MEMORANDUM REPORT

ON SURFACE WATER AVAILABILITY IN THE

LAKE ISTOKPOGA-INDIAN PRAIRIE AREA

RESOURCE PLANNING DEPARTMENT

JULY, 1974

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MEMORANDUM REPORT ON SURFACE WATER AVAILABILITY IN THE LAKE ISTOKPOGA - INDIAN PRAIRIE AREA

INTRODUCTION

The Istokpoga - Indian Prairie basin occupies the northeast corner of Glades County and the southeast corner of Highlands County. It is bordered on the north by Lake Istokpoga, on the south by Lake Okeechobee. The Kissimmee River lies on the east, while the Highlands Ridge borders the west. It is approximately 416 square miles in area. Of this total, approximately 55 sq. mi. lies between the interceptor levees (L-59, 60, and 61) and Lake Okeechobee.

Roughly 70% of the land within the basin is undeveloped. Of the 30% which is developed, approximately 26% lies in improved pasture; the remaining 4% is citrus and, to a lesser extent, truck crops.

Four canals (C-40, C-41, C-39A and C-41A) traverse the basin from Lake Istokpoga to Lake Okeechobee. The canals are the main water control system. They remove excess water from the basin during the wet season to Lake Okeechobee and are the primary conveyors of supplemental water from Lake Istokpoga during the dry season. Only the Istokpoga Marsh Drainage District and an area around Istokpoga Canal obtain supplemental water directly from the lake. This latter area is approximately 16 sq. mi. in extent (not included in the 416 sq. mi. total, above).

The lower portion of the study area does not discharge into the canal system, but discharges directly into Lake Okeechobee by way of Pumping Stations 127, 129 and 131. Irrigation supply for this area is derived from Lake Okeechobee directly and, in a limited area, from the canal system by way of the interceptor levee canals.

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The map of Figure 1 shows the drainage basins of the primary canals, the drainage areas of Pumping Stations 127, 129 and 131, the boundaries of the Istokpoga Marsh district, and the area irrigated from the Istokpoga Canal.

The number of agricultural water users is presently very small but represents a large portion of the total potentially irrigatable areas. Under the existing permit system these users are restricted to a maximum of 7.5 inches of water per month. However, this is presently the only constraint on water use. This constraint is not related to hydrologic conditions of water availability in the basin.

The main purpose of this study is to identify, quantify and evaluate the hydrologic constraints operative in the study area which can have a bearing on surface water allocations for agricultural irrigation use.

A corollary purpose of this study is to establish, in accordance with the statutory requirements, minimum levels for Lake Istokpoga, minimum flows to Lake Okeechobee to be maintained from the study area, and minimum flows into Lake Istokpoga. These requirements, once established, act, in turn, as three of the major hydrologic constraints on the amount of surface water generated within the study area which is available for beneficial use and allocation.

Recommendations will be made concerning:

- Guidelines for use in the evaluation of new surface water permit applications;
- Treatment of valid surface water use permits in existence prior to March 1, 1974;
- Guidelines for water supply operations of the District system in the study area;
- 4. Future courses of action, and continuing studies and data collection.

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GENERAL

The volume of surface water which is potentially available for allocation for beneficial use in the Indian Prairie Area consists of three components: (a) run-off generated over the basin south of Lake Istokpoga and which is conveyed to Lake Okeechobee by Canals 40, 41, and 41A; (b) water in canal storage which represents that fraction of groundwater in-seepage which is not discharged at the downstream spillways plus any irrigation return flow which similarly is not discharged from the basin; and (c) stored water in Lake Istokpoga which can be conveyed into the basin south of Istokpoga by means of the same canals.

The first component is transient water and although it can potentially be made available for beneficial irrigation use by the development of off-line storage by individual users, it is at present only marginally useful, if at all, for meeting supplemental water requirements.

The second component undoubtedly plays some part in meeting supplemental water requirements in the basin. It can probably be approximately quantified, but not from presently available data. No attempt has been made in this study to quantify it and consequently it is not considered at this time as part of the allocable surface water.

The third component furnishes by far the greatest portion of the basin's supplemental water supply. Lake istokpoga serves as the study area's water supply reservoir.

The total amount of water potentially available for allocation, therefore, is considered to be surplus run-off water and some portion of the water stored in Lake Istokpoga. The canal storage (in-seepage) component is available for use but because it is unquantifiable at this time, it is

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not included in the potentially allocable volumes. From the user's standpoint, it provides a "cushion" of some unknown value.

All of the excess run-off is potentially available for allocation and use. However, minimum flow requirements to Lake Okeechobee must be met. These requirements come "off the top" and thus the volume of excess run-off water available for allocation is the potential volume minus the minimum flow volume.

In further connection with the minimum flow requirement, only the excess run-off component is used to meet this requirement. Under natural conditions (prior to any canal construction) Lake Istokpoga only rarely, if at all, contributed flows to Lake Okeechobee. It is not considered reasonable to impose the minimum flow requirement on the limited stored water resource of Lake Istokpoga.

Theoretically, all the stored water in Lake Istokpoga down to the limits imposed by the configuration of S-68 and the adjacent lake bottom is potentially available to meet supplemental water requirements. The statute requires only the establishment of minimum lake levels. On the above basis, then, the minimum level for Lake Istokpoga could be established in conformity with the physical constraints of S-68 and the lake bottom. However, the statute also instructs the water management districts to consider such other factors as fish, wildlife and recreation. Recreational boating use of the lake is an important consideration and together with esthetic considerations, must be taken into account in setting minimum levels.

The water actually available for allocation to the basin south of Lake Istokpoga, then, is constrained by whatever minimum lake levels are established. In addition, it is considered that not all of the allocable lake storage be made available for use in the basin south of the lake;

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that is, that some portion be reserved for contingent uses not now in existence and not foreseen at this time. Consequently, it is believed prudent at this time to reserve as unallocated 15% of the total allocable lake storage volume for: (a) potential users around the lake, and (b) possible permissible allocations from tributary streams; i.e., Arbuckle Creek, Josephine Creek.

EXCESS RUN-OFF COMPONENT

This component is termed "basin yield." The computation of monthly basin yield is facilitated by dividing the basin into three parts, determining the yield of each area, then summing. The major area of yield consists of that region north of the interceptor canals whose runoff passes through S-71, S-72, and S-84. The second area consists of a strip one mile wide north of the interceptor canals whose runoff does not pass through S-71, S-72, or S-84; and the third area of yield passes its water through Pumping Stations S-127, S-129, and S-131.

Yield in the first area was calculated by summing daily discharges through S-71, S-72, and S-84. From this sum, daily discharges through S-68 were removed. The period of record used was from January, 1964 through December, 1973.

Yield in the second area was estimated, since surplus runoff generated in this area discharges below the lower control structures. This yield was estimated, by proportioning areas, to be about 5 percent of the yield produced from the first area.

Monthly values of discharge through S-127, S-129, and S-131 were used for yield in the area south of the interceptor canals. Five years of record was available for this area. Averaged monthly values were used to supply missing data.

Monthly yields in each of the three areas were summed to give the total basin yield (Table 1). Monthly basin yields were then arrayed in a frequency distribution (Figures 2a, 2b, 2c, and 2d).

The question arises as to what yield volume should be considered that which is allocable. It should be a volume on which the user can place some reasonable reliance. Certainly neither the maximum nor minimum values meet

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this criterion. Use of the averages can result also in an unrealistic picture, because of the short record; see for example the March average which is obviously unbalanced because of the single large value for 1970.

Since it is a matter of probability, the two-year frequency value for each month was selected (see Figures 2a, b, c and d) as representing the potential allocable volume for the excess run-off component of available water supply.

An arbitrary judgment was made that the low flow on a five year recurrence interval would be established as the minimum flow to be maintained out of the basin into Lake Okeechobee.

Table 2 lists the monthly values for total basin yield, flow maintenance requirement, and adjusted basin yield (or allocable volume), in acre feet.

None of these values have been adjusted to include irrigation withdrawals which were made during the record period. The impact of such withdrawals during the wet season is negligible. During the dry season the operating policy of generally maintaining "irrigation stage" by supply from Lake Istokpoga makes it probable that the impact during those months is also negligible; i.e., supplemental water supply during the irrigation season is largely derived from lake storage and therefore irrigation withdrawals are not a deduction from the basin yield component.

