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Lower Colorado River Authority

WATER MANAGEMENT PLAN

FOR THE

LOWER COLORADO RIVER BASIN

Prepared By

The Lower Colorado River Authority

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TABLE OF CONTENTS

VOLUME I

WATER MANAGEMENT PLAN FOR THE LOWER COLORADO RIVER BASIN

PREFACE

The "business" of water resources management in Texas, and throughout the nation, is in the midst of transition and transformation. The transition is largely the result of ever increasing demands and competition for renewable but limited water supplies and a growing awareness of the limits of "traditional" water supply management strategies. Additionally, the spectra of long-range shifts in global climatic patterns have injected a new element of uncertainty in water resources planning and management. Clearly, the past may no longer be a valid guide to the future.

In response to new challenges and uncertainties, it is imperative that water management institutions, at all levels, adopt a balanced, flexible, and feasible approach that gives due weight to all the conflicting demands on the water, including the heavy economic dependence of the rice farmers on historic uses of irrigation water, rapidly emerging public interest in recreation, and environmental values. The challenge is to recognize both the historic uses and the forces of change, transform emerging problems into new opportunities, and guide the institutions of water resources management toward a new era where clean water in Central Texas is recognized as a scarce commodity.

The purpose of this document, Water Management Plan for the Lower Colorado River Basin, is to define LCRA's water management programs and policies. This plan, it should be noted, is not the final word on LCRA's water management activities. LCRA's Water Management Plan will evolve over the years in response to changing conditions, new information, and emerging issues and opportunities.

LEGAL AUTHORITY

The legal authority underlying the development of the Water Management Plan is derived from four principal sources:

(1) The final order of adjudication of the water rights of the Lower Colorado River Authority;
(2) The enabling act of the Lower Colorado River Authority;
(3) General law of the State of Texas, particularly the Texas Water Code; and
(4) The water policies of the Lower Colorado River Authority Board of Directors.

In combination, the authorities establish and define LCRA's responsibility to develop and implement a Water Management Plan. In particular, the final adjudication of LCRA's water rights

includes provisions relating to the manner in which LCRA will manage the Highland Lakes and the Colorado River above and below the Highland Lakes and directs the LCRA to prepare and submit a proposed Water Management Plan to the Texas Water Commission. This document was developed by the LCRA pursuant to that directive.

LCRA's Water Resources Management

It is important to consider the historical context in which this Water Management Plan has evolved. In the early years of LCRA's existence the predominant priorities in water resources management were to moderate and control the floods and droughts in the Lower Colorado River Basin. This was accomplished, appropriately, through the construction of dams in the Hill Country west of Austin which created the Highland Lakes.

The results have been impressive. The ravages of flood waters have largely been controlled. These same dams have also provided a dependable source of water supply for municipal, industrial, agricultural, and mining uses. Additionally, the Highland Lakes provided the source of inexpensive, renewable electrical energy, and recreational opportunities for the citizens and communities of Central Texas. In sum, the work of the LCRA in its early years provided the foundation on which the present day population and economy of Central Texas depend.

Notwithstanding the successes of the past, in developing a Water Management Plan for the river, LCRA today faces an array of water management issues and opportunities that were scarcely envisioned a half century ago. Recreation has emerged as a major use, both on the lakes and the river. Maintaining the aquatic habitat in the river channel and in the bays and estuaries is a major use, as is water quality and the use of the river to sustain a growing population and economy. This intensified competition among the various users of the water resource is placing increasing stress on the ecologic and environmental resources supported by the Colorado River. LCRA, in partnership with the State of Texas, local governments, and private interests, must confront these challenges as we develop a meaningful Water Management Plan.

LCRA's Water Management Plan is grounded in these key principles:

(1) LCRA recognizes the supremacy of the State of Texas, acting through the Texas Water Commission, as the ultimate authority for water resources management and as the arbiter of disputes involving the allocation of water from the Colorado River and its tributaries. LCRA, within the intent and meaning of its legal authority, is the steward of the water rights granted to it by the State of Texas. Further, LCRA recognizes the responsibilities and prerogatives conferred upon local political subdivisions of the State and the rights of private citizens and corporations.

(2) Many water management issues and opportunities are regional in scope and effect. Solutions and strategies must be built upon regional consensus and action. LCRA considers its role as one of consensus-building among competing users of Colorado River water and among the public and private interests concerned with the management of the Colorado River.

(3) LCRA, in exercising its responsibilities as a steward of the water resources of the Colorado River and its tributaries, will strive to maximize the beneficial use of Colorado River water and achieve a sustainable balance among the competing demands on the system. In pursuing this objective, LCRA will implement management procedures and programs addressing:

   (A) The efficient management of available water supplies as an integrated system;
   (B) Water demand management measures including long-term conservation measures and short-term drought contingency measures;
   (C) Protection and, where possible, enhancement of water-related environmental values; and
   (D) Future water supply development and augmentation.

DEFINITIONS

To understand the Water Management Plan, it is important to know the definitions of the key legal and hydrologic terms used in this plan . The major terms are defined below and should be considered specific to LCRA.

adjudication - a court proceeding to determine all rights to the use of water on a particular stream system.

beneficial use of water - Use of the amount of water which is economically necessary for a purpose authorized by law, when reasonable intelligence and reasonable diligence are used in applying the water to that purpose. Such uses include domestic use, municipal uses, industrial use, agricultural use, hydroelectric power, navigation, fish and wildlife, etc. The benefit may vary from one location to another and by custom. Beneficial uses are defined by statute in the Texas Water Code.

combined firm yield - a specific amount or quantity of water usually stated in acre-feet or millions of gallons per year which represents the maximum average annual demand that can be met through storage in a reservoir during a simulation of a repetition of the system's Drought of Record.

curtail (water)-to reduce the supply being provided through a diversion by reducing the amount served under the contract for a specific period of time. Curtailment may occur during drought or other emergency conditions.

critical drought period - the period of time during which the reservoir system was last full and refilled, and the storage content was at its minimum value.

cutoff (water) - to discontinue, or to terminate completely, the supply of water provided under contracts for diversion for a certain period of time. Cutoff may occur during drought or other emergency conditions.

diversion demand - the water pumped from a water body for beneficial use.

domestic water use - water used for household purposes such as bathing, food preparation, waste removal, and landscape irrigation.

drawdown - the lowering of the water level in a water body by diversion, pumping, or release.

drought - a prolonged period of dryness or lack of rainfall that has a significant effect on water or water-related uses.

drought of record - the drought which occurred during the critical drought period.

firm water - a supply of stored water that is drawn from the combined firm yield of the reservoir system. Such supplies are diverted under a contract or resolution issued by the LCRA Board.

firm yield - the maximum annual supply of water which can be supplied from a water source without shortages during a repetition of the critical drought period.

gaging station - particular site on a stream, canal, or lake where systematic observations of hydrological data are obtained.

interruptible water- stored water supplied pursuant to contract or resolution, where the contract, resolution or special conditions defining the commitment specifically provides that such commitment is "subject to interruption or curtailment."

irrigation - The use of water for the irrigation of crops, trees, and pasture land, including, but not limited to, golf courses and parks, which do not receive water through a municipal distribution system.

minimum streamflow - the specific amount of water reserved to flow in a stream or river to support aquatics life, minimize pollution, or for recreational use.

run-of-river flows - the natural flow in the river that is available under law at a given point on the river at a given instant in time to honor a right with a given priority date. This

flow is determined by hydrologic studies that assume that all reservoirs and diversions under upstream junior rights do not exist. Rights to use run-of-river flows for beneficial uses, rights to store inflows in reservoirs, and pass-through of inflows and releases from reservoirs, are regulated by the Texas Water Commission.

storage capacity - the quantity of water that can be contained in a reservoir.

streamflow - rate of flow of water that occurs in a natural channel.

water conservation - those practices, techniques, and technologies that will: (1) reduce the consumption, loss or waste of water, (2) improve the efficiency in the use of water, or (3) increase the recycling and reuse of water, so that a water supply is made available for future or alternative uses.

water permit - a legal document which grants authority to take unused water and put it to beneficial use.

water right - a legally protected right, granted by law, to take possession of water occurring in a water supply and to divert the water and put it to beneficial use.

SUMMARY OF WATER MANAGEMENT PLAN

A. KEY ELEMENTS OF THE WATER MANAGEMENT PLAN

The key elements of the WMP include the following:

- The Highland Lakes and the Colorado River will be managed together as a single system for water supply purposes.
- LCRA will manage the system to maximize the beneficial use of water derived from inflows below the Highland Lakes.
- LCRA will manage the system to stretch and conserve the waters stored in the Highland Lakes.
- All demands for water from the Colorado River downstream of the Highland Lakes should be satisfied to the extent possible by run-of-river flows of the Colorado River.
- Inflows should be passed through the Highland Lakes to honor downstream senior water rights only when those rights cannot be satisfied by the flow in the river below the Highland Lakes.
- The firm, uninterruptible commitments of water from Lakes Travis and Buchanan should not exceed the Combined Firm Yield.
- The water from Lakes Travis and Buchanan will be available on an interruptible basis as long as LCRA's ability to meet the demand for uninterruptible water is not impaired.
- Water shall not be released through any dam solely for hydroelectric generation, except during emergency shortages of electricity, and during other times that such releases will be needed for another beneficial purpose.
- Competing demands on the system include water quality matters, flood control, water supply, recreation and tourism, hydroelectric power, instream flows and bays and estuaries.
- The Combined Firm Yield of Lakes Buchanan and Travis is determined to be 535,812 acre-feet.
- To supply existing firm water demands during a repetition of the critical drought would require an average of 421,919 acre-feet per year to be released or diverted from storage in Lakes Buchanan and Travis.

- 50,000 acre-feet of the remaining Combined Firm Yield of Lakes Buchanan and Travis has been placed in reserve for the future needs of many areas within the LCRA 10-county district that are now using ground water supplies which are becoming depleted or are of poor water quality.

