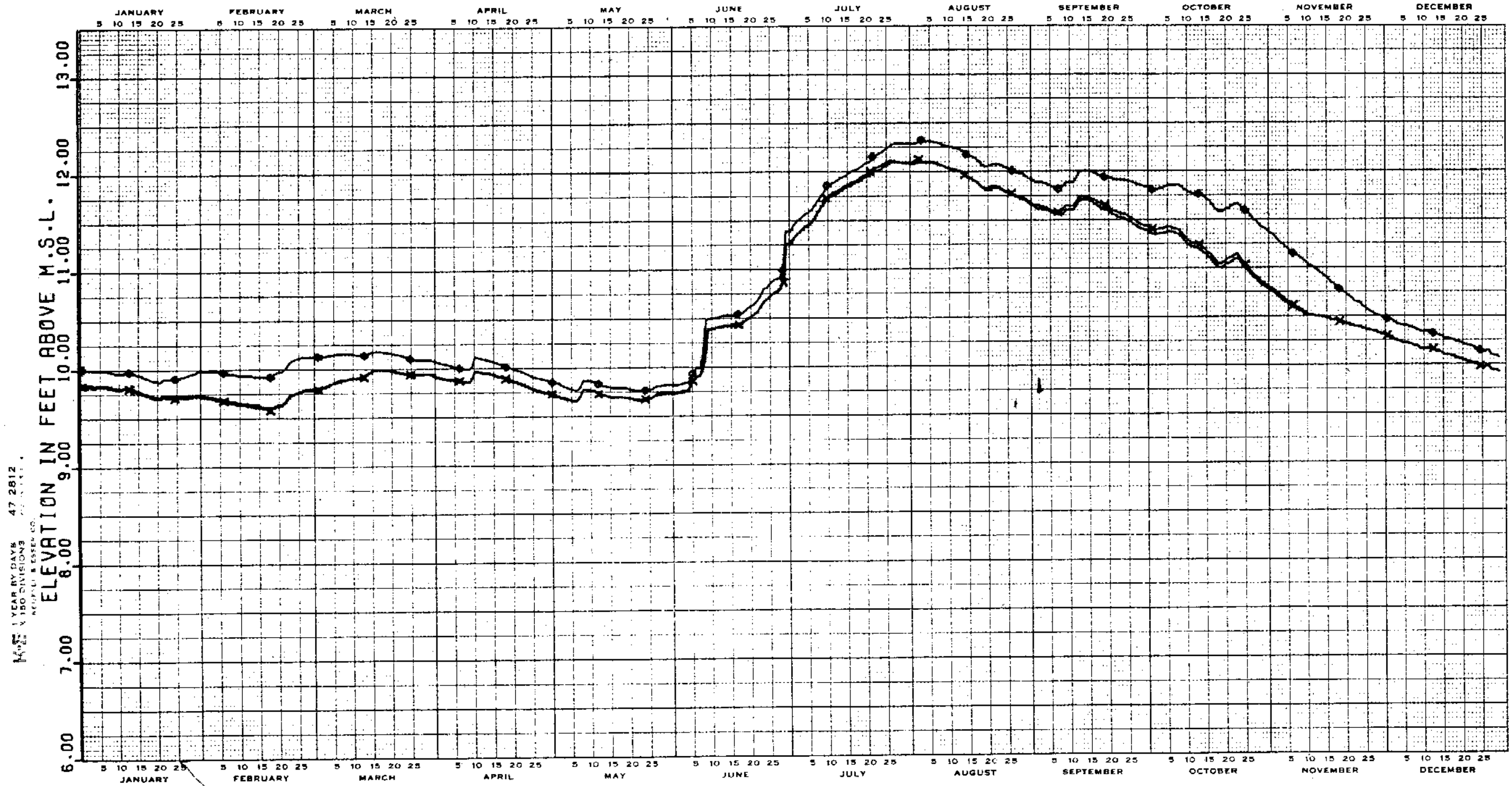
× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