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LAKE ISTOKPOGA STORAGE COMPONENT

This portion of the water supply availability study necessarily starts with the establishment of a minimum stage for Lake Istokpoga. The interpretation taken for "minimum stage" in this instance is that it is that lake level below which no further releases would be made for irrigation water use in the basin south of the lake and in the areas served directly from the lake.

Based on staff knowledge of recreational navigation access problems in the lake, and lake residents' views of desirable lake stages as expressed at public meetings and in correspondence to the District, a judgment determination was made setting minimum lake stage at 37.0 ft.msl. For comparison, the Project regulation schedule calls for a minimum flood storage pool stage of 37.5 ft. msl. on June 1.

The first full year of project regulation was 1963. From 1963 through 1974 stage was at or slightly below 37.0 ft. msl. in June and July, 1967 and from mid-May to date, 1974. From May-August, 1971, subsequent to the severe 1970-71 drought, stage was below 37.0 ft. msl. with a low stage approximating 36.1 ft. msl. Accordingly, from several standpoints a stage of 37.0 ft. msl. appears to be a reasonable minimum. If anything, this minimum favors agricultural water supply values over recreational navigation and esthetic values.

Two approaches are possible: (a) to establish monthly minimum stage values; and (b) to establish only a single absolute minimum stage. Each approach has certain disadvantages. In the latter case it would be theoretically possible to draw the lake stage down for irrigation water supply to the minimum stage of 37.0 ft.msl. in February or March. Under this circumstance natural dry season recession would produce stages well below 37.0 ft. in

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missing data was estimated using averages of existing data.

The minimum monthly stages established in this fashion are keyed directly to average monthly "natural" depletion rates expressed as a percentage of seasonal natural depletion. The stage recession (depletion) calculated in this fashion is conservative in that tributary inflow is not considered. It will be noted, also, that the greatest permissible drawdowns for irrigation water supply occur during the months of April and May, normally the months of greatest supplemental water demand.

In order to arrive at both minimum monthly stages for the wet season (June through October) and the total volume of water potentially available for allocation from Lake Istokpoga storage a theoretical, or "fictitious", stage computation was made. This fictitious stage is the stage to which the lake would rise were there no discharges. It was calculated by adding monthly discharges to actual lake stage.

Table 4 shows Lake Istokpoga monthly discharges in acre-feet. This is the sum of S-68 discharges, Istokpoga Canal discharges (averaged for missing data) and Istokpoga Marsh Drainage District discharge (estimated).

Accumulated monthly discharges for each season are shown in Table 5. The equivalent lake storage stage for this monthly accumulated discharge was added to actual month-end lake stage (Table 6) to compute the fictitious stage (Table 7). From the monthly fictitious stages, monthly <u>changes</u> in fictitious stage were found using May 31 actual stage as the starting base (Table 8). The changes in stage were then arrayed in a frequency distribution (Figure 3).

The frequency distribution of monthly, and accumulated, stage accretions during the wet season shows that, theoretically, the October stage of 39.5 ft. msl. can be achieved during the 1 in 20 year frequency rainfall deficient period provided no regulatory or irrigation discharges are made during the period. From this distribution wet season minimum monthly stages were

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derived using the accretions for the 20-year deficiency occurrence. These, together with the suggested preliminary dry season minimums, are plotted with the Project regulation schedule on Figure 4.

As noted above, the "fictitious" stage was also used to calculate the total volume of water which arrives in Lake Istokpoga and can be considered potentially available to meet agricultural irrigation requirements in the basin south of the lake. The once-in-two-year frequency actual end-of-May lake stage is 37.6 ft.ms1. (see data listed for May 31 stage in Table 8). The frequency array of Figure 3 shows the June 1 to November 1 once-in-twoyear frequency stage change to be 5.4 feet. Accordingly, the two-year frequency November 1 fictitious stage is 43.0 ft. ms1.

The total water potentially available, on a once-in-two-year frequency, during the wet season is the difference between the fictitious November 1 stage of 43.0 ft. and the regulated stage of 39.5 ft. Using the Corps of Engineers stage-storage curve for Lake Istokpoga, this volume is 108,500 acre-feet. Expressed in another fashion, and in practical terms, this is the total volume of water which could potentially be drawn off from the lake during the wet season and diverted into off-line reservoirs in the basin south of the lake.

In the event water arriving in the lake is used in this fashion, the minimum monthly wet season lake stages have some significance. They then represent wet season lake stages below which diversions to off-line reservoirs would not be permitted. If diversions were permitted to continue at stages below these minimums, the District and other irrigation users could not be reasonably assured that a November I stage of 39.5 ft. msl. would be achieved.

On the other hand, if no off-line reservoir storage is created in the basin south of the lake, the minimum monthly wet season stages have no

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practical application at this time. The reason for this is that releases from the lake for "as needed" irrigation water supply during this period are practically non-existent and thus insignificant.

The total volume of water arriving in the lake and potentially available for irrigation water supply during the dry season can be similarly calculated using the fictitious stage. The average end of May fictitious lake stage is 41.5 ft.msl. (see Table 7); this also approximates the once-in-two-year frequency fictitious stage of 41.6 ft. msl. The water potentially available during the dry season, therefore, is that between 41.5 ft. msl. and the established May minimum of 37.0 ft. msl. The stage-storage curve gives a volume of 132,500 acre-feet between these stages. This method indirectly accounts for inflow to the lake, evaporation losses and rainfall on the lake.

An approximate verification of this value is obtained by examining the releases actually made from the lake (whether regulatory or for water supply) during the period of record. Table 4 lists the lake releases. The average dry season release volume approximates 123,500 acre feet.

On page 5 of this report it was determined that 15% of the total volume of water which arrives in Lake Istokpoga, and which is potentially available for irrigation supply south of the lake, should be reserved for other contingent purposes. Accordingly, the seasonal volumes of water arriving in the lake which are allocable to agricultural users in the basin to the south are 85% of the values given above, or:

Wet season - June through October - 92,200 A.F.

Dry season - November through May - 112,600 A.F.

As noted on page 1, the entire study area contains 416 sq. mi. All of this area is involved in, and contributes to, the basin yield component of allocable water. In considering the lake storage component the 55 sq. mi.

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area downstream of the interceptor levees must be subtracted from, and the 16 sq. mi. area adjacent to the Istokpoga Canal must be added to, the 416 sq. mi. figure to arrive at the total area which receives supplemental water supply, or can potentially receive such supply, from Lake Istokpoga. This area, then is 377 sq. mi.

On this basis, the following tabulation gives an approximate indication of water availability in acre-feet and in inches/acre for the area which presently, or is potentially, irrigatable with water supplied from the District system.

	From lake		From basin		Το	Total	
	<u>A.F.</u>	In/A	<u>A.F.</u>	ln/A	A.F.	In/A	
Wet Season	92,000	4.6	55,900	2.6	148,100	7.2	
Dry Season	112,600	5.6	12,990	0.6	125,590	6.2	
Annua 1	204,800	10.2	68,890	3.2	273,690	13.4	

Final values to be used for permit application evaluation are presented in Table 14 and are discussed under the heading "Surface Water Allocations." It is recognized that establishing the tributary minimum flows in this fashion in effect reserves upstream water for future downstream users. However, at this time it appears that the ultimate demand for water genererated in this basin will be significantly greater in the area below Istokpoga. Circumstances can nevertheless change and the equity of this type of distribution of available water must be periodically evaluated.

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PRESENT IRRIGATION USE

Irrigation withdrawals from Lake Istokpoga are accomplished by two means. These are: (a) withdrawals directly from the lake to Istokpoga Marsh and to the area adjacent to Istokpoga Canal, and (b) withdrawals from the canal system fed by the lake via S-68. Withdrawals from the canals were calculated on a daily basis as the difference between that water which passed through S-68 but did not leave through the lower structures (S-71, S-72, and S-84). These daily amounts were summed to determine monthly values. From these sums and the total irrigated area, the amount of water applied per acre was computed. This monthly amount applied per acre was used as the basis for estimating withdrawals directly from the Lake to Istokpoga Marsh.

Table 13 gives the total estimated withdrawals. It can be seen that the average dry season irrigation use has been approximately 36,000 acre feet. This amount is one half of lake storage between stages 39.5 and 37.0 feet. However, this figure does not include evaporation, inflow, precipitation or seepage.