- The four downstream irrigation operations (Gulf Coast, Lakeside, Garwood and Pierce Ranch) will have first priority for all the interruptible stored water in the annual allocation process to the extent of their Conservation Base acreage or Priority Allocation acreage.

- In recognition of the importance of recreation and tourism demands, additional sales of interruptible stored water, other than for the four irrigation operations, will be limited based on the projected volume of water in Lakes Buchanan and Travis, as of January 1 of each year. No sales will occur if either lake is less that 94% of its maximum conservation capacity. If both lakes are projected to be at their maximum conservation capacity on January 1, then such interruptible water sales will be limited to a total of 80,000 acre-feet for that year. For projected lake volumes between 94% and 100% of conservation capacity, such interruptible water sales will be limited proportionately, based on the storage reservoirs with the lowest projected percentage of capacity on January 1.

- Instream flow needs will be met by the release of stored water from the Highland Lakes to maintain the daily river flows at no less than the critical instream flow needs in all years and maintain daily river flows at the target instream flow needs in those years when the four major irrigation districts are not curtailed, to the extent of inflows each day to the Highland Lakes as measured at the upstream streamgages. An average of 28,700 acre-feet per year during any ten consecutive years from the Combined Firm Yield of the Highland Lakes is committed for instream flow and bay and estuary needs.

B. KEY ELEMENTS OF THE DROUGHT MANAGEMENT PLAN

The key elements of the DMP include the following:

- A 10 year time period from 1990 - 2000 is the time frame for the Plan.
- The Plan establishes criteria for the curtailment of stored water that is committed through contract or by LCRA Board resolution.
- Establishes a criteria for interruptible water supply curtailments which protects firm demands, establishes a Reserve Storage Pool, and provides for gradual curtailment in order to protect the full demand of first crop rice in all years of the critical drought.
  - Open Supply occurs when January 1 storage levels are greater than 1.4 million acre-feet.
  - Gradual Curtailment occurs in stages between 1.4 million acre-feet and 325,000 acre-feet.
  - Cutoff of interruptible supply for the coming year occurs when storage is less than 325,000 acre-feet on January 1.
  - Review and cancel the curtailment of interruptible stored water for the irrigation districts at any time during the year prior to July 31, if the combined storage of Lakes Buchanan and Travis is projected to be equal to or greater than 1.4 million acre-feet anytime in July.
  - Reserve Storage Pool cutoff of all interruptible supplies when storage levels are less than or equal to 200,000 acre-feet.
  - Allow each irrigation operation the option of a fixed maximum amount of interruptible stored water or all the water necessary to cultivate a maximum acreage agreed upon by the operation and LCRA.
  - LCRA will request voluntary curtailment of firm water demands when there is a curtailment of interruptible water supplies and/or the total storage in Lakes Buchanan and Travis is less than 1.6 million acre feet.
  - LCRA will request that all LCRA firm water customers reduce water use by their end users when the combined storage for Lakes Travis and Buchanan

is at or below 900,000 acre-feet.

- During a drought more severe than the Drought of Record, LCRA will curtail and distribute the available supply of firm water among all of its firm water supply customers on a pro rata basis according to their demand for stored water. All uses of interruptible stored water will be totally cutoff prior to and during any mandatory curtailment of firm stored water supplies.

- Petition TWC to adopt definitions of essential and non-essential water uses.

- Require legally enforceable local drought management plans for LCRA firm water customers and the four major irrigation operations.

SECTION 1

CHAPTER 1

INTRODUCTION TO THE WATER MANAGEMENT PLAN

On April 20, 1988 Judge J. F. Clawson of the 264th Judicial District of Bell County, Texas, signed the Final Judgement and Decree relating to LCRA's and City of Austin's respective water rights. (see Appendix 1A, Volume II) This settlement was the product of a long series of negotiations among LCRA, the City of Austin, and the Texas Water Commission (TWC).

Under the Final Judgement and Decree, LCRA was granted the right to use 1,500,000 acre-feet annually from the Highland Lakes. As part of this settlement LCRA was required to determine the Combined Firm Yield of both Buchanan and Travis Reservoirs. An interim level of Combined Firm Yield of 500,000 acre-feet was established by the TWC with an understanding the LCRA would establish the basis for the Combined Firm Yield calculation and submit it to the TWC. The amount of water above the firm yield is considered interruptible water and may be sold only on a interruptible basis subject to annual availability and certain rules and conditions required by the TWC.

A. Goals of the Water Management Plan

The Final Judgement and Decree required LCRA to submit a reservoir operations plan describing how LCRA would determine the amount of firm and interruptible waters and how LCRA would manage the waters in the Highland Lakes and the Colorado River. The Water Management Plan for the Lower Colorado River Basin was developed using the following goals and guidelines as provided in the Final Judgement and Decree:

1. The Highland Lakes and the Colorado River will be managed together as a single system for water supply purposes.

2. LCRA will manage the system to maximize the beneficial use of water derived from inflows below the Highland Lakes.

3. LCRA will manage the system to stretch and conserve the waters stored in the Highland Lakes.

To achieve the goals stated above, LCRA will manage the system according to the following guidelines:

(a) All demands for water from the Colorado River downstream of the Highland Lakes should be satisfied to the extent possible by run-of-river

flows of the Colorado River;

(b) Inflows should be passed through the Highland Lakes to honor downstream senior water rights only when those rights cannot be satisfied by the flow in the river below the Highland Lakes;

(c) The firm, uninterruptible commitments of water from Lakes Travis and Buchanan should not exceed the Combined Firm Yield;

(d) The water from Lakes Travis and Buchanan will be available on an interruptible basis as long as LCRA's ability to meet the demand for uninterruptible water is not impaired;

(e) Water shall not be released through any dam solely for hydroelectric generation, except during emergency shortages of electricity, and during other times that such releases will be needed for another beneficial purpose.

B. LCRA Act

Through the passage of the LCRA Act by the Texas Legislature in 1934, LCRA was established as a "conservation and reclamation district" consisting of ten counties which comprise the watershed of the lower Colorado River. Those ten counties are Blanco, Burnet, Fayette, Colorado, Llano, Travis, Bastrop, Wharton, San Saba, and Matagorda. (see Figure 1) LCRA was delegated the responsibility of harnessing the Colorado River and its tributaries and making them productive for the people of the 10-county district.

The Act establishes LCRA's mission in four areas--water, electric energy, conservation and lands. In water, LCRA is empowered to control floods and control, store, sell, preserve and distribute the waters of the Colorado River and its tributaries. The waters are to be used for beneficial purposes including irrigation, generation of electric energy, reclamation of arid lands and the creation of lakes for water storage. LCRA is required to prevent flood damage to people and property by the Colorado River and to control the uses of the surface of the lakes it created.

Consistent with the control of the waters, LCRA is empowered to develop, distribute, and sell the energy created through hydroelectric generation both inside and outside the 10-county district. Later legislation allowed LCRA to expand its electric generation capabilities beyond hydropower through developing fossil fuel generation facilities.

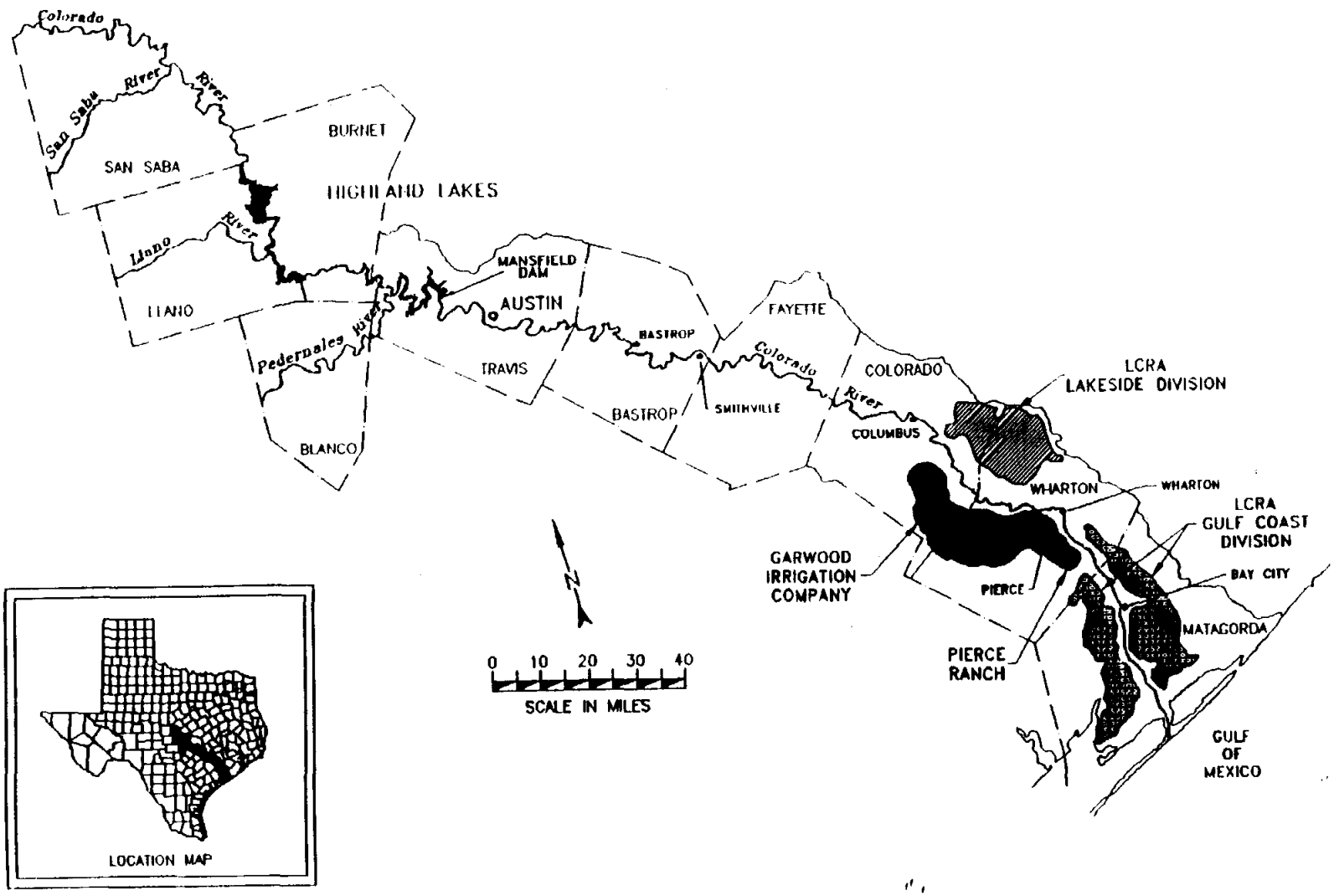


FIGURE 1. LOWER COLORADO RIVER AUTHORITY DISTRICT

As a conservation and reclamation district, LCRA is to conserve and develop the lands, forests and water of the district and to study and correct both artificial and natural sources of pollution which may affect the ground and surface waters within the district. LCRA is also empowered to provide water and wastewater treatment services within the district.