NO BACKPUMPING

FIGURE 31C

Y R 1966



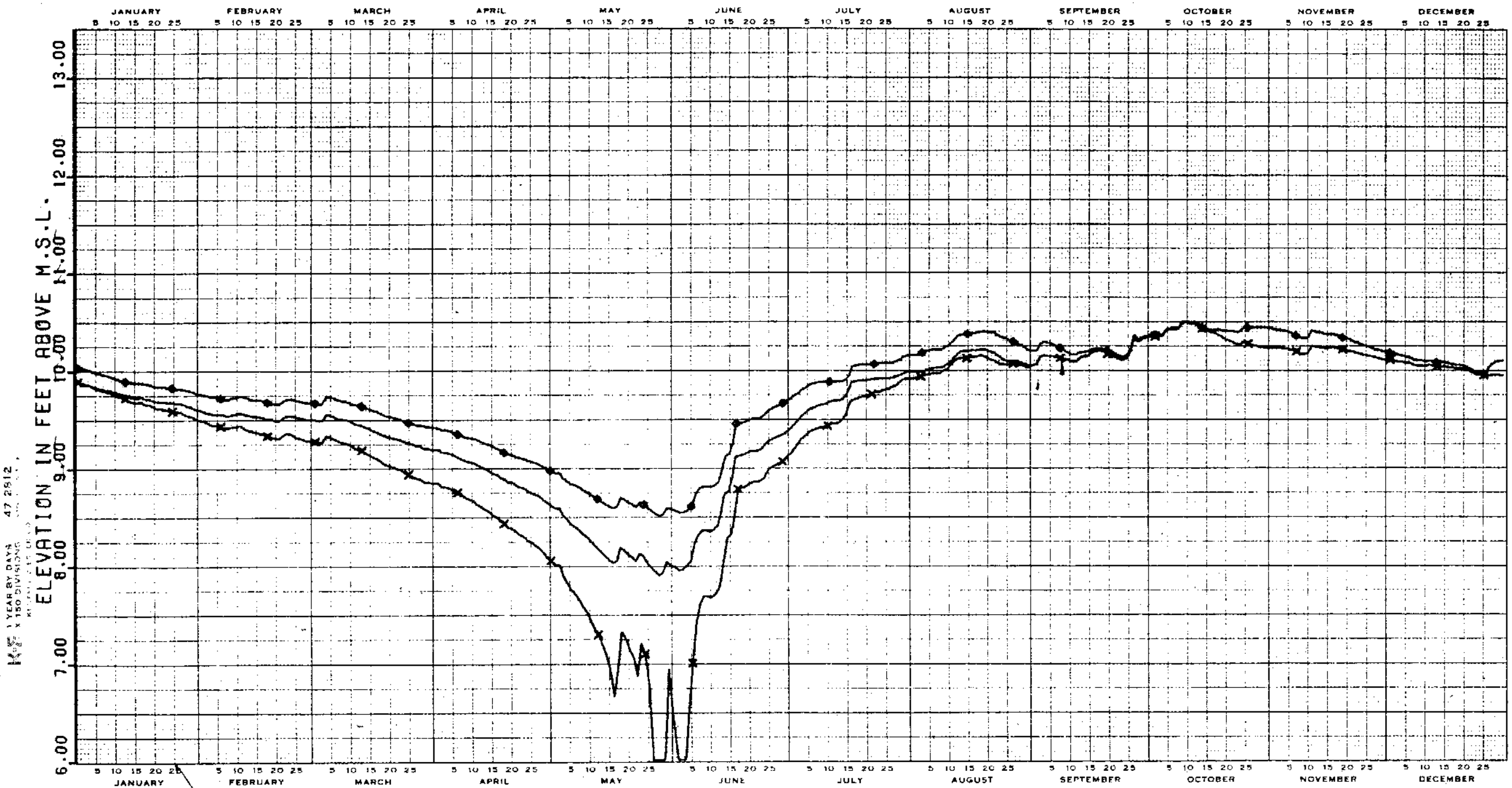
× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