The area presently being irrigated is estimated at 55,000 acres. The average dry season irrigation use of about 36,000 acre feet is, of course, for the period of record during which irrigated acreage has obviously increased. A general idea of the magnitude of supplemental water use in the basin south of Lake 1stokpoga can be obtained by using the present estimated irrigated acreage and the calculated average irrigation use over the period of record. Using these values an average seasonal supplemental water application figure of 7.9 inches per acre is derived. This somewhat low use rate is probably accounted for by the high proportion of pasture land in the total irrigated acreage.

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Referring to the tabulation on page 12, it will be noted that the water available in the dry season alone is not sufficient to meet the estimated level of demand with full basin development. To sustain a full level of development or more intensive development, and to provide for rainfall deficient periods, it appears that off-line storage of wet season surpluses will be required or groundwater sources must be developed. Groundwater use in the basin is presently limited to certain citrus groves in the northerly portion of the study area which do not have ready access to surface water sources.

Until larger private capital investments in facilities for making water available "on the land" are made, it appears that agricultural development will largely be limited to improved pasture in areas having comparatively easy and inexpensive access to the primary canal system.

Under present conditions of land development and irrigation practice, demands can ordinarily be met. But critical conditions can arise in rainfall deficient dry seasons, such as the 1973-74 season. Lake Istokpoga storage just barely met minimum irrigation requirements as a result of a November, 1973 through April, 1974 rainfall deficiency of 7 inches. Lake Istokpoga dry season storage alone will obviously be incapable of meeting expanded needs during future periods of even moderate stress.

SURFACE WATER ALLOCATIONS

The basic premise is that, initially at least, the surface water which has been determined to be available for allocation to the area south of Lake Istokpoga be allocated on a unit land area basis. The tabulation on page 12 of this report is such a unit area allocation.

The second premise, based on the data compiled and analyzed in the preparation of this report, is that surface water allocations to users in this basin should be based on hydrologic considerations. After taking into consideration the mandated hydrologic constraints of:

- 1. Maintenance of minimum flows to Lake Okeechobee;
- Maintenance of minimum flows in Arbuckle and Josephine Creeks; and
- 3. Minimum Lake Istokpoga stages;

it is guite apparent that the basin does not generate abundant water surpluses.

The surface water available to the basin can be appropriated by users through two means:

- On an "as-needed" basis either directly from the lake or from the District canal system; or
- By impoundment either by diversion from the lake or canal system, or by capture of runoff before it enters the canal system.

It is possible to issue allocation permits on a monthly, seasonal, or annual basis; or some combination of these. The monthly, seasonal, and annual values presented herein are to be used only as guides in the evaluation of new applications or in the consideration of existing water use permits. They represent maximum allocable volumes only; i.e., if an applicant requests a lesser amount, that lesser amount will be allocated provided all other required criteria are met.

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An applicant whose use will be on an "as-needed" basis should be issued an allocation only for an irrigation season withdrawal and an annual total. The maximum permissible allocations for those applicants who draw directly from Lake Istokpoga (except the Istokpoga Marsh D.D.) will consist only of the lake storage component. Except for the 55 sq.mi. area below the interceptor levees, the maximum permissible allocations for all others in the basin will consist of both the lake storage component and the basin yield component. The Istokpoga Marsh D.D. is included in this latter group since runoff from that area contributes to basin yield. Water allocations for the area below the interceptor levees will be treated in another report.

Applicants whose use involves impoundment should be issued allocations on a monthly basis. The basis for this is the assumption that this type of use will involve provision of facilities capable of diverting and impounding large volumes of water. Without a monthly limitation the potential exists for drawing lake and/or canal stages below established minimums to the detriment of other users. As above, the distinction is to be made in maximum permissible allocation volumes between direct lake withdrawals and withdrawals from the canal system.

It is considered important to maintain as much flow of surplus water into Lake Okeechobee as possible consistent with reasonable water use within the basins in which the flow is generated. This consideration applies in this study area. Consequently, impoundment permittees should not be allowed to divert or impound more than the maximum allowable monthly volumes unless concurrent regulatory discharges from Lake Okeechobee are being made. This constraint applies both to regulatory discharges from Lake Istokpoga and to excess basin runoff.

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Table 14 lists the maximum permissible allocations for the two types of use and the two withdrawal categories identified above. The table lists total allocable volume for the basin and the unit land area maximum, based on a 416 sq.mi. service area for the basin yield component and a 377 sq.mi. service area for the lake storage component. The monthly volumes for the lake storage component have been distributed in five equal amounts for the wet season. The distribution of the lake storage component for the dry season is in accordance with the monthly percentages listed in Table 3.

The basin yield (or run-off excess) component incorporated in the values listed in Table 14 assumes a uniform yield over the entire 416 sq.mi. drainage basin. It may become necessary at a later date to refine these values on a canal drainage basin basis; but only when it becomes apparent that off-line storage will be created to make maximum use of this component.

MINIMUM STAGES AND MINIMUM FLOWS

 A comparison of the suggested preliminary monthly minimum lake stages presented on Figure 4 with the actual month-end stages listed in Table 6 indicates the following:

Month	Actual Month-end Stage Lower than Suggested Min.	Average Stage Deficiency,ft.
November	3 of 10 months	0.57
December	2 ** ** **	0.70
January	1 n 'n 'n	0.72
February	1	0.42
March	ј н н н	0.75
April	1	0.50
May	2 " "	0.38
June	2 " " "	0.32
July	2 " " "	0.45
August	י יי יי	1.16
September	3 11 11 11	0.25
0ctober	6 11 11 11	0.48

The months with only 1 or 2 stage deficiency occurrences (December through August) experienced the one deficiency during the 1970-71 drought; in other words this deficiency represents a single severe occurrence. This indicates that the minimum monthly Lake Istokpoga stages initially suggested for these months theoretically are generally appropriate. The above tabulation also indicates that the suggested preliminary minimum stages for the months of September through November require some adjustment to conform more closely with actual experience. A comparison of present irrigation demand levels reveals that some further adjustment is desirable in order to minimize the objections noted on page 8 concerning termination of irrigation supply flows while apparently ample storage still remains in the lake.

A more or less arbitrary judgment was applied in making these adjustments. The following tabulation lists the recommended minimum monthly stages for Lake Istokpoga. These represent those stages below which, when reached at any time during the month, no further water supply releases will be made at S-68 and users withdrawing directly from the lake will be notified to terminate such withdrawals.

MONTH	RECOMMENDED	MIN.STAGE
November	38.8	
December	38.5	
January	38.4	
February	38.4	
March	38.3	
April	37.5	
May	37.0	
June	37.0	
July	37.3	
August	38.0	
September	38.3	
October	39.0	

A visual representation of the storage represented by these minimum stages in comparison with present average irrigation demand levels plus P-ET is presented in Figure 7.

The recommended minimum lake stage schedule is a step-type schedule, and is shown on Figure 4. It is expected that some flexibility will be possible, and applied, in actual operations; for example near the end of the month of

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March where there is a difference of 0.8 ft. between the March and April minimums. The allowable margin of flexibility is to be established, administratively, by the Department of Field Services. The stages listed above, however, will be those officially adopted and published.

In adopting and publishing the minimum lake stage schedule the District must reserve the right to periodically depart from that schedule for environmental/water quality reasons.

2. Having established a schedule of minimum monthly stages below which no irrigation releases will be made at S-68 and no irrigation withdrawals directly from the lake will be permitted, it will be necessary to establish minimum canal stages in the several reaches of Canals 40, 41, 41A and 39A. Without establishing such minimum stages, when irrigation supply releases at S-68 are terminated the tendency will be for irrigators to draw on canal storage to the potential detriment of the canal section.

The minimum canal stages are to be determined by the Department of Field Services. These minimums are to be officially established and published, and should be made conditions of the water use permits issued by the District for withdrawals from the canal system.

It is recommended that the termination of releases at S-68 when minimum lake stage is reached be applicable only to irrigation water supply releases. Releases required to maintain minimum canal stages (replacement of evaporation losses, and seepage losses - if any) are to be made regardless of Lake lstokpoga stage. The maintenance of minimum canal stages for the purposes of protecting the District facility takes precedence, therefore, over the maintenance of minimum lake stages.