During the construction of the dams and development of the Highland Lakes system LCRA acquired large tracts of land which surround the reservoir system. The Act authorizes LCRA to develop, manage, and promote the use of these lands for parks, recreational facilities and natural science laboratories and to promote the preservation of fish and wildlife. LCRA must also provide public access to, and use of, its lakes and lands for recreation.

Each of the many purposes, functions, and uses of the elements of the river--the lakes, the lands, the ground and surface waters, the bays and estuaries--must be considered as parts of an integrated system.

The Water Management Plan will describe the issues and conflicts which LCRA must recognize and, where possible, resolve.

C. LCRA's Comprehensive Water Policy Review

As a foundation for the Water Management Plan, LCRA began a comprehensive review of the policies and programs that guide and shape the way LCRA manages the river system. This review was conducted as a series of meetings held as joint public meetings of the LCRA Board's Planning and Public Policy and Natural Resources Committees. The meetings were designed to use staff expertise and information from outside experts to analyze the environmental, social, economic and legal factors that shape the issues which LCRA faces in managing the Colorado River system.

An important part of these public meetings was the involvement of the State agencies, environmental groups, business, industry and agricultural interests, wholesale electric customers and other constituencies whose interests are affected by LCRA policies.

The process was designed to assure that participation was effective in informing LCRA of public views and also so that these constituencies would be better informed about the issues involved in the policy decisions. An issues inventory was developed and briefing papers were prepared for each of the meetings. Summaries of the meetings elements were developed and distributed to the LCRA Board and members of the public.

As a result of the Board and the public review, LCRA has adopted a set of water and flood control policies to address many of the issues in water quality and water supply that face LCRA today and will continue to face the agency well into the future. (see Appendix A, Volume I) . They form the foundation of this Water Management Plan.

D. Scope of Water Management Plan

LCRA approached the development of the Water Management Plan as much more than a set of complex engineering tools to serve as guidelines for operating the structures on the Colorado River system. The development of the Water Management Plan stimulated a comprehensive review of how LCRA has developed and operated the Highland Lakes and the lower Colorado River system for almost 50 years to meet the needs of the area it serves.

Volume I of the Water Management Plan is organized as follows:

(1) Section 1 of the Water Management Plan describes the issues and conflicts in the demands on the Colorado River system and lays out the policies and management actions LCRA will use to accommodate the variety of demands on the system.

(2) Section 2 of the Water Management Plan describes the issues and conflicts in the demands on the Colorado River system during drought periods and sets forth the policies and management actions LCRA will use to address the competing demands for water in times of shortage.

(3) Section 3 of the Water Management Plan describes the engineering and hydrological models and data sources and the process for the determination of the Combined Firm Yield.

Volume II of the Water Management Plan is a compilation of several technical appendices used to develop the Water Management Plan.

E. Annual Review

The Water Management Plan will be reviewed on an annual basis by LCRA. A compliance report will be provided to the Texas Water Commission each year on or before March 1.

CHAPTER 2

MANAGING THE SYSTEM AMONG COMPETING DEMANDS

Demands on the Highland Lakes and the lower Colorado River system are many, varied, and often are in competition with one another. These demands are dynamic and will evolve as the population grows.

LCRA's reservoir system is designed to store waters from winter and spring rains and make that water available for use during the summer months for hydroelectric generation, water supply and irrigation needs downstream of the reservoirs. During the summer months these releases cause a decline in the reservoir levels thus providing storage for the next year winter and spring rains. This type of operating pattern enables LCRA to serve a variety of functions with its reservoir system. It can also create conflicts among these functions. If the system's ability to meet all of these demands is to be maximized, compromises must be made among the competing demands.

LCRA must continually re-evaluate its Water Management Plan to assure that the competing demands are being met according to their priority within the framework of legal and financial constraints on the system. This chapter states the measures LCRA is taking to accommodate the demands on the system and identifies those areas where continued analysis is needed.

A. Water Quality Issues and Demands

Everyone favors "clean water," but achieving an understanding of the value of water quality so that the necessary investments and efforts are made is a major challenge to LCRA's management responsibility. This is an issue in which every user of the river has a stake. LCRA will need every concerned citizen's help in taking the actions to make cleaner water a reality. The problem areas are as follows:

1. Point Source Pollution: In managing the river system LCRA must consider the impact of point sources of pollution entering the tributaries and the river, even though we recognize that the TWC is the agency that establishes regulatory standards to control point sources of pollution. But even if a point source of pollution is lawful, the assimilation of sewage treatment plant wastes is a function and use of the lakes and the river for which no one pays in dollars and everyone pays in quality. During the low flow periods of the year when LCRA is not releasing water for the irrigation operations downstream the body of the Colorado River below Austin may be as much as 70-80 percent effluent on a given day. This condition is exacerbated during periods of low rainfall or drought that affect not only the quality of the river but also its aesthetic value. Downstream residents complain about the smell

of the river and its loss of use for recreation, fishing, and as a water supply for grazing livestock.

During the policy and issue review process for the Water Management Plan, LCRA received numerous comments and letters regarding LCRA's role in monitoring and reducing the volume and concentration of point source pollution. The Protect the Lakes organizations for Lakes Buchanan, Inks, LBJ, Marble Falls, and Travis have been particularly concerned about this issue. LCRA has also received requests from communities upstream and downstream for assistance in planning for new and expanded wastewater treatment plants which would have higher treatment standards.

Point source discharges into the Highland Lakes present a much more serious problem due to the reduced assimilative capacity of the lakes. LCRA is working with the communities which currently discharge into the lakes to develop land application and irrigation projects to eliminate such discharges.

2. Nonpoint Source Pollution: Runoff from urban and agricultural areas, soil erosion, and leakages from faulty septic tank and waste dumps all represent nonpoint sources (NPS) of pollution. The EPA estimates that approximately 73 percent of the pollution in the nation's rivers is caused by nonpoint sources.

Due to the high quality of water in the Highland Lakes chain there is great concern for preventing NPS pollution and maintaining this high quality water for the future. The lakes serve as a source of drinking water for over a million citizens of the Austin-Travis County metropolitan area and all of their uses are enhanced by maintaining a high degree of purity.

While LCRA is encouraging and supporting economic development, tourism, and recreation activities in the Highland Lakes and the Colorado River downstream, there is the awareness that increased usage and development will result in more nonpoint source pollution unless effective controls are put in place.

The causes and sources of NPS pollution are dispersed and difficult to manage without broad public awareness and support. LCRA's Water Quality Leadership Policy requires effective implementation to control NPS pollution through research, monitoring, education and the use of LCRA's ordinance making powers to prevent and control sources of nonpoint pollution within the 10-county district.

LCRA has received comments and letters of support regarding its efforts in nonpoint source pollution abatement from the Protect the Lakes Groups, Clear Clean Colorado Association and the Lone Star Chapter of the Sierra Club and Travis County.

3. Soil Erosion and Sedimentation: Soil Erosion and the resulting sedimentation in the Highland Lakes, the Colorado River and its streams and tributaries is a cross cutting issue in water quality and water supply. The sedimentation in the lakes causes problems for boating and fishing. The build up of silt also reduces the storage capacity of the lakes for water supply and for holding flood waters. Siltation downstream of the Highland Lakes in the river channel reduces the capacity of the river for holding flood releases. Both in the lakes and in the river the silt in the water causes problems of turbidity or cloudiness thus reducing the aesthetics of the water and may cause higher water treatment costs. This factor often shows up in LCRA's Water Quality Index and causes lower ratings for many areas. Beyond increased turbidity, soil erosion can contribute to water quality problems by carrying pesticides, herbicides and other pollutants into the water along with the soil particles.

4. Dissolved Oxygen Problems: The dissolved oxygen content of LCRA's releases of stored water through the hydroelectric turbines in the dams has caused water quality problems in the summer months. The deep lakes stratify during the warmer months of the year which prevents replenishment of oxygen at the levels from which the turbines draw water. The passage of water with low levels of dissolved oxygen from one reservoir into another or into the river system can cause fish kills and reduce the assimilative capacity of the river system. LCRA has concluded its research and has determined that there is no benefit to changing current management practices.

5. Upstream Pollutants: Pollutants from the watershed upstream of the Highland Lakes and outside of LCRA's district can also affect the resources for which LCRA is responsible. An example of this is the inflows of high concentrations of salts in the water from seepage from natural springs and highly concentrated bodies of salty water in the upper watershed combined with high rainfall in the "salt water" basin. Abandoned unplugged oil wells may also be a cause of this problem. Remedial action has been taken by the Colorado River Municipal Water District, but the problem persists.