NO BACKPUMPING

FIGURE 31D

YEAR 1967



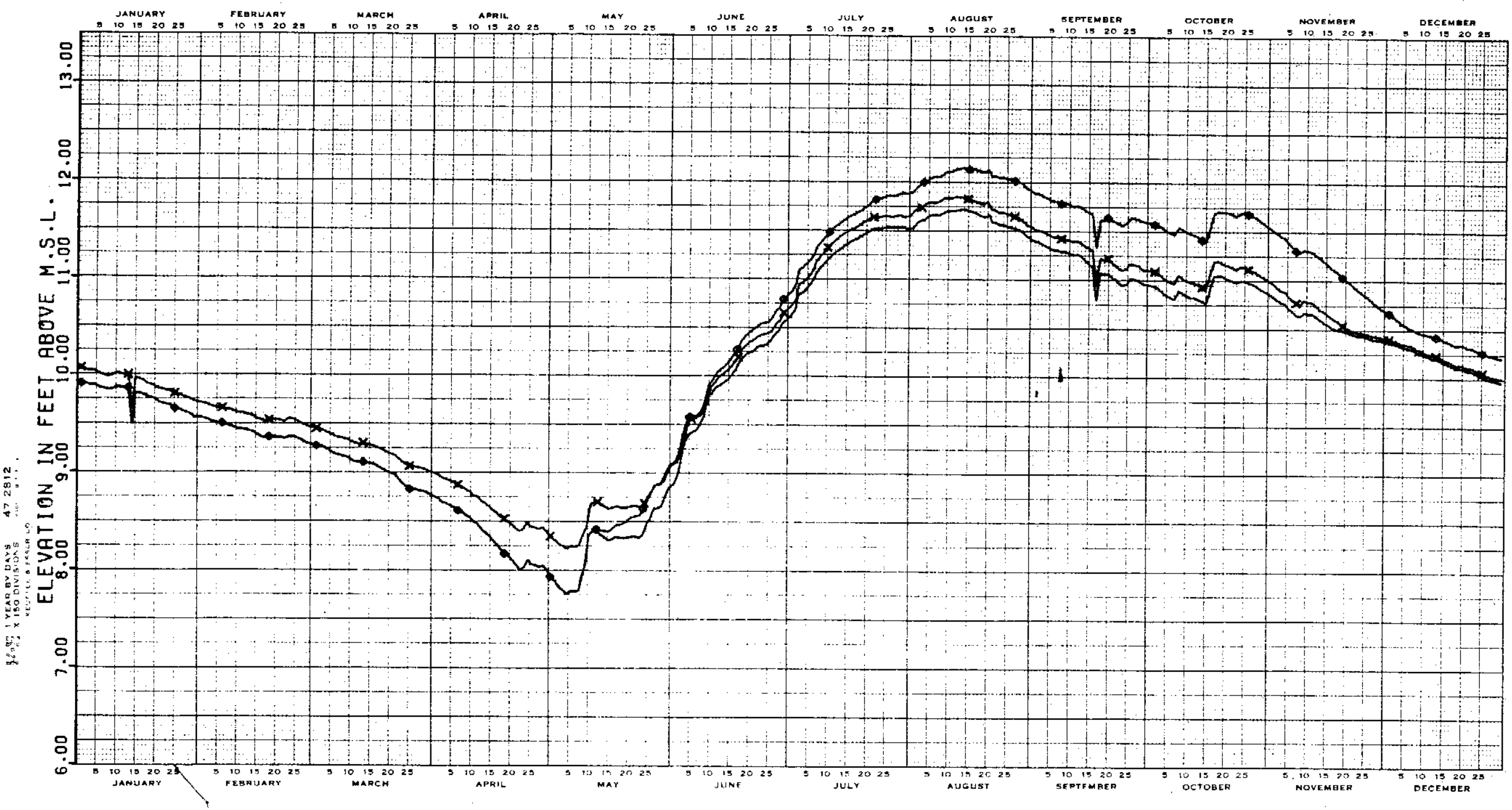
× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