3. Monthly minimum flow maintenance requirements to Lake Okeechobee are listed in Table 2. At this point it appears to make little difference at

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which of six different discharge points (S-71, 72, 84, 127, 129, or 131) the minimum flows are delivered to the Lake. Accordingly, the sum of the discharges at all six locations will be used to determine if minimum flow maintenance requirements are being met. However, further studies in the Lake may indicate the desirability of specifying amounts by location.

The Department of Field Services will have the responsibility for ensuring that minimum flow requirements are met, applying whatever accounting procedures are suitable.

Lake Istokpoga water is not to be deliberately used to maintain minimum flows to Lake Okeechobee. Consequently, when minimum Lake Istokpoga stage is reached and only minimum stages in the canal system are being maintained, the requirement for minimum flows to Lake Okeechobee is terminated. Both the maintenance of minimum stages in Lake Istokpoga and the maintenance of minimum canal stages takes precedence over flow maintenance requirements to Lake Okeechobee.

It is recognized that there will be some difficulty during certain periods in determining if minimum flows to Lake Okeechobee are being maintained by Lake Istokpoga water, basin base flow, or a combination of both. This does not appear to be too important a consideration and for present purposes can be ignored.

Monthly minimum flow maintenance values from the basin to Lake Okeechobee are to be officially adopted and published.

4. Flows in Arbuckle and Josephine Creeks are unregulated by the District. Therefore, the minimum flow values listed in Tables 11 and 12 have no operational implications. The establishment of these values is solely for the purpose of providing the Regulation Division an upper limit for the maximum permissible future water use diversions in each of these watersheds.

These minimum monthly flow values are to be officially adopted and published by the District.

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SHALLOW GROUNDWATER USE

For all practical purposes nothing is known concerning the extent, depth and hydraulic characteristics of the shallow groundwater systems (water table aquifers) in the basin south of Lake Istokpoga. The important consideration is the degree of hydraulic connection of these aquifers with the surface water system; that is, the extent to which shallow groundwater extractions affect surface water availability from the primary canals. Accordingly, a highly arbitrary determination of criteria must be made on an interim basis until more knowledge is obtained in this regard.

It will prima facie be assumed that all non-exempt groundwater extraction systems:

- (a) which are located within one mile of the centerline of any of the primary canals;
- (b) which are located within one mile of the centerline of any canal connecting with the primary system and whose depth below ground-level is in excess of 15 feet; or

(c) whose zero drawdown contour falls within these one mile limits, are the equivalent of a system which withdraws water directly from the primary canal network and will be treated in all respects in the same fashion. The applicant will, of course, be given the opportunity to demonstrate that his proposed extraction does not influence surface water availability. Failing such demonstration to the satisfaction of the District, the prima facie assumption initially made will hold.

The above equivalency of groundwater extraction to surface water extraction applies only to the basin yield component of total available, and allocable, surface water.

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WATER SUPPLY AND WATER USE ACCOUNTING

Chapter 373.042 provides that the Governing Board shall establish minimum water levels and states that "the minimum water level shall be --- the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area." This section of the statute further states that "when appropriate, minimum --- levels may be calculated to reflect seasonal variations." Finally, this section states that "the governing board shall also consider --- the protection of nonconsumptive uses in the establishment of minimum --- levels."

The approach recommended herein concerning minimum Lake Istokpoga stages follows the above, admittedly discretionary, language. That is, by recommending the establishment of monthly minimum stages full account is taken of "seasonal variations" and due consideration is given to "protection of nonconsumptive uses." Neither of these factors is given appropriate weight if only a single absolute minimum stage is established. Furthermore, the data presented herein indicates that this approach will not be unreasonably restrictive of present consumptive beneficial uses in the basin.

The provisions of the statute in another area, Chapter 373.175 dealing with the declaration of water shortage and emergency orders, raise an issue of some potential concern in terms of possible conflict with the provision for establishing minimum stages. In practical terms the situation is this: when Lake istokpoga stage is above the monthly minimum full water allocations can be met, but when stage recedes to the minimum, withdrawals are terminated; this is a situation which can develop overnight.

The potential conflict arises from the fact that the statute implies that, except under unusual circumstances, reasonable notice be given that a

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water shortage exists. The situation described in the previous paragraph does not, presumably, meet the requirement of reasonable notice to permitted water users of an impending water shortage. (See also here Ch. 16CA-2.12(1), Ch. 16CA-2.13(1) and (2) of District Rules and Regulations).

This indicates that it will be necessary to establish a simplified continuous accounting procedure wherein water supply is related to and compared with estimated (or actual) water use. A plotting of Lake Istokpoga storage above elevation 37.0 ft.msl. versus reverse accumulated (remaining) demand from November 1 through May 31 will provide such an accounting method. This is a set of graphs similar to that prepared for Lake Okeechobee and described in the recent issue of "In Depth Report."

This set of supply-demand graphs should be maintained by the Regulation Division, and can be developed in that Division. It is recommended that the average monthly estimated irrigation withdrawals, November-May, presented in this memorandum report, together with the monthly P-ET values, be used initially to develop the "remaining demand" curve. To plot available supply, daily lake stages (S-68) are to be furnished by the Department of Field Services, and the Resource Planning Department will furnish stage-storage curves for conversion of lake stage to stored water volume above elevation 37.0 ft.msl.

Figure 7 displays a set of supply-demand curves in which average period of record month-end stage is used to determine available storage, as an example.

By maintaining a continuous plotting of available storage during the irrigation season and relating this to both estimated remaining demand and monthly minimum stages (storage levels) the Regulation Division will be in a position to notify permittees of impending water shortages and the estimated size of the deficiency. It will also be possible to develop a procedure whereby water use can be reduced on a percentage basis when minimum monthly stages are approached.

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PERMIT CLASSIFICATION

Chapter 373.246 states that the "Governing Board shall adopt a reasonable system of permit classification according to source of water supply, method of extraction or diversion, use of water, or a combination thereof." The Rules and Regulations adopted by the District pursuant to the statute state in Chapter 16CA-2.12(2) that "for the purpose of the water shortage plan only, each permit shall be classified according to source and use." (underscoring supplied).

The Rules and Regulations specify that each permit be given one or both of the following source classifications: groundwater, and surface water. They further specify that each permit be given one or more of the following classifications as to use: domestic, essential services, public supply, livestock, agricultural, industrial, mining, power and recreational.

A water shortage condition is normally considered as being applicable to a geographical area. However, a water shortage can occur with respect to a particular source as well. Consequently, it is entirely possible that within any geographical area there may be a shortage of water in one water source located within that area and no shortage in another water source. The classic example is a water shortage in a surface water/water table aquifer system separated by an aquiclude from a deep aquifer system in which there is ample water. The controlling factor is the degree of hydraulic interconnection between the several elements of the surface water system, the surface water system and the groundwater table aquifers, and the shallow aquifers and the deeper aquifers.

Therefore, a declaration of water shortage must, in most cases, describe not only the geographical area in which the shortage exists but the source which is deficient. The classification of permits as to "source" must also

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take this into account. This means that, generally speaking, a simple source classification distinction between "ground" and "surface" sources is insufficient. Adequate qualifiers must be applied to the two basic source descriptions to clearly and sufficiently define the separable sources which may possibly be treated differently under a water shortage declaration.

For the purposes of permit classification, the geographical area to which the system recommended herein will apply consists of:

- All land areas which presently, or will in the future, receive their water supply directly from Lake Istokpoga;
- All of the lands which lie within the designated drainage basins of Canals 40, 41, 41A and 39A, as generally shown on the map of Figure 1; and
- Those lands which presently receive their water supply from the borrow canals of interceptor levees L-59, 60 and 61.

This specifically excludes those lands located between the interceptor levees and Lake Okeechobee, except for those parcels which by separate agreement have been permitted to irrigate from water in the interceptor borrow canals. As noted on page 16, this 55 sq. mi. area will be covered in a separate report.

The following will be considered as a single source when application of water shortage measures becomes necessary:

- 1. Lake Istokpoga.
- 2. Canals 40, 41, 41A and 39A.
- 3. The borrow canals of Levees 59, 60 and 61.
- All ditches and canals connecting with items
 2 and 3.