B. Flood Control Responsibilities

Flood control is one of the primary reasons for LCRA's existence. The series of dams and reservoirs from Buchanan, through Mansfield, contribute to the control of the lower Colorado River and the protection of lands and communities within the basin . While all the dams and reservoirs aid in controlling and storing the waters of the Colorado, Mansfield Dam is the only designated flood control structure. Mansfield Dam flood storage space is between the elevation of 681 feet mean sea level (msl) and the spillway crest elevation of 714 feet msl providing 800,000 acre-feet of dedicated flood control storage. During flood control operations, Mansfield Dam is operated in accordance with regulations specifically

developed for that facility by the U.S. Corps of Engineers, the U.S. Bureau of Reclamation, and LCRA and published in the Code of Federal Regulations (see Appendix B, Volume 1).

Over the years, as the floods no longer ravaged the river basin washing out river banks and clearing away vegetation, the capacity of the channel to contain water releases, especially during flood conditions has been reduced. LCRA must limit the rates of releases during flood events if it is to minimize downstream damage. This reduction in outflow causes increases in water levels upstream of Mansfield Dam which results in more frequent damages to properties around Lake Travis. This balancing problem is compounded by encroachments on the floodplains both upstream and downstream. Lake and river residents have built boat houses and structures into the floodplain and suffer property losses during flood occurrences. LCRA's management requires renewed efforts to remove encroachments and put people on clear notice that they are at risk.

The extent of potential damages to areas downstream of Mansfield Dam, including the City of Austin, from various flood levels resulting from releases from Mansfield Dam and other inflow is being evaluated by the U. S. Army Corps of Engineers. LCRA is cooperating in this study and its results will be used to inform the public as well as provide direction for any necessary modifications to the flood control operations.

LCRA is cooperating with the U.S. Army Corps of Engineers in a reconnaissance study of possible additional flood control and water supply in a new reservoir on the Llano River or the Pedernales River upstream of Lake Travis, or on the San Saba or Colorado River upstream of Lake Buchanan.

One alternative is to create additional flood control space in Lake Travis by reducing the conservation capacity to some level below 681 feet msl. However, this would have an adverse impact on LCRA's ability to meet its commitment for water supply during a critical drought situation. It would also reduce lake levels and thus have a negative impact on recreational interests around Lake Travis.

The schedule by which floodwaters must be released from the flood control storage space between elevations 681 feet msl and 714 feet msl in Lake Travis is governed by the U. S. Army Corps of Engineers' Water Control Manual for Mansfield Dam. This release schedule was designed to minimize damages both downstream and upstream of the dam without endangering the safety of the dam. A brief description of this schedule is as follows:

RESERVOIR ELEVATIONS feet msl	RELEASE cfs	
681 to 683	3,000	
683 to 685	5,000	
685 to 691	5,000	during Jan/Feb/ Mar/Apr/July/Aug/ Nov/Dec
	30,000	during May/June/ Sept/Oct
691 to 710	30,000	
710 to 714	50,000	
714 to 722	90,000	

While public interests were carefully considered in developing the schedule, a continuous public information program is necessary to assure that everyone who may be at risk from flooding, either upstream or downstream, is made aware of the risks. LCRA will initiate a program of notices and public forums to assure that the affected public is informed.

LCRA believes that the existing policy of delicately balancing the adverse impacts of rising flood waters in the reservoir against the damages resulting from downstream flood releases is the best option.

C. Water Supply

Under the constraints specified in the Final Judgement and Decree, LCRA has determined the Combined Firm Yield of Lakes Travis and Buchanan to be 535,812 acre-feet per year. Of that amount, 90,546 acre-feet are committed to Owen Ivie Reservoir. The remaining 445,266 acre-feet are available to supply LCRA's current and future contractual commitments and agreements for firm water supply.

Currently LCRA estimates that 85 percent of the Combined Firm Yield available for sale (445,266 acre-feet per year) is under contract or held in reserve to back up existing or new contracts for firm water such as those held by the City of Austin and Houston Lighting and Power Company.

All of the municipalities downstream of Austin currently draw their water supplies from ground water sources. Ground water also supplies 40 percent of the agricultural irrigation in the LCRA service area. Two counties--Matagorda and Colorado--have areas on the Texas Water Development Board's list of critically depleting ground water resources. Upstream of Austin the municipalities use a mixture of ground and surface waters.

As economic and industrial development increase the demand for water, and as other uses such as the fresh water needs in the bays and estuaries are determined, more demands will be made upon surface water resources. One of the greatest demands will be due

to ground water sources degrading, depleting, and becoming more expensive to use due to higher pumping costs. LCRA is thus faced with the conflict between near-term demands and holding some remaining amount of the firm waters in reserve for future users. This conflict may be partially resolved by the LCRA Board reserving 50,000 acre-feet of firm water for uses authorized under LCRA's certificates of adjudication within the 10-county district until water supply and demand assessments of the individual counties within the district are completed or three years, whichever is sooner.

1. Municipal Water Use: Municipal use includes water used by private residences, commercial establishments, public offices, industries and institutions to the extent that such uses are included in the definition of municipal use as provided by the rules of the Texas Water Commission. Eighty percent of the municipal use in LCRA's service area is in Travis County. The Austin area experienced rapid population growth during the early and mid 1980's. This growth has slowed over the last 2-3 years, but, the Austin area is expected to show a steady growth over the long-term with the normal cycles of advances and pauses associated with economic growth.

The City of Austin's total diversion from Lake Austin and Town Lake for 1988 was 118,750 acre-feet. Approximately 75 percent of this was served through their own senior water rights. While at present the City of Austin's water is supplied from the Colorado River under its own rights, LCRA provides stored water from the Highland Lakes to back-up Austin's water rights. Also, some portion of the growth in the Austin area will be in municipal utility districts and other communities in Travis County and may use stored water from the lakes.

Over the long-term, Bastrop and Burnet Counties are forecasted to be the other two counties with the greatest gains in municipal use. This is due to their proximity to Travis County and the associated spillover of population growth and related services.

LCRA currently supplies water to 43 Municipal Utility Districts (MUDs), communities, and cities within LCRA's 10-county district, exclusive of Austin. The current annual demand of all these contracts is approximately 14,200 acre-feet per year.

At present, no communities below Austin are supplied water from the firm yield for potable water use.

LCRA currently requires an approved conservation plan of its new water customers through its water sale contracts.

2. Industrial Demands: Industrial demands include both water for manufacturing use and cooling water for electric power production other than hydroelectric generation.

a. Manufacturing Use: LCRA supplies water for various industrial uses within its 10-county statutory district. The water supply for these industrial uses is considered a firm demand on the system. The largest current and projected manufacturing water users are located in Travis and Matagorda counties and account for slightly more than 80 percent of total manufacturing water use. Most of the manufacturing in Travis County is served by treated water from the City of Austin which is considered to be municipal use by the rules of the Texas Water Commission. Growth in demand in this sector is expected to increase, particularly in microelectronic manufacturing--a high water demand industry. Downstream, Matagorda County is experiencing growth in the petrochemical industry. Overall manufacturing is projected to increase from about 2 to 6 percent of the total base case water use during the period from 1990 to 2030.

LCRA has established programs for industrial water conservation and encourages existing and new industrial users to consider efficiency and re-use strategies for industrial processes.

b. Steam Electric Use: Much of the demand for steam electric use is from electric generating plants in Bastrop, Fayette, Llano, Matagorda, and Travis Counties. LCRA's own system of power plants makes up the largest demand for this sector at an average of about 50,000 acre-feet per year. Uses include total evaporative use, plant use and the addition of a reservoir at the Fayette Power Project (FPP). The second largest user, the South Texas Project demand is served by run-of-river contract rights jointly owned by LCRA and Houston Lighting and Power. These run-of-river rights are backed-up by a firm contract for LCRA stored waters. The City of Austin serves its generating plants under its own rights, also firmed up by LCRA stored water pursuant to the LCRA-City of Austin December 10, 1987 Comprehensive Water Settlement Agreement.

Most of the current industrial users are located downstream of the Highland Lakes thus allowing a portion of their demand to be supplied from the run-of-river water originating below Lake Travis. LCRA's system under the Water Management Plan allows for full utilization of the water in the river before calling for releases from storage in the reservoirs.

The demand for use in this sector is projected to increase from 4 to over 7 percent of the total base case water use by the year 2020. LCRA is committed to the most efficient and beneficial uses of water for cooling purposes at it power plants and will encourage implementation of similar programs in other plants served by water from the LCRA system.

3. Demands for Interruptible Water: Under the Final Judgement and Decree LCRA is permitted to develop contractual commitments with water users whose demands do not have to be met 100 percent of the time. Such demands for interruptible water would be met to the

extent water is available each year after firm demands are satisfied. At the present time the contracts for the firm yield of the system are not using their full commitment. By applying an "overdraft" concept the portion of the firm yield that is not yet committed and the water that is committed but not yet being used increases the interruptible water that is available each year. The water that is captured and stored from flood flows also adds to the amount of interruptible water that is available. Over time, as the current firm contracts draw fully on their commitments and the remainder of the firm yield is contracted for, there will be less interruptible water available on an annual basis.

a. Irrigation Demands: Currently the vast majority of LCRA's commitments for interruptible water are for irrigation downstream. Most of the irrigation is for rice farming, although other crops such as pecans and turf grass as well as golf courses also use irrigation. As the rice farmers have an historic use of the waters that are now considered interruptible, one way of mitigating the potential future conflicts is to assure the rice farmers a priority on a portion of the interruptible waters that will be allocated on an annual basis.

In good years with adequate rainfall there is an abundance of interruptible water compared to the current demand, which is largely for growing rice. The real conflict would occur during a drought in the years ahead as other demands compete.