NO BACKPUMPING

FIGURE 31E

YEAR 1968



× FIRST 1000 CFS RELEASED TO EAST COAST

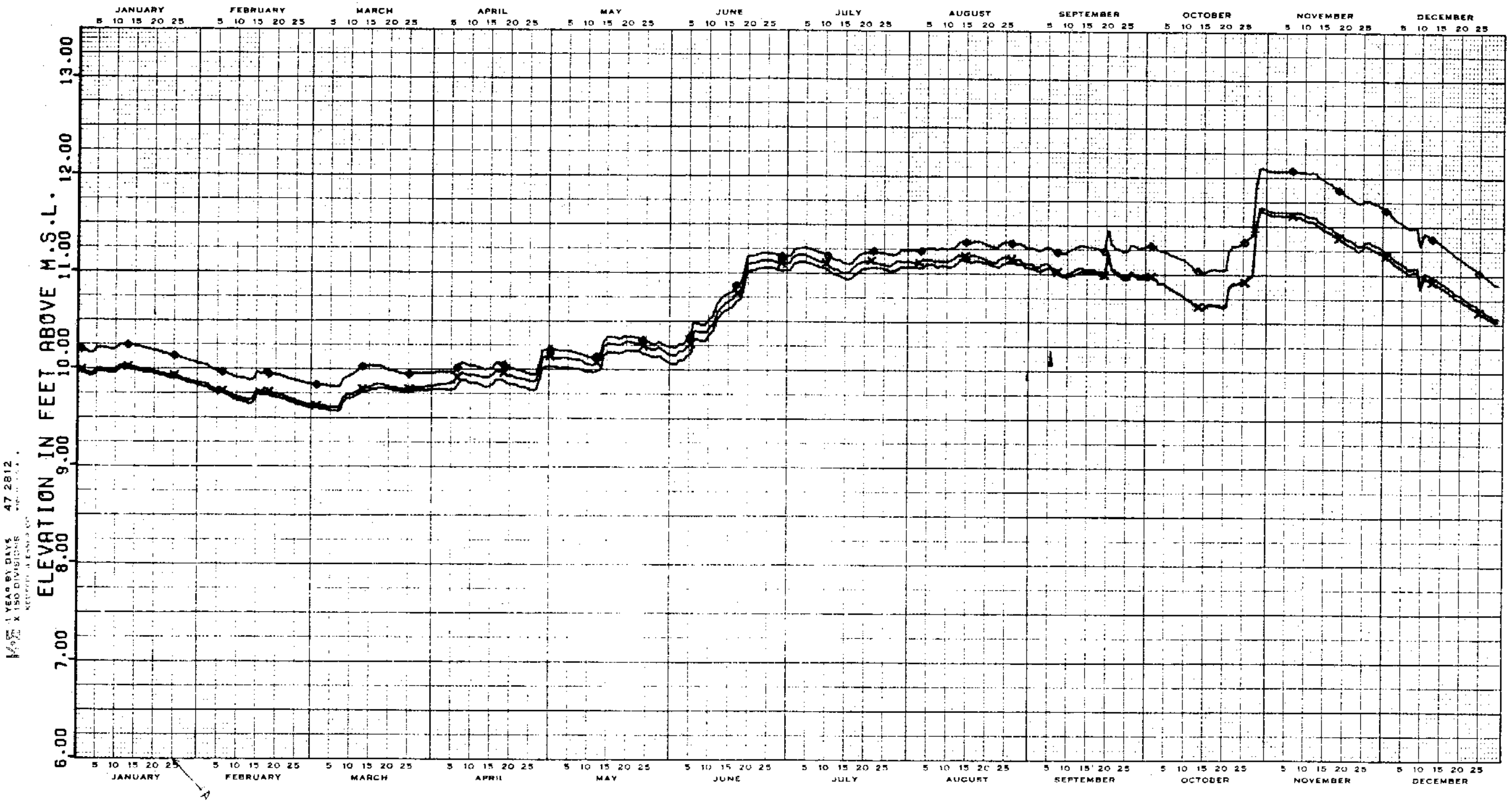
◇ NO RELEASE TO EAST COAST

NO BACKPUMPING

FIGURE 31F

STAGE IN CONSERVATI AREA NO. 3 (IND. GAGE)