- All ditches and canals from which water can be extracted from Lake Istokpoga.
- The water table aquifers having substantial hydraulic connection with the elements of the surface water system enumerated in items 1, 2, 3, 4 and 5.

Water shortage measures, when found necessary, will be applied to the abovedescribed elements as if they were a single water body.

The first 5 items are all surface water bodies and it is suggested permits issued for water withdrawals from all of these be given the designation "S." Item 6 is a goundwater source and it is suggested permits for extraction from that source be given the designation "G-1."

It is further suggested that all other water table aquifers in the designated geographical area be given the designation "G-2", and that the water body which has the generic name "Floridan Aquifer" (Artesian) be given the designation "G-3."

No overall classification as to use has been made as yet by the District. However, it is not believed necessary to do this first; it is believed appropriate wherever possible, to establish use classifications on a basin basis.

Considering the "source" factor of the classification system as being the practical equivalent of a geographical description for purposes of a water shortage declaration, "use" becomes the only factor of the classification system (in the case of the study area of this report) which bears on the manner in which use restrictions are to be applied. For example, under present conditions of water use in this area, if there is a deficiency of stored water in Lake Istokpoga a water shortage would be declared for the area with restrictions to be applied only to those permits designated "S" and "G-1." The "G-2" and "G-3" permits would not be affected. The nature of
the restrictions in the area defined by geography <u>and</u> source, would be dependent only on use.

It is believed that a pragmatic approach must be taken in establishing use classifications for the Lake Istokpoga - Indian-Prairie Area and in developing the use restriction formulae to be applied in the event of a water shortage declaration. Such an approach takes cognizance of existing water uses within the area and probable water uses in the immediately foreseeable future. In addition, the District's immediate concern is with respect to the single source having the source designations "S" and "G-1." Consequently, use classification (and restriction formulae) should at this time be primarily oriented toward consideration of that source, and present and foreseeable future uses of that source.

On this basis water use for power production and for major mining and industrial enterprises can be eliminated from consideration. The large supplies of water needed to meet the requirements for such uses are not available and the District would not consider issuing allocation permits for such quantities of water. Smaller-size mining or industrial operations (shell-pits, concrete batch plants, etc.) should, however, be considered.

Public recreational use has already been considered in the establishment of minimum levels for Lake Istokpoga. Therefore, it can also be eliminated from consideration in establishing use classifications.

Remaining to be considered, then, of the use types enumerated in Chapter 16 CA-2.12 (2) (b) of the Rules and Regulations, are:

- 1. Domestic 5. Agricultural
- 2. Essential Service 6. Industrial (minor)
- 3. Public Supply 7. Mining (minor)
- 4. Livestock

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Items 1 and 2 carry equal weight, as do items 4 and 5*, and items 6 and 7. A general ordering of priority would then be:

- 1. Domestic and Essential Services
- 2. Public Supply
- 3. Livestock and Agricultural
- 4. Industrial and Mining

* There is some merit in the view that stock-watering is a superior use in comparison with irrigation. For present purposes, however, the assumption of equivalency is adequate.

Public supply use is essentially a mixture of uses. It includes uses which are "domestic" and "essential services" (drinking, cooking, sanitation, fire-fighting, etc.). But it also includes uses which are the equivalent of "agricultural" (lawn sprinkling) and even the lower priority use "recreational" (filling swimming pools, car-washing, etc.). For this reason it is given a priority ranking between priority 1 and priority 3. This mixture of uses under the broad term "Public Supply" plays a part in the development and application of use restriction criteria.

If an appropriate water supply/demand accounting procedure is established, as recommended herein, the advent of a potential water shortage condition will be tracked. In addition, it is most likely that such conditions will occcur for only comparatively short periods of time (April, May). For these reasons (i.e.,timely action by the District, and short duration shortages) there should be no reason for having to restrict priority 1 uses.

Concerning public water supplies, information which we have unofficially obtained from reliable sources over the past several years indicates that lawn irrigation can account for anywhere between 25% and 65% of the finished water production of municipal suppliers. When the application of restrictions becomes necessary, this share of public water supply allocation should be treated the same as the priority 3 uses. It is recommended that this share be established at 25%, with a maximum of 35%. (see following presentation).

Finally, to reflect the somewhat lower priority for mining and industrial uses (priority 4) it is suggested that, arbitrarily, the percentage restriction applied to users (permittees) in this classification be 5 percentage points greater than the percentage applied to priority 3 users.

In developing a water use restriction procedure it is recommended that the primary basis be the assessment or forecast of monthly supplies and demands. The capability should be developed, however, to make assessments on a shorter time interval. The recommended procedure is described below.

 If the forecast shortage for the month is 25% or less than the estimated (or permitted) monthly demand:

In this case the priority 2 and priority 3 use restrictions are the same.

Let D = estimated deficiency for month Q = total monthly demand = $Q_1 + Q_2 + Q_3 + Q_4$ X = percent reduction to be applied to priority 2 uses where Q_1 = total demand for priority 1 uses Q_2 = total demand for priority 2 uses Q_3 = total demand for priority 3 uses Q_4 = total demand for priority 4 uses

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since priority 1 uses are not restricted, the $\ensuremath{\mathtt{Q}}_1$ term is eliminated. Then:

 $100D = X(Q_2+Q_3) + (X+5(Q_4)) = X(Q_2+Q_3+Q_4) + 5Q_4$ Example: D = 20,000 A.F.; Q = 110,000 A.F.; Q_1 = 10,000 A.F. Q_2= 20,000 A.F.; Q_3= 70,000 A.F.; Q_4 = 10,000 A.F. 2 x 10⁶ = 100,000X + 50,000 X = 19.5%

And restriction percentages would be:

Priority 1 permits - 0% Priority 2 permits - 19.5% Priority 3 permits - 19.5% Priority 4 permits - 24.5%

 If the forecast shortage for the month is between 25% and 35% of the estimated monthly demand:

In this case, the formula for case 1 is to be applied to the first 25% of the total estimated monthly demand and a remaining shortage volume determined. For the remainder of the shortage volume it is recommended that the priority 3 use restrictions be set at 5 percentage points higher than the priority 2 values.

For this remainder the formula would be:

 $\begin{aligned} 100D^{1} &= X \cdot Q_{2}^{1} + (X+5)Q_{3}^{1} + (X+10)Q_{4}^{1} \\ &= X(Q_{2}^{1}+Q_{3}^{1}+Q_{4}^{1}) + 5Q_{3}^{1} + 10Q_{4}^{1} \end{aligned}$

Where ${\tt D}^1, \ {\tt Q}_2^1, \ {\tt etc.}, \ {\tt are} \ {\tt the} \ {\tt remaining} \ {\tt shortage} \ {\tt and} \ {\tt demand} \ {\tt values}.$ Example:

D = 38,000 A.F.; all other values same as in previous example. 25%:110,000 A.F. = 27,500 A.F.

> $2.75 \times 10^6 = 100,000 X + 50,000$ X = 27%

RECOMMENDATIONS

The following recommendations are made:

- That the District adopt and publish by the appropriate and necessary means the values for:
 - (a) Maintenance of minimum flows to Lake Okeechobee(see page 7 and Table 2)
 - (b) Maintenance of minimum flows in Arbuckle Creek (see Table II)
 - (c) Maintenance of minimum flows in Josephine Creek (see Table 12)
 - (d) Minimum monthly stages in Lake Istokpoga(see page 32 and Figure 4)
- 2. That the Department of Field Services establish minimum stages for each controlled reach of Canals 40, 41, 41A and 39A, and that these be adopted and published by the District by the appropriate and necessary means. (see page 27).
- That new surface water allocations in the basin be made using the values presented in Table 14 as guidelines for technical evaluation.
- 4. That serious consideration be given to applying the allocation criteria of Table 14, based on hydrologic constraints, to existing permits to be converted; the final decision here to be made by the Executive Director upon the recommendation of the Regulation Division.
- 5. That all permittees, both old and new, be placed constructively on notice concerning the impact on water supply of the establishment of minimum monthly stages for Lake Istokpoga; preferably as a special condition of the permit.

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- 6. That the potential for conjunctive use of groundwater from the water table aquifers and surface water be taken into account in considering applications for shallow groundwater use in the basin south of Lake Istokpoga. (see page 25).
- 7. That the Department of Field Services adopt the following order of operational priorities when circumstances exist such as to make choices necessary: (see pages 23 and 24).