Irrigation water represents the largest demand of any user on the lower Colorado River system with rice irrigation in the lower basin constituting about 70 percent of the total annual use. The demand for water to irrigate rice varies greatly from year to year based upon the number of acres irrigated and weather conditions throughout the irrigation season. The number of acres irrigated is highly dependent upon the federal allocation program for rice as well as the world market for rice. Currently, about 95 percent of the rice farmers in the LCRA service area participate in government support programs.

Most of the rice irrigated by water from the Colorado River is concentrated in four irrigation operations whose annual demand on the system is about 500,000 acre-feet of water. These operations include Lakeside and Gulf Coast, which are owned and operated by LCRA, and Garwood and Pierce Ranch Irrigation Companies. These irrigation operations represent about 60 percent of total irrigated agriculture for water use in the three counties. The remaining 40 percent comes from pumped ground water.

The four irrigation operations hold their own senior water rights for direct diversion from the Colorado River. These water rights allow the operations to pump water from the river as it is available without calling upon LCRA to release water from storage. However, often in the height of the irrigation season, rainfall

inflows are insufficient to supply these needs. During these periods LCRA is called upon to release water from storage to make up the deficit. The demand on the Highland Lakes System for the release of stored water for the rice irrigation season varies greatly from year to year. During an average year, about 30 percent of the total water needed for irrigation comes from water released from storage in the Highland Lakes.

Because a very large percentage of the overall demand on the system is related to irrigated agriculture that demand must be met in the most efficient way possible. LCRA's ability to constantly monitor the amount of water in the river available to meet these demands through the Hydromet System allows full utilization of the flows originating below Lake Travis prior to making any releases from storage. The operational goal for the system is to reduce the amount of flow passing the last diversion point to a level compatible with the instream flow needs and requirements for the bays and estuaries.

Under the Water Management Plan the four downstream irrigation operations (Gulf Coast, Lakeside, Garwood, and Pierce Ranch) will have first priority for the interruptible stored water in the annual allocation process. This priority will be set by establishing a Conservation Base for LCRA's two irrigation districts.The Conservation Base acreage will be the historical 10-year average acres irrigated (see Table 2 "Allocation Table for Interruptible Water") at a total of 5.25 acre-feet of water per acre irrigated. LCRA currently has a contract dated December 1987 to supply interruptible water to Garwood to the extent necessary to firm up Garwood's 168,000 acre-foot-per-year independent run-of-river water right. This contractual commitment to Garwood is not based on a "Conservation Base acreage" calculation, but the 5.25 acre-foot-per-acre duty will apply to the acreage irrigated. LCRA has also entered into an agreement with Pierce Ranch to firm up 55,000 acre-feet of Pierce Ranch's independent run-of-river water right at an annual rate of 20,000 acre-feet based on a five year average with a 30,000 acre-feet one year maximum.

b. Agriculture Conservation: As the largest user of water from the lower Colorado River system, irrigated agriculture also provides the best opportunity for reduction of the overall demand through conservation programs. LCRA currently has underway a water conservation program with its two irrigation companies, Lakeside and Gulf Coast. These conservation activities are directed at improving the efficiency of the water delivery systems and improving water use efficiency on the individual farms served by the companies.

Historical data shows that as much as seven acre-feet of water had to be pumped from the river to irrigate one acre of rice. The Texas Water Commission, in its Final Adjudication order of all of the irrigation rights in the lower Colorado River stated that the

use of more than 5.25 acre-feet of water for the irrigation of an acre of rice constituted a waste of water. This goal can be achieved and, in fact, recent results indicate that the overall irrigation demand can be reduced by as much as 25 to 30 percent, thus bringing water use per acre to well within the Commission's required 5.25 acre-feet. A reduction of this magnitude could have a major impact on the reservoir system's ability to meet other competing demands.

Currently, LCRA provides water to individual customers of the irrigation districts on a per acre of rice irrigated basis. A major goal for LCRA's irrigation operations is to move toward selling water on a per acre-foot basis if this can be done effectively and efficiently. To accomplish this goal will require individual meters for each major diversion point in the irrigation system. The initial capital cost for such a system is very high and would have to be recovered in the rates for irrigation water. Also, the meters available in the market have data retrieval problems and are subject to tampering in the field. LCRA is working with Texas A & M University Agricultural Extension Service, The U.S. Bureau of Reclamation, the other irrigation districts, and equipment manufacturers to analyze the technical and economic feasibility of metering water use in the district.

4. Recreation and Tourism Demands: The use of water for recreation and tourism is closely linked to the population of an area, nearness of the recreation, and the value of the resource to recreational users. Recreational users are interested in qualities including: full lakes, flowing rivers, clean water, and aesthetics.

In many areas recreational uses of the waterways are increasing steadily. The entire Highland Lakes area, from Lake Austin to Lake Buchanan, receives a great deal of recreational use from boaters, park visitors, swimmers and windsurfers from all over Texas and the Southwestern United States.

Recreation and tourism demands in the Highland Lakes area is an important contributor to the local area economies. Recreation is not just fun, it is a critical economic factor in the life of citizens of the Hill Country.

a. Managing Lake Levels for Recreation and Tourism: The recreation industry associated with the Highland Lakes has experienced a phenomenal growth over the past decade and is currently the major economic stability factor in many of the counties surrounding the Highland Lakes. The viability of this recreational industry is strongly tied to the level of water in the reservoirs. In the pass through lakes--Inks, LBJ, Marble Falls, and Austin--little impact is felt from variations in the levels of Lake Travis and Buchanan.

The original purposes of flood control and water supply for the rice farmers and others for which Lake Travis and Buchanan were constructed dictate that the lake levels will follow an annual cycle--that of filling the conservation storage space in the winter and spring months of the year to be drawn down by water uses during the summer months. The recreational users of these reservoirs are accustomed to a certain amount of variation in the lake levels. However, two or more consecutive years of below normal streamflow into the reservoirs results in some extreme variations which have an adverse impact on recreational interests.

Because these multiple purpose reservoirs were not constructed to maximize the recreational use of the reservoirs, the demands for stability in the reservoir levels by these incidental beneficiaries (the recreation interests) present conflicts which are extremely difficult to accommodate. If limits are to be placed on how far down the reservoirs' water levels are allowed to decline, a corresponding limitation on the amount of water that is available to supply the other demands on the reservoir system must also be agreed to.

It is neither practical, nor in the public interest, to limit drawdown from demands for essential uses for water, such as municipal, industrial, and historic irrigation demands or existing irrigation commitments. To the extent that the annual analysis of the amount of water in storage reveals that there are interruptible water supplies available after meeting the demands of the irrigation operations, interruptible water may be held in the reservoirs to maintain lake levels.

LCRA recognizes the importance of the recreational economy of the region by limiting additional sales of interruptible stored water, other than for the four irrigation districts' Conservation Base acreage or Priority Allocation acreage, based on the projected volume of water in Lakes Buchanan and Travis, as of January 1 of each year. No such sales would occur if either lake is less than 94% of its maximum conservation capacity. If both lakes are projected to be at their maximum conservation capacity on January 1, then such interruptible water sales would be limited to a total of 80,000 acre-feet for that year. For projected lake volumes between 94% and 100% of conservation capacity, such interruptible water sales would be limited proportionately, based on the storage reservoir with the lowest projected percentage of capacity on January 1.

The consideration for the use of interruptible water and the projections for water availability would occur during the annual allocation process.

b. Downstream Recreation: The river downstream of the Highland Lakes is a potential source of recreation of vast importance to the people who live along its shores. Unfortunately, pollution has

degraded the river to the point that it is often considered a dangerous place to swim or fish. Furthermore, water levels are very low, especially in the winter months when the river below Austin is primarily wastewater which further reduces access for canoeing and boating. LCRA's commitment to maintain instream flows may partially ameliorate this condition. However, as with many rivers, the Colorado has many broad low areas where the flow is not sufficient for boating.

The more fundamental conflict is between people who want LCRA to keep the Highland Lakes full for recreation upstream and people who live along the river who want LCRA to release water to improve the downstream recreation potential. Crucial to improving downstream recreation are better controls on both wastewater treatment plants and nonpoint pollution from Austin, the downstream communities, and other users.

Gaining access to the river downstream of Austin is often difficult because there are few boat ramps and riverside parks. LCRA is developing additional boat launches and recreation areas to the river throughout the 10-county district in order to give the public better access to the Colorado River.

5. Hydroelectric Power Demand: Hydroelectric power plants located in each of the dams owned and operated by LCRA total 242 megawatts of capacity. Until the 1960s the hydro plants represented LCRA's total capability for generating electric energy. These plants still represent the cheapest power produced. The Final Judgement and Decree recognizes the competing needs for the stored water in the reservoirs, and as a result hydropower has been subordinated to be a by-product of the release of water for other purposes. To the maximum extent possible, releases of water through all of the structures are made to take maximum advantage of the energy produced by those releases. LCRA retains the right to make releases solely for hydropower production in times of emergency as part of the Water Management Plan operating policies.

6. Mining Demand: There presently is very little demand for water for mining purposes, and LCRA does not anticipate any major increases in these demands.

7. Instream Flow Requirements: The amount of water flowing within the river channel supports the strengths and diversity of the aquatic life in the system. As flows decrease, the river ecosystem can be depleted and some species destroyed.

LCRA entered into a memorandum of understanding (MOU) with the Texas Parks and Wildlife Department which provides that LCRA and TPWD will cooperate in developing a Water Management Plan with a goal of maintaining and, where reasonably possible, improving fish and wildlife resources in the lower Colorado River basin.

Pending completion of the studies which will serve as a basis for defining the flow regime necessary to sustain or enhance the aquatic life in the river, LCRA committed to maintaining a minimum monthly mean flow of 200 cfs throughout the lower basin. This flow may, at times be satisfied from inflows into the river channel and releases made by LCRA to satisfy the demands of downstream users. To assure that sufficient water will be available to satisfy this instream flow requirements, LCRA allocated 25,000 acre-feet of firm water supply to back-up both this demand on the system and the demand for inflows into the bays and estuaries.