YEAR 1969



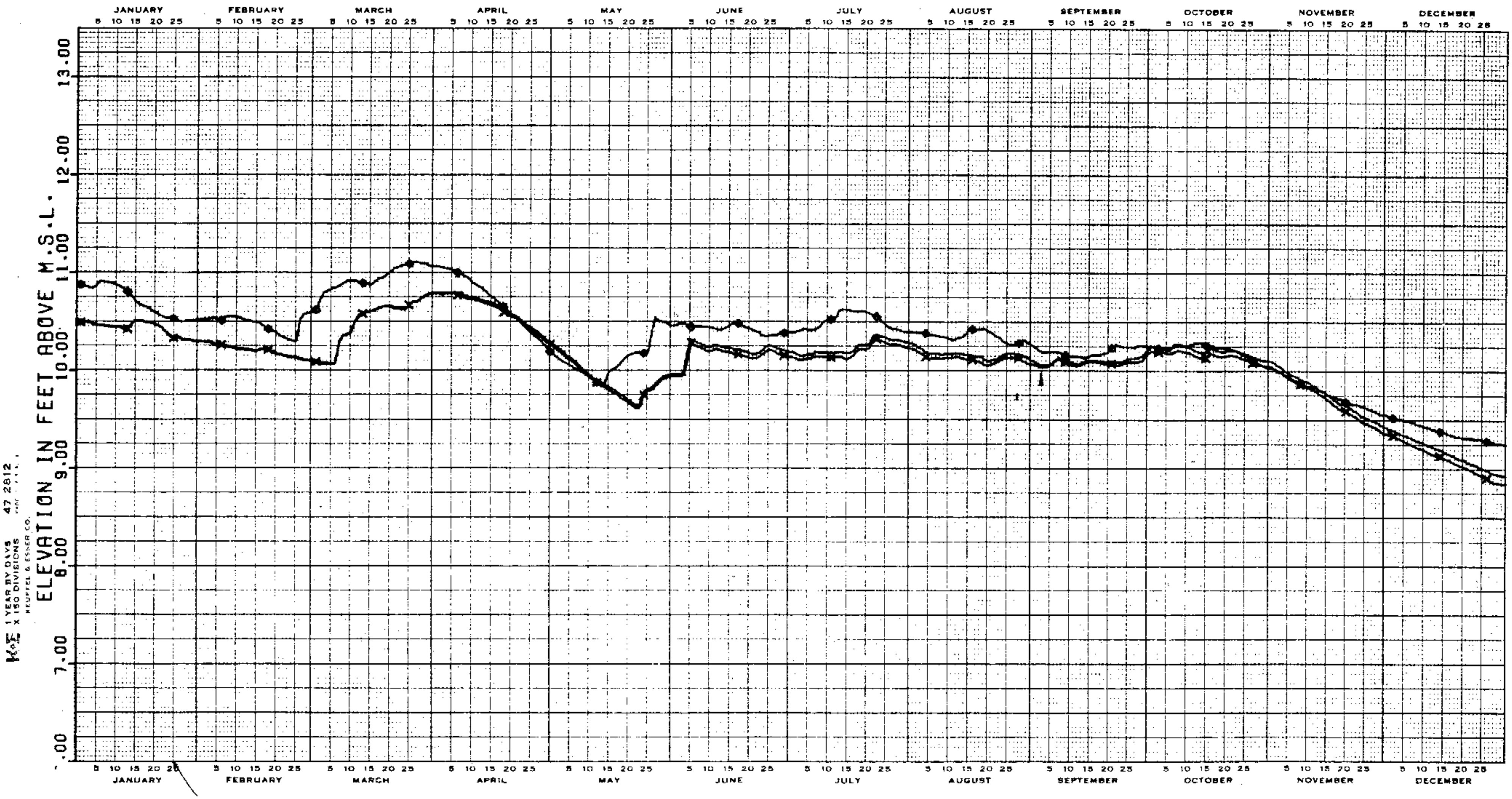
× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

NO BACKPUMPING

FIGURE 31G

YEAR 1970



× FIRST 1000 CFS RELEASED TO EAST COAST

◇ NO RELEASE TO EAST COAST

NO BACKPUMPING

FIGURE 31 H