Priority 1: Maintenance of minimum canal stages. Priority 2: Maintenance of minimum Lake Istokpoga stages. Priority 3: Maintenance of flows to Lake Okeechobee.

- 8. That in issuing permits for impoundments in the basin such permits stipulate that impoundment of surplus surface waters above the allocated monthly amounts will not be allowed unless concurrent regulatory discharges from Lake Okeechobee are being made. (see page 19).
- 9. That the Regulation Division develop and maintain a supplydemand accounting procedure for the purpose of providing notice to permittees of an impending or existing water shortage in the area. (see page 27 and Figure 7).
- That a permit classification system and water shortage plan for the Lake Istokpoga - Indian Prairie Area be established. (see page 28).
- 11. That all permittees, both old and new, be required to submit monthly reports of water usage in a form satisfactory to the District.
- 12. That the Resource Planning Department define the locations and characteristics of the shallow aquifer systems in the basin south of Lake Istokpoga to the extent necessary to reasonably

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establish the hydraulic relationships between the aquifers and the surface water system.

13. That all permits, both old and new, be re-evaluated as a unit at the same time, and no later than mid-1977.

DEC.	3,107	2,145	1,251	1,251	1,746	24,533	191	218	266	1,356	3,606
. NOV	1,765	21,108	3,106	2,291	13,329	36,321	4,751	9,596	1,644	1,395	9,530
<u>0CT</u> .	7,464	36,515	30,704	19,452	26,691	111,334	4,619	37,866	10,630	23,569	30,884
SEPT.	42,990	8,757	40,978	18,521	17,720	25,391	1,431	114,080	4,455	83,629	35,795
AUG.	29,254	6,183	71,087	13,925	7,792	71,550	5,106	42,499	3,956	35,420	28,677
JULY	2,890	5,754	83,260	21,575	60,429	6,999	13,838	17,050	5,817	51,085	26,869
JUNE	5,439	7,624	37,212	10,408	80,601	23,536	3,729	9,461	42,446	9,14]	22,959
MAY	2,810	912	4,174	912	1,260	8,830	867	117	6,398	1,530	2,781
APRIL	818	1,826	9,375	818	818	066	17,081	137	5,318	2,469	3,965
MARCH	5,652	3,633	9,113	3,768	1,874	31,040	106,663	127	693	5,379	16,794
FEB.	13,902	1,614	19,815	1,695	1,285	1,661	11,080	143	6,981	3,949	6,212
JAN.	9,766	661	15,648	675	650	3,621	56,623	141	133	1,278	8,920
YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	AVG.

ISTOKPOGA - INDIAN PRAIRIE BASIN YIELD IN ACRE-FEET

BASIN YIELD

MONTH	TOTAL BASIN YIELD	FLOW MAINTENANCE REQUIREMENT	ADJUSTED BASIN YIELD (ALLOCABLE VOLUME)
JAN.	1,500	220	1,280
FEB.	3,000	650	2,350
MAR.	4,000	800	3,200
APR.	1,800	540	1,260
МАҮ	1,500	440	1,060
JUNE	15,000	6,500	8,500
JULY	15,000	5,800	9,200
AUG.	18,000	5,500	12,500
SEPT.	20,000	6,100	13,900
OCT.	21,000	9,200	11,800
NOV.	4,700	1,600	3,100
DEC.	1,100	360	740
TOTAL	All values in a	cre-feet	

NONTH	AVERAGE PAN EVAPORATION	ACTUAL EVAPORATION(a)	AVERAGE	AVERAGE EVAPORATION MINUS AVERAGE PRECIPITATION	PERCENTAGE	PERCENTAGE X (39.5-37.0)FT.	MINIMUM MONTHLY STAGE
.VOV	4.64	3.62	1.31	2.31	14.2	0.35	39.15
DEC.	3.59	2.80	1.20	1.60	9.8	0.24	38.91
JAN.	3.67	2.86	1.76	1.10	6.7	0.16	38.75
FEB.	4.25	3.32	2.25	1.07	6.5	0.16	38.59
MAR.	6.15	4.80	2.73	2.07	12.7	0.32	38.27
APR.	7.87	6.14	1.06	5.08	31.3	0.78	27.49
ЧАҮ	7.96	6.21	3.22	2.99	18.4	0.46	27.0
TOTAL	38.13	29.75	13.53	16.22			

LAKE ISTOKPOGA DRY SEASON STAGE

(a) Evaporation Pan reading X 0.78 coefficient

Lake Istokpoga.

DEC.	2,209	8,929	5,836	5,089	4,353	42,897	12,123	6,408	4,470	7,058	from
NON	1,409	15,330	5,932	5,947	25,880	44,637	8,777	11,219	5,069	8,255	directly
<u>0CT</u> .	18,296	25,975	38,977	30,220	11,079	121,436	2,640	12,744	8,141	24,614	ithdrawals
SEPT.	51,101	27,733	66,400	1,919	18,043	57,639	12,731	7,131	12,052	81,105	ʻigation w
<u>AUG</u> .	12,355	46,531	83,659	385	18,015	50,445	14,049	2,561	6,241	44,131	imated irr
	2,401	33,374	2,713	304	82,103	21,391	21,185	648	17,859	16,145	and est
JUNE	18,515	1,113	5,498	1,600	96,899	57,370	6,528	5,437	28,801	7,602	discharge
MAY	40,686	11,282	25,071	11,400	6,151	26,455	20,455	5,603	31,139	24,595	ja Canal
APRIL	11,131	8,083	23,137	15,788	9,176	32,185	30,534	12,448	28,007	29,838	d Istokpoç
MARCH	11,643	8,083	23,137	15,788	9,176	32,185	30,534	15,635	9,122	46,696	of S-68 an
FEB.	26,386	4,689	37,462	2,160	6,091	7,141	25,647	9,514	18,400	3,381	the sum o
JAN.	25,800	10,502	23,606	4,384	4,597	13,875	37,013	10,885	8,140	5,218	ırges are
YEAR	1964	1965	1966	1967	1968	6961	1970	1971	1972	1973	Discha

LAKE ISTOKPOGA MONTHLY DISCHARGE IN ACRE-FEET

Accumulated Seasonal Monthly Discharges from Lake Istokpoga

NOV.,DEC. JAN.,FEB. MAR.,APR. MAY	63561	197882	60065	43173	176988	258460	74985	112435	119267	
NOV.,DEC. JAN.,FEB. MAR.,APR.	52279	172811	48665	37022	150533	238005	69382	81296	94672	
NOV.,DEC. JAN.,FEB. MARCH	44196	149674	32877	27846	118348	207471	56934	53289	64834	
NOV. JAN. FEB.	18809	85327	18312	21724	51249	150194	41299	44167	18138	
NOV. DEC.	14120	47865	16152	15633	44108	124547	31785	25767	14757	
NOV.	3618	24259	11768	11036	30333	87534	20900	17627	9539	15313
NOV.	1409	15330	5932	5947	25880	44637	8777	11219	5069	8255
JUNE,JULY AUG.,SEPT. OCT.	102668	134678	197247	34428	226139	308281	57133	28524	73094	173597
JUNE JULY AUG. SEPT.	84372	108751	158270	4208	215060	186845	54493	15780	64953	148983
JUNE JULY AUG.	33271	81018	91870	2289	197017	129206	41762	8646	52901	67878
JULY	20916	34487	8211	1904	179002	78761	27713	6085	46660	23747
JUNE	18515	1113	5498	1600	96899	57370	6528	5437	28801	7602
YEAR	1964-1965	1965-1966	1966-1967	1967-1968	1968-1969	1969-1970	1970-1971	1 971-1972	1972-1973	1973