LCRA has completed this instream flow needs study. The results of that study are two sets of instream flow needs: critical flows and target flows. The following schedule of flows takes into consideration the water quality and physical habitat requirements of the fish community native to the Colorado River.

Subsistence and critical flows: Since all City of Austin wastewater plants discharge into the Colorado River downstream of Highway 183, return flows of treated effluent bypass the Austin gage, effectively dewatering parts of the river immediately downstream of Longhorn Dam when no releases are being made from the dam. Flows of less than ten cfs have been common at this gage during the non-irrigation season although flows are substantially higher immediately downstream. Although this segment does not have the capacity to support a balanced, natural community due to its proximity to the dam, a minimum flow should be maintained in this reach. A review of historical flow records indicate that flow seldom fell below 50 cfs during dry periods before impoundment by the Highland Lakes. It is recommended that a flow of at least **46 cfs** be maintained at the Austin gage at all times. This is the 7Q10 (the seven-day average low flow expected to occur every ten years) for the Austin gage based on the period of record prior to impoundment by the Highland Lakes (1898 to 1940). Maintenance of low flows at the Austin gage will require the City of Austin to alter operational procedures at Longhorn Dam to avoid pulsed discharges from the dam's automatic gates.

A mean daily discharge of greater than **120 cubic feet per second** as measured at the Bastrop Gage should be maintained at all times except March, April, and May (critical flow months) in order to provide adequate water quality conditions in the Colorado River. This is a minimum flow based on the Texas Water Commission's standard of a daily average of greater than five milligrams per liter dissolved oxygen and meets the criteria for the high quality aquatic habitat designation in segment 1402 and 1428. Model simulations indicate that this discharge will provide a minimum daily average of greater than six mg/l dissolved oxygen throughout most of segment 1428. This recommendation is based on the assumption that the City of Austin will maintain an effluent quality at or above current levels and amend their TWC permits to require that they meet those standards in the future. Minimum flow

recommendations should be considered subject to revision as predictive capabilities are improved.

The seasonally adjusted target flow recommendations given below are largely adequate to meet the critical flow requirements for the target species during the spawning season. However, until more information on the flow requirements of the Blue Sucker (Cycleptus elongatus) during critical periods are available, it is recommended that flow be maintained at or above **500 cfs** at Bastrop for a continuous period of not less than six weeks during the months of March, April, and May. Further studies on the life history of the Blue Sucker in the Colorado River are needed.

Target flows: A schedule of flows that provides an optimal range of habitat complexity to support a well balanced, native aquatic community was determined for each study reach. These flow regimes are considered an optimal range and should be maintained whenever water resources are adequate but should be classified as an interruptible demand subject to curtailment when water resources become limited during drought periods. Since native fish species are adapted to normal seasonal variations in flow regimes, target flows were adjusted monthly to emulate the annual cycle. It is interesting to note that the composite optimal flows are roughly equivalent to the historic median flows prior to impoundment. The following recommended target flows are based on the Bastrop study reach since this segment contains suitable habitat for the Blue Sucker (Cycleptus elongatus), listed as a threatened (protected nongame) species by the Texas Parks and Wildlife Department. Since diversions for irrigation have the potential to reduce flows significantly in the lower reaches, flows should be monitored at Eagle Lake and Egypt to assure that target flows for those reaches are also met.

Maintenance flows: Periodic spates of high flows are needed to prevent siltation and dense macrophyte growth. It is presumed that these flows would be provided by natural rainfall events but may occasionally require dam releases in excess of generation capacity for short periods. Frequency and duration of maintenance flows will be determined by examination of historical data on flow regimes and macrophyte growth patterns. Macrophyte studies are in progress.

These recommendations as shown on Table 1, below, represent a balanced approach to instream flow requirements that take into account both natural flow regimes and water quality conditions needed to support a healthy, diverse native fish community downstream of Austin and should provide a strong technical foundation for the development of instream flow policy for the Lower Colorado River.

TABLE 1
Schedule of recommended flows for the Colorado River Downstream of Austin:

Month	Subsitence/Critical Flows (cfs)		Target Flows (cfs)		
	Austin	Bastrop	Bastrop	Eagle Lake	Egypt
January	46	120	370	300	240
February	46	120	430	340	280
March	46	500[b]	560	500[a]	360
April	46	500[b]	600	500[a]	390
May	46	500[b]	1030	820	670
June	46	120	830	660	540
July	46	120	370	300	240
August	46	120	240	200	160
September	46	120	400	320	260
October	46	120	470	380	310
November	46	120	370	290	240
December	46	120	340	270	220

[a]Since target flow at Eagle Lake (based on overall community habitat availability) were insufficient to meet Blue Sucker (Cycleptus elongatus) spawning requirements during March and April, target flows were superseded by critical flow recommendations for this reach.

[b]This flow should be maintained for a continuous period of not less than six weeks during these months.

LCRA will release water from the Highland Lakes to:

1. Maintain the daily river flows at no less than the critical instream flow needs in all years, and

2. Maintain daily river flows at the target instream flow needs in those years when the four major irrigation districts are not curtailed, to the extent of inflows each day to the Highland Lakes as measured at the upstream streamgages.

This recommendation fully meets the most important instream flow needs at all times and meets the desirable (target) flows during periods of normal or above normal streamflow conditions.

To fully honor this recommended commitment, LCRA recommends increasing the present commitment for instream flow and bay and estuary inflows from 25,000 acre-feet per year to an average of 28,700 acre-feet per year during any ten consecutive years, from the Combined Firm Yield of the Highland Lakes. The actual annual releases of stored water will vary from year to year depending of hydrologic conditions.

8. Bay and Estuary Requirements: LCRA recognizes the importance of fresh water inflows to the productivity of the bays and estuaries to which the Colorado River contributes. A study is now underway by the Texas Parks and Wildlife Department and the Texas Water Development Board, that hopefully, will provide a resolution as to how much fresh water is necessary to maintain the productivity of the bays. The current schedule for completion of this study is by the end of 1992 . Earlier studies indicate that this requirement has the potential for establishing a demand far greater than any other category of use on the system. The mechanism for meeting this demand is one which will require very careful analysis and consideration.

The TWC's Order, dated September 20, 1989, approving the Water Management Plan (see Appendix C) establishes a schedule of interim minimum freshwater inflows to the Lavaca-Tres Palacios estarine system. The schedule calls for a minimum monthly mean flow of 200 cfs, a minimum seasonal mean flow of 375 cfs, and a minimum annual flow of 272,000 acre-feet measured at the USGS gage at Bay City. While the source of this flow may be made of inflows into the river system downstream of Austin and runoff or tailwaters from the rice irrigation districts, it will be backed up with the firm commitment of an average of 28,700 acre-feet per annum during any ten consecutive years from the Combined Firm Yield of the Highland Lakes.

CHAPTER 3

DEVELOPMENT OF THE WATER MANAGEMENT PLAN

A. Highland Lakes Operations Procedures

The Highland Lakes system is comprised of two water storage reservoirs, Lake Buchanan and Travis and three intermediate pass-through reservoirs, Lakes Inks, LBJ and Marble Falls. Lake Austin, the last of the lakes in the chain is owned by the City of Austin, but operated by LCRA under agreement and may be referred to as part of the system from time to time. Technical data on each of the dams and lakes in included in Appendix 2A of Volume II.

The Highland Lakes operations procedures discussed in Chapter 5 define how the storage water from Lakes Buchanan and Travis is used to meet downstream demands. Buchanan has a large surface area when it is at or near conservation storage, thus it has large losses due to evaporation. Lake Travis generally receives more inflow than Lake Buchanan and is more susceptible to spilling during normal operations. The Highland Lakes operations procedures were developed to minimize the impacts of the losses due to evaporation and spills and thus maximizes the beneficial use of waters in the system. Chapter 5 describes the data, methodology, and models used to develop this policy including information on reservoir inflows, junior and senior water rights priorities and demands, reservoir evaporation data, return flows and other critical information.

B. Determination of Combined Firm Yield of Lakes Buchanan and Travis

One of the primary assumptions for the Highland Lakes operations procedures is the Combined Firm Yield for Lakes Buchanan and Travis. This amount was determined in accordance with the Final Judgement and Decree. The Combined Firm Yield of Lakes Buchanan and Travis is determined to be 535,812 acre-feet. An essential criteria specified in the Final Judgement and Decree for the determination of the Combined Firm Yield was that all senior downstream water rights must be honored by LCRA by passing through inflows necessary to meet those senior water rights to their fullest extent. The senior water rights include those belonging to the City of Austin, Garwood and Pierce Ranch Irrigation Companies, and Lakeside and Gulf Coast Irrigation operations owned by LCRA.

A full description of those water rights and the method used to determine their demand on a daily pass through basis is found in Chapter 5. The upstream reservoir demand for Owen Ivie Reservoir (90,546 acre-feet) is considered in the calculation of the Combined Firm Yield based on the commitment for these upstream inflows to be withdrawn from the inflows prior to their flows into Lake Buchanan.

Honoring these senior water rights at their fully authorized diversion rate and annual demand has a major impact on the firm yield determination of Lakes Travis and Buchanan. The current annual demand of these senior downstream rights is about 65 percent.

Streamflows into the Highland Lakes will be passed through on the basis of the senior right holder's actual demands. At the present time, and for the next several years, the actual demands can be expected to be less than the maximum authorized rights. This system of operation allows LCRA to conserve the stored waters and increases the water supply available from the existing reservoirs by stretching their yield.

C. Commitments Against Combined Firm Yield of Lakes Buchanan and Travis

The Combined Firm Yield of Lakes Travis and Buchanan represents the maximum average annual demand that could be met by these two lakes during a repetition of the most critical drought of record on the lower Colorado River. That drought period was from 1947 to 1957, an eleven year period that was identified as the most severe occurring during the 90 years since data collection started in February 1898. The Combined Firm Yield was calculated while honoring all senior water rights to their fullest extent granted by the Texas Water Commission.

A question of primary interest is how much of this firm supply of 535,812 acre-feet is LCRA committed to supply and how much is remaining that can be devoted to future needs for firm water. Currently, there are six groups of commitments that are considered firm demand:

1) Owen Ivie Reservoir: Permit No. 3676 authorizes Owen Ivie Reservoir. Operation of the reservoir will be under an operating agreement between LCRA and the Colorado River Municipal Water District (CRMWD) which calls for a gradual filling of Owen Ivie Reservoir. (see Appendix 1B, Volume II) This will allow an incremental increase in Owen Ivie Reservoir's firm demand as CRMWD's contractual commitments increase. The maximum impact of Owen Ivie Reservoir on the firm yield of Lakes Travis and Buchanan is 90,546 acre-feet per year.

2) City of Austin: Under the Comprehensive Water Settlement Agreement between the City of Austin and the Lower Colorado River Authority, LCRA agrees to make available to the City stored water from Lakes Travis and Buchanan as may be required from time to time to firm up or supplement the City's independent water rights to the extent of 290,156 acre-feet per year. In order to fulfill this agreement, present studies by LCRA show that a commitment of approximately 148,300 acre-

feet per year from the Combined Firm Yield of Lakes Travis and Buchanan will be required.

3) Contracts for use from Highland Lakes: As of May 1, 1992, LCRA has committed through contracts for the diversion of water either directly from the Highland Lakes or releases a total of 84,842 acre-feet per year. These contracts are for municipal and industrial purposes and because they call for a designated quantity of water each and every year with no other independent water rights available, they are considered to be a firm commitment for the supply of water.

4) Cooling Water for LCRA Power Plants: LCRA's power plants have a demand for cooling water and other plant uses which is considered to be a commitment against the Combined Firm Yield. By LCRA Board Resolution on January 22, 1987, the following commitments were made to each of the power plants:

Ferguson	15,000	
Sim Gideon	10,750	
Fayette	38,101	
TOTAL	63,851	acre-feet per year

5) South Texas Project (STP): LCRA currently has a contract in effect with Houston Lighting and Power (HL&P) to serve the South Texas Project (STP). HL&P as project manager of STP acts on behalf of, and for the benefit of, itself and the other participants in STP, which presently are: 1) the City Public Service Board of the City of San Antonio; 2) Central Power and Light Company; and 3) the City of Austin, to supply cooling water for the South Texas Project in an amount up to 102,000 acre-feet per year. This water is to be made up of run-of-river water available and back-up stored water from Lakes Travis and Buchanan. To the extent that stored water is required to fulfill this commitment, it is considered a commitment against the Combined Firm Yield of Lakes Travis and Buchanan.

In order to determine what impact this commitment would have on the commitment of firm yield water, a simulated operation was conducted through the critical drought period with a demand for cooling water generated by four units at the South Texas Project with a combined generating capacity of approximately 5,000 megawatts. This simulation showed that the South Texas Project would not require any water from storage to be released during most of the critical drought period.

However, the simulation through the critical drought period indicated a demand for stored water in one year of 51,700 acre-feet, the average of 5,680 acre-feet per year could be accumulated over the eleven year critical period to provide

for this larger annual demand.

6) Instream Flows and Bays and Estuaries:

As previously discussed, LCRA is recommending to increase the present commitment for instream flow and bay and estuary inflows from 25,000 acre-feet to an average of 28,700 acre-feet per year during any ten consecutive years.

7) Summary: To supply the demands of the preceding commitments for firm water existing during a repetition of the critical drought would require an average of 421,919 acre-feet per year to be released or diverted from storage in Lakes Buchanan and Travis. This commitment is comprised of:

Owen Ivie Reservoir	90,546	
City of Austin	148,300	
Contracts from Highland Lakes	84,842	
LCRA Power Plants	63,851	
South Texas Project	5,680	
Instream Flows/ Bays and Estuaries	28,700	(annual average during any ten consecutive years)
TOTAL	421,919	acre-feet/year

Out of concern for the future needs of the many areas in the LCRA 10-county district that are now using ground water supplies which are becoming depleted or are of poor water quality, the LCRA Board committed to reserving 50,000 acre-feet of the remaining Combined Firm Yield. In the future this reservation of the firm yield will be available for uses authorized under LCRA's certificates of adjudication. This interim reservation was to be in effect until water supply and demand assessments for the 10-county district were completed by LCRA staff or three years, whichever was sooner. The evaluation of projected new water demands on the firm water supplies of the Highland Lakes has been completed. A high population and economic growth and irrigation demand scenario was used in evaluating future demands. These demands were allocated to surface and groundwater sources in determining areas of water shortage. A twenty year (2013) time horizon was used in estimating likely new firm water demands.

The year 2013 projected new surface water need was estimated to be approximately 39,000 acre-feet annually. Since this amount is close to the current reservation of 50,000 acre-feet LCRA does not recommend a change in the reservation amount at this time. However, the demand projections were developed in 1988 and are currently being revised. Therefore, the reservation of 50,000 acre-feet will be reevaluated in 1993.

This leaves an uncommitted balance of the Combined Firm Yield of 63,893 acre-feet per year.

D. Annual Allocation of Firm and Interruptible Water

Each year LCRA will determine the amount of water that is available for interruptible commitments to supply the uses authorized under LCRA's certificates of adjudication.

No interruptible water will be supplied to cities or other industries which should be served on a firm basis. Interruptible water will be limited to irrigation or other similar uses where the value of water is well below firm water rates and the purchase is for one year only. New contracts for firm and interruptible water are subject to the Administrative Procedures and Rules for Water Contracts as specified in Appendix 4C of Volume II.

In November of each year LCRA will determine the amount of water which is available in the following year to meet firm and interruptible demands in the system. LCRA manages the conservation storage of the reservoirs by using the interruptible waters to increase the average yield of the system.

Should an emergency occur which causes a demand for additional allocations of water to either firm or interruptible water contract holders, any interested party will be able to petition the LCRA Board for such additional purchases.

1. Allocation of Firm Water

The amount of water required to meet the firm demand within the system for the preceding year will be calculated in early October. This amount will be compared to the projections for that year, and any variations will be noted and documented. LCRA will solicit information and projections of use from all of its firm supply contract holders and other firm uses provided for by resolution of the LCRA Board. This information will be used to develop a projection of firm demands for the coming year.

LCRA will assess the contents of Lakes Buchanan and Travis as of November 1 to project the storage levels for January 1 of the next year. Inflows into Lakes Buchanan and Travis from the upstream tributaries will be added to this preliminary storage level based on the minimum annual inflow from the period of drought.

This process will allow LCRA to reserve sufficient water in the system to meet all firm demands for one year beyond the year being considered for allocation.

Estimates for firm demand commitments for the next year will be subtracted from the total water supply available. The amount of water remaining will then be available for interruptible allocation for that year.

2. Allocation of Interruptible Water

As part of the overall allocation process, in November LCRA will determine the amount of water that is available in the following year for interruptible contracts. LCRA may make commitments for interruptible water for terms in excess of one year. However, the allocation of interruptible water to be supplied under such commitments will be determined on an annual basis. All interruptible commitments are subject to full or partial curtailment.

3. Priority Uses in the Allocation of Interruptible Water

In the allocation process, priority will be given to the irrigation operations (Lakeside, Gulf Coast, Garwood, and Pierce Ranch) in order to firm-up the independent water rights associated with individual irrigation operations. The LCRA Board will establish, by resolution, a Conservation Base number of acres determined by the historical (10-year) average acres that have been irrigated by its two irrigation operations. The amount of surface water to be used for irrigation under this Conservation Base is based upon a limit of 5.25 acre-feet of water per acre irrigated (see Table 2). The priority allocation for Garwood Irrigation Company is based on a contract which defines LCRA's commitment to supply interruptible stored water to Garwood to the extent necessary to firm up Garwood's 168,000 acre-foot-per-year independent run-of-river water right. The priority allocation for Pierce Ranch is based on a contract which defines LCRA's committment to supply interruptible stored water to Pierce Ranch to firm up Pierce Ranch's 55,000 acre-foot-per-year independent run-of-river water right. These contractual commitments to Garwood and Pierce Ranch are not based on a "Conservation Base acreage" calculation, but the 5.25 acre-foot-per-acre duty will apply to the acreage irrigated.

The Conservation Base acreage will be served without charge for the amount of water designated under each operations' run-of-river rights. In years when the amount of run-of-river water is projected to be insufficient to serve the Conservation Base and the priority allocations for Garwood and Pierce Ranch, the annual allocation of interruptible water will provide back-up for those rights. The charge for the allocation of interruptible stored water shall be at the prevailing interruptible water rate set by the LCRA Board or in the case of Garwood and Pierce Ranch, in accordance with their respective contracts with LCRA.

TABLE 2

RICE IRRIGATION
CONSERVATION BASE ACREAGE OR OTHER PRIORITY ALLOCATION OF INTERRUPTIBLE WATER

	LAKESIDE	GULF COAST	GARWOOD[1]	PIERCE[3]
Acres x Duty[2] = Ac. Ft.	25,000 x 5.25 = 131,250	50,000 x 5.25 = 262,500	32,000 x 5.25 = 168,000	25,000 with 55,000
Conservation Base[6] Or other Priority Allocation	26,000 x 5.25 = 136,500	50,000 x 5.25 = 262,500	32,000 x 5.25 = 168,000	10,476 x 5.25 = 55,000
% R-O-R Rts.[4]	53.5%	76.5%[7]	93.4%	46.8%[8]
% Stored Int.[5]	46.5%	23.5%[7]	6.6%	53.2%[8]

1) Garwood Irrigation Company and LCRA entered into a contract dated December 10, 1987, which defines LCRA's commitment to supply interruptible water to Garwood and the terms for curtailment during periods of shortages. This contractual commitment to Garwood is not based on a "Conservation Base Acreage" calculation, but the 5.25 acre-foot-per-acre duty will apply to the acreage irrigated.