LAKE ISTOKPOGA ACCUMULATED TOTAL DISCHARGE IN ACRE-FEET

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		MARCH	APRIL	MAY	JUNE	<u>יי</u> <u>יי</u>	<u>AUG</u> .	SEPT.	<u>0CT</u> .	NOV.	DEC.
38.92 38.68 3	38.68 31	ñ	3.47	37.54	37.18	37.47	38.46	38.86	90.95	39.04	cU. 65
38.83 38.79 38	38.79 38	38	.41	37.87	38.51	38.50	38.60	38.75	39.49	39.48	39.51
39.46 38.76 38	38.76 38	38	.23	37.73	37.56	38.59	38.73	38.99	39.34	39.26	39.15
39.24 38.64 37.	38.64 37.	37.	74	36.85	36.93	37.12	38.20	39.46	39.34	39.17	39.23
39.04 38.68 38.0	38.68 38.0	38.0	2	37.86	38.22	38.03	38.57	38.87	39.48	39.45	39.47
39.20 39.11 38.3	39.11 38.3	38.3	2	37.62	37.94	38.12	38.45	39.55	39.55	39.56	39.60
39.49 39.03 38.3	39.03 38.3	38.3		37.62	37.76	38.29	38.47	38.77	39.09	38.74	38.39
38.17 37.77 36.9	37.77 36.9	36.9	ő	36.40	36.63	36.58	36.84	38.54	39.57	39.40	39.40
39.35 39.12 38.	39.12 38.	38.	61	37.51	37.97	37.97	38.54	38.35	37.90	37.96	38.00
39.27 38.65 38.	38.65 38.	38.	15	37.64	38.07	38.44	38.64	39.22	39.39	39.38	39.3]

LAKE ISTOKPOGA MONTH-END STAGE

LAKE ISTOKPOGA MONTH-END FICTITIOUS STAGES

DEC.	39.1	40.3	39.5	39.5	40.4	42.4	39.1	39.9	38.3	39.7
NOV.	39.1	40.0	39.4	39.3	40.2	41.]	39.0	39.7	38.1	39.6
<u>0CT</u> .	42.5	43.8	45.3	40.4	46.2	48.3	41.0	40.6	40.3	44.7
SEPT.	41.7	42.3	43.9	39.6	45.6	45.2	40.6	39.0	40.4	43.9
AUG.	39.6	41.3	41.7	38.3	44.8	42.8	40.0	37.0	40.3	40.8
JULY	38.3	39.7	38.8	37.1	43.8	40.7	39.2	36.9	39.6	39.2
JUNE	37.8	38.5	37.8	37.0	41.4	39.9	38.1	36.8	39.0	38.3
MAY		40.0	44.1	38.9	39.3	43.4	45.7	39.1	41.3	41.7
APRIL		40.2	43.7	39.8	39.3	43.2	45.7	39.5	40.9	41.2
MARCH		40.3	43.6	39.7	39.6	42.9	45.4	39.8	40.8	40.8
FEB.		39.5	42.2	39.8	39.8	40.7	44.2	39.6	40.8	39.8
JAN.		39.2	40.9	39.6	39.7	40.7	43.6	39.1	40.1	39.2
YEAR	1964	1965	1966	1967	1968	1969	1970	1261	1972	1973

LAKE ISTOKPOGA CHANGE IN FICTITIOUS STAGE

	<u>0CT</u> .	5.0	5.9	7.6	3.6	8.3	10.7	3.4	4.2	2.8	۲.٦
	SEPT.	4.2	4.4	6.2	2.8	7.7	7.6	3.0	2.6	2.9	6.3
c cnn1 1	AUG.	2.1	3.4	4.0	1.5	6.9	5.2	2.4	9.	2.8	3.2
TIN LTCI	JULY	æ.	1.8	1.1	۳ <u>.</u>	5.9	3.1	1.6	•2	2.1	1.6
A UNAIVAG	JUNE	ę.	9.	-	.2	3.5	2.3	·2	4.	1.5	
LAKE ISLUNFUG	MAY 31 ACTUAL STAGE	37.5	37.9	37.7	36.8	37.9	37.6	37.6	36.4	37.5	37.6
	YEAR	1964	1965	1966	1967	1968	1969	1970	1671	1972	1973

ARBUCKLE CREEK MONTHLY DISCHARGE IN ACRE-FEET

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DEC.	7,803	12,227	4,861	7,653	6,918	11,246	8,126	22,125	20,067	10,858	9,443	12,246	14,593	54,478	11,179	2,610	6,849
. VOV	8,318	17,509	5,061	11,664	11,300	17,600	12,846	30,045	30,579	17,438	16.234	20,436	38,335	45,334	13,824	3,425	14,757
0CT.	27,738	19,758	13,985	33,482	17,107	44,023	25,033	69,821	104,471	66,716	27,639	49,167	62,384	157,054	30,237	6,675	50,914
SEPT.	53,830	20,952	16,549	35,092	17,600	87,164	27,623	102,683	109,395	80,152	7,005	29,581	15,721	112,009	36,505	9,710	12,830
AUG.	28,726	27,069	16,303	32,543	34,014	43,720	17,701	72,686	62,392	40,131	4,261	42,861	17,291	35,517	25,716	6,273	6,562
JULY	30,625	54,903	23,730	39,986	11,559	59,079	8,872	58,559	14,250	10,502	5,106	41,705	9,993	31,629	34,345	8,094	2,829
JUNE	11,048	12,385	23,140	8,116	4,154	2,404	4,059	51,801	6,574	5,180	2,612	4,118	5,578	33,296	53,072	2,196	1,919
MAY	6,401	13,579	8,722	2,590	6,215	804	2,772	10,401	8,960	3,176	1,956	6,227	6,213	12,609	12,851	2,837	598
APRII	18,388	22,146	14,282	2,897	6,797	1,632	3,437	15,905	11,270	4,004	2,188	30,250	11,514	21,489	14,395	5,601	556
MARCH	20,832	13,603	27,108	4,954	3,726	3,364	5,203	22,227	10,534	5,451	3,766	4,843	13,820	10,545	13,492	6,033	1,372
FEB.	16,986	16,602	15,921	3,627	4,449	5,176	5,871	6,467	18,721	7,829	5,019	6,453	11,009	10,276	16,559	8,136	2,061
JAN.	14,502	16,955	18,804	3,829	6,075	7,746	9,900	5,881	20,556	13,478	7,823	7,217	8,300	13,890	29,128	10,003	2,424
YEAR	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956

TABLE 9a

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DEC.	10.419	6 524	18 184	14.900	2.321	6.946	8,102	5.835	11_636	5.374	4.788	7.708	35,994	3.780	6.643	6.447		
. NOV	11.490	12U T	42 323	20.417	2,485	15,101	7.647	6.205	17,293	8.142	6.492	19.774	40.453	4,075	10.131	2.705	20.11	
<u>0CT</u> .	39.697	8,030	94.557	81,863	4.336	23,966	13.333	16.721	29.783	25.199	31.512	22.604	108,108	10.536	33,555	3.457	6	
SEPT.	41.635	16,291	93,963	145.239	9.953	45,904	14.767	37,741	19,198	44.324	26,952	10.472	65,346	10,454	25.447	5.485	57,390	
AUG.	48.754	14.410	47.566	94,939	4.877	43,806	7,869	15,503	38,115	62,913	26,682	24,449	36,202	9,832	5.397	9,348	45,809	
JULY	44,841	19.707	51.617	30.506	6,043	30,850	16,072	6,931	32,805	26,696	7,288	75,686	15,442	10,357	3,400	20,099	18,030	
JUNE	32,070	11,985	75,563	16,012	4,930	11,486	10,842	7,451	9.557	20,659	1,432	49,308	25,679	4,598	1,810	18,473	7,742	
MAY	34,765	15.747	10,852	14,288	5,851	1,018	5,073	8,441	3,992	10,019	212	4,247	4,604	4,934	1,123	6,863	13,755	
APRIL	19,083	28,563	18,044	33,870	9,439	2,649	5,853	6,722	6,827	13,088	984	1,370	6,003	16,056	2,622	3,592	20,406	
MARCH	13,420	33,416	40,426	32,030	12,369	116,1	26,809	10,797	18,095	36,285	4,041	2,782	41,235	26,092	3,669	4,726	15,517	
FEB.	4,768	26,461	7,292	22,020	12,815	1,786	18,640	18,523	5,665	30,751	4,281	3,067	6,694	14,185	4,285	11,955	13,153	
JAN.	5,728	31,088	8,754	14,098	18,731	2,635	7,874	15,404	5,055	13,638	3,338	3,994	9.102	32,023	3,970	5,853	9,641	
/EAR	1957	1958	959	1960	1961	1962	1963	1964	1965	1966	1967	1968	96 <u>9</u>	970	1971	972	973	

TABLE 9b

JOSEPHINE CREEK MONTHLY DISCHARGE IN ACRE-FEET

	155,652	161,285	65,698	15,521	44,134	52,401	134,794	86,308	30,151	14,878	67,213	78,945	135,973	185,738	39,334	43,827	34,177	28,793	26,264	78,966	15,426	38,772	84,328	65,019	25,048	24,035	
DEC.	12,159	9,664	3,008	1,348	4,328	3,570	12,335	4,558	1,123	1,239	3,934	1,558	7,566	3,994	788	3,219	1,517	619	1,384	1,724	750	1,578	7,407	916	1,350	1,756	
. NON	17,598	13,915	4,473	2,156	5,805	5,997	15,846	5,160	1,536	2,657	5,354	1,990	13,664	10,153	933	3,437	1,925	1,118	3,449	2,977	675	3,217	8,064	1,338	1,659	932	
<u>0CT</u> .	26,651	34,765	11,159	2,607	10,264	7,975	36,879	9,555	3,493	6,201	14,630	3,188	29,813	28,651	1,689	9,045	2,445	3,785	6,745	12,586	3,920	3,783	13,149	3,403	4,874	1,063	
SEPT.	28,259	37,293	15,424	2,618	5,778	7,821	27,152	15,452	5,918	1,800	14,090	6,538	26,087	45,730	3,685	9,579	3,105	8,383	5,367	19,697	3,267	4,229	11,880	3,601	9,977	3,716	9,353
AUG.	20,111	22,647	11,405	545	6,108	6,231	14,018	13,163	3,255	647	9,183	8,573	21,334	37,671	3,740	6,120	3,364	2,880	4,565	11,054	1,805	5,724	11,440	6,298	2,768	4,813	3,245
<u>JULY</u>	19,511	7,520	4,180	618	4,209	3,330	11,462	10,470	3,443	192	5,661	6,958	15,228	16,691	4,198	8,082	2,721	1,188	1,463	8,781	475	8,017	5,650	006'6	530	3,154	2,253
JUNE	13,151	2,263	1,632	404	394	2,629	6,827	6,574	939	186	3,132	5,239	8,459	7,092	3,645	2,439	1,982	704	453	5,304	344	10,195	12,456	2,651	322	2,617	2,108
MAY	4,255	3,600	1,715	356	1,594	2,340	1,008	1,903	537	65	3,540	8,059	1,927	4,813	1,606	194	1,216	1,013	178	1,233	298	251	1,437	1,354	334	833	912
APRIL	5,461	4,803	1,832	360	2,984	2,721	1,491	3,089	1,038	113	3,061	10,512	4,520	9,920	2,606	354	1,655	948	291	2,229	368	283	3,259	8,264	423	1,199	1,815
MARCH	5,742	5,548	1,994	849	620	3,578	1,923	3,972	1,853	305	2,679	10,862	4,362	9,130	2,843	347	7,504	2,421	1,098	5,296	760	465	6,979	11,466	1,116	966	3,179
FEB.	1,481	9,013	3,305	1,374	1,186	3,128	2,631	4,663	3,111	628	923	7,678	1,299	6,886	6,378	370	4,004	3,599	619	5,977	1,296	409	1,005	5,755	869	1,879	3,829
JAN.	1,273	10,252	5,574	2,186	863	3,025	3,221	7,750	3,907	861	1,026	7,789	1,715	5,005	7,225	640	2,740	2,128	641	2,102	1,463	615	1,597	10,068	821	1,102	2,874
YEAR	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	6961.47	, 1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973

ARBUCKLE CREEK DISCHARGE DATA IN ACRE-FEET

MONTH	TWO YEAR FREQUENCY DISCHARGE	TRIBUTARY ALLOCATION	MINIMUM DISCHARGE TO LAKE ISTOKPOGA	MINIMUM MONTHLY FLOW RATE <u>IN CFS</u>
JANUARY	9,500	475	9,025	4,558
FEBRUARY	9,500	475	9,025	4,558
MARCH	9,500	475	9,025	4,558
APRIL	8,200	410	7,790	3 ,9 34
MAY	5,800	290	5,510	2,783
JUNE	9,000	450	8,550	4,318
JULY	20,000	1,000	19,000	9,596
AUGUST	28,000	1,400	26,600	13,430
SEPTEMBER	29,000	1,450	27,550	13,910
OCTOBER	30,000	1,500	28,500	14,390
NOVEMBER	12,000	600	11,400	5,758
DECEMBER	8,200	410	7,790	3,934

JOSEPHINE CREEK DISCHARGE DATA IN ACRE-FEET

MONTH	TWO YEAR FREQUENCY DISCHARGE	TRIBUTARY ALLOCATION	MINIMUM DISCHARGE TO LAKE ISTOKPOGA	MINIMUM MONTHLY FLOW RATE IN CFS
JANUARY	2,100	105	1,995	1,008
FEBRUARY	2,100	105	1,995	1,008
MARCH	2,100	105	1,995	1,008
APRIL	1,700	85	1,615	816
MAY	1,100	55	1,045	528
JUNE	2,200	110	2,090	1,056
JULY	4,500	225	4,275	2,159
AUGUST	6,100	305	5,795	2,927
SEPTEMBER	8,500	425	8,075	4,078
OCTOBER	6,700	335	6,365	3,215
NOVEMBER	3,100	155	2,945	1,487
DECEMBER	2,400	120	2,280	1,152

AVERAGE WET SEASON WITHDRAWALS - 9,078 ACRE-FEET

AVERAGE DRY SEASON WITHDRAWALS - 36,050 ACRE-FEET

DEC.	303	4,887	3,917	4,364	3,284	686	11,149	5,396	3,453	2,276	3,971
. <u>NON</u>	89	1,198	3,476	4,487	1,539	220	3,600	1,062	1,456	1,907	1,903
<u>0CT</u> .	14,546	589	22	373	0	2,023	0	0	1,672	0	1,922
SEPT.	2,673	3,939	0	0	1,492	5,284	4,862	0	2,254	0	2,050
AUG.	342	3,464	0	0	733	2,002	2,731	0	3,504	0	1,096
<u> </u>	1,851	8,220	270	0	1,865	1,456	3,834	0	1,628	0	1,913
JUNE	8,737	515	2,625	1,203	469	1,250	858	1,664	925	2,720	2,097
MAY	12,581	10,376	9,779	11,162	5,812	6,357	15,502	5,456	10,392	7,990	9,541
APRIL	10,187	6,295	960'6	15,093	8.693	11,443	3,834	11,353	6,809	5,783	8,859
MARCH	4,982	4,895	2,867	5,682	5,662	1,106	498	12,079	5,453	6,417	4,964
FEB.	194	2,289	2,203	458	5,396	2,934	3,011	6,167	5,361	0	2,801
JAN.	789	7,310	3,992	2,703	3,197	3,387	114	8,854	6,362	3,398	4,011
YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	AVG.

TOTAL IRRIGATION WITHDRAWALS FROM LAKE ISTOKPOGA IN ACRE-FEET

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	VOL UME	E - ACRE FEET		FROM	LAKE	FROM C	ANALS
PERIOD	BASIN YIELD	LAKE STORAGE	TOTAL	AS NEEDED "/A	IMPOUNDMENT "/A	AS NEEDED "/A	IMPOUNDMENT "/A
. NOV	3,100	15,900	19,000		0.8		6.0
DEC.	740	10,900	11,640		0.5		0.5
JAN.	1,280	7,900	9.180		0.4		0.4
FEB.	2,350	7,700	10,050		0.4		0.5
MARCH	3,200	14,300	17,500		0.7		0.8
APRIL	1,260	35,200	36,460		1.8		1.8
МАΥ	1,060	20,700	21,760		1.0		1.0
DRY SEASON	12,990	112,600	125,590	5.6		5.9	
JUNE	8,500	18,400	26,900		0.9		1.3
JULY	9,200	18,450	27,650		0.9		1.3
AUG.	12,500	18,450	30,950		0.9		1.4
SEPT.	13,900	18,450	32,350		0.9		1.5
OCT.	11,800	18,450	30,250		0.9		1.4
WET SEASON	55,900	92,200	148,100	4.5		6.9	
ANNUAL	68,890	204,800	273,690	10.1		12.8	
"/A = inches/a	cre						

MAXIMUM PERMISSIBLE ALLOCATIONS

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FIGURE