2) Duty set by Texas Water Commission (5.25 Ac.Ft./Ac.) for rice irrigation. Pierce Ranch's current water rights are 55,000 acre feet to irrigate 25,000 acres.

3) LCRA has entered into a contract with Pierce Ranch regarding LCRA's commitment to supply interruptible stored water to Pierce Ranch and the terms for curtailment during periods of shortage. This contractual commitment to Pierce Ranch is not based on a "Conservation Base Average" calculation, but the 5.25 acre-foot-per-acre duty will apply to the acreage irrigated.

4) % of Conservation Base or other priority Allocation Supplied by Run-of-River Rights.

5) % of Conservation Base or other Priority Allocation Supplied by Stored Interruptible Water.

6) Limit on Surface Water for Lakeside is 131,250 acre-feet; the additional acres in the Conservation Base (1000 acres) and under the maximum allocation (2,300 acres) can be served by an alternate source.

7) % based on water used for 37,000 acres (194,250 acre-feet)

8) % based on water use for 7,200 acres (37,800 acre-feet)

There are two exceptions to the amounts of water to be provided to the Conservation Base acres for the two LCRA operations. The first concerns the Lakeside Irrigation Division's Conservation Base acres (26,000) which exceeds the number of acres (25,000) that can be irrigated from the Lakeside Division under the surface water rights set by the Final Judgement and Decree. This additional 1,000 acres of land in the Conservation Base acres will be supplied, as needed, by one of the six ground water wells owned and operated by the Lakeside Division.

The second exception to the Conservation Base allocation of interruptible water is a provision for supplying water to the Lakeside Division in years when the federal allocation for the number of acres of rice that can be grown exceeds the Conservation Base. The federal allocation is set each year by the U. S. Department of Agriculture and is a percentage of the acres of farmable land established as a historic base for each individual tract of land.

There are limits that must apply when considering any expansion of the Conservation Base to serve a greater number of acres as allocated under all governmental programs. The amount of surface water, either stored or run-of-river, which may be used for irrigation is set by the water rights for each district as established by the Final Judgement and Decree. As stated above, for Lakeside the limit is 25,000 acres, to be supplied at a limit of 5.25 acre-feet of water per acre irrigated. In years when the federal allocation for acres of rice planted is greater than the Conservation Base for Lakeside LCRA will provide back up stored water for up to 28,300 acres at Lakeside. These limits represent the maximum number of acres served by the Lakeside during the 10 year historic period that was used to establish the Conservation Base. For the Lakeside Division, any acreage over 25,000 and up to 28,300 can be served from an alternate source.

4. Use of Interruptible Water for Recreation

Interest groups around the Highland Lakes such as marina owners and other tourist and recreation industry members represented by the Highland Lakes Tourist Association expressed the need for recreation to be given some priority in the allocation of interruptible water.

In developing the annual interruptible allocation process, LCRA has considered the needs of the recreation industry around the lakes and proposes establishing some use of the interruptible waters to maintain lake levels in Lake Travis and Buchanan. These levels would be above the possible minimal drawdowns of the lakes under the operating rule curve and would be established in recognition of LCRA's public

interest responsibilities.

The conflict between supplies of interruptible water being held in the lakes for recreation or being released and sent downstream for rice irrigation, and public recreation downstream, is one of the most difficult issues for LCRA to balance. The rice farmers have a historic claim to a "first call" on the water used for rice farming as shown in Table 1. However, LCRA believes that the needs and interests of the recreation industry that has developed around the Highland Lakes must be heard and given due consideration.

Once the first priority allocation of interruptible stored water has been made to supply the Conservation Base of the Lakeside and Gulf Coast irrigation operations and LCRA's contractual commitments to Garwood and Pierce Ranch, LCRA staff will make recommendations to the LCRA Board for the remainder of the interruptible water available for supplying other authorized uses under LCRA's water rights. In recognition of the economic benefits to the recreation industry in the Highland Lakes region the Water Management Plan establishes a process to consider the levels of Lakes Travis and Buchanan.

LCRA will limit additional sales of interruptible water other than for the four irrigation districts' Conservation Base or Priority Allocation acreage, based on the projected volume of water in Lakes Buchanan and Travis, as of January 1 of each year. No such sales would occur if either lake is less than 94% of its maximum conservation capacity. If both lakes are projected to be at their maximum conservation capacity on January 1, then such interruptible water sales would be limited to a total of 80,000 acre-feet for that year. For projected lake volumes between 94% and 100% of conservation capacity, such interruptible water sales would be limited proportionately, based on the storage reservoir with the lowest projected percentage of capacity on January 1. This use of a portion of the interruptible water for recreation does not preclude the recreation industry groups from making purchases of interruptible water after the priority needs of the irrigation operations are satisfied. Such purchases would be on a basis equal to other contractual customers if the supply is available and they are willing to bear the market price for interruptible water.

No maintenance, except for emergencies which would require the lowering of Lakes LBJ, Marble Falls, and Inks,will be permitted if the refilling of those lakes would result in Lakes Travis or Buchanan being less than 80% full . Periodic lowering and refilling of Lake Austin will be done pursuant to the Settlement Agreement (December 10, 1988) between LCRA and the City of Austin.

5. Publication of Annual Allocation of Firm and Interruptible Water

LCRA will publish the results of the allocation process and notify the LCRA Board, the firm supply contract holders, and any existing or potential interruptible contract holders of the results in November . During the November LCRA Board meeting, the firm and interruptible supply and demand estimates will be provided to the Board, and any significant issues presented for discussion.

Prior to developing a final recommendation, the LCRA staff will consider public comments on the recommended Annual Allocation Plan published in November and take into account any significant water events that may have occurred up to the date of publication. At this time, the Annual Allocation plan for firm and interruptible waters will be prepared and submitted as a recommendation for Board approval and adoption in November.

6. Monthly and Quarterly Operations

The operational rule curve will be applied to the system on a monthly basis to determine how the system is responding to current conditions as compared to historical operations. This will allow LCRA to optimize reservoir operations on a real time basis and to determine if adjustments to the amount of interruptible water should be considered. The monthly allocation model serves to continually evaluate inflows into the system, to evaluate risks, and to assess system reliability. The monthly analysis would detect early signs of drought and allow LCRA to develop and implement contingency measures in a timely fashion.

A quarterly system operations report showing inflows to the system, monthly releases for firm and interruptible commitments, and important operating characteristics will be provided to the LCRA Board.

E. Water Conservation Plan and Programs

Increasing competition for available water supplies can be moderated, to some degree, by the implementation of water conservation programs. While not a panacea, water conservation can provide a potentially large and inexpensive source of "new" water supply and reduce the risk of disruptive water shortages. Additionally, water conservation can favorably effect the timing and amount of future capital investments in new supply development and water and wastewater utility infrastructure, as well as reduce utility operating costs. Water conservation will also help preserve environmental and recreational values by preventing the

overuse of limited water supplies and by reducing both point and non-point sources of water pollution.

Recognizing these and other benefits, the LCRA Board of Directors has adopted water conservation policies intended to place the agency in a leadership role in encouraging, and where appropriate, requiring the conservation of ground and surface water within the 10-county district. The goal is to promote the development and application of practices and technologies that will improve water use efficiency, increase the beneficial re-use of water, and minimize the waste of water. Consistent with this policy, LCRA has initiated a comprehensive water conservation plan targeted at the two largest water use sectors within the 10-county district; that is, irrigated agriculture and municipal water use which together account for more than 90 percent of total water use.

1. Agricultural Water Conservation Programs: LCRA's agricultural water conservation effort is focused on reducing total water use associated with rice production in Colorado, Wharton, and Matagorda counties. Specific goals are to reduce agricultural demands for stored water from the Highland Lakes and reduce costs associated with the operation of LCRA-owned irrigation water delivery systems. LCRA's agricultural water conservation programs are also intended to strengthen the long-term economic viability of the rice industry in Colorado, Wharton, and Matagorda counties.

   LCRA's agricultural water conservation programs currently consist of activities aimed at improving the operating efficiency of irrigation water delivery systems, and improving on-farm water use efficiency. At present, LCRA is implementing an irrigation canal rehabilitation program designed to "re-capture" distribution system efficiencies within the Gulf Coast canal system. The major elements of this program are:

   - Improved operational control and management of the system;
   - Vegetation removal and control;
   - Improved hydraulic characteristics of canals;
   - Installation of water control and measurement structures; and
   - Automation of water diversion facilities.

   The canal rehabilitation program is expected to reduce water use by 30 percent within the Gulf Coast canal system. Routine preventative maintenance is expected to maintain existing

canal operations efficiencies within the Lakeside canal system.

LCRA's efforts to promote on-farm water conservation in Colorado, Wharton, and Matagorda counties began in 1986. To date, the program has focused on accelerating the development of new cultural and irrigation water management practices that will improve on-farm water use efficiency and reduce waste. Key elements of the on-farm water conservation program include:

- Direct support (funding and staff) for the Cooperative Rice Water Management Research Program (i.e., "Less Water, More Rice");
- Assistance with the transfer of information from the research arena to the rice producer;
- Conservation demonstrations (e.g., development and testing of an automated levee gate); and
- Inclusion of water conservation stipulations in LCRA's standard irrigation water service contract.

Based on the preliminary results of the "Less Water, More Rice" research program, improved cultivation and management practices (e.g., precision land leveling, multiple inlet systems, etc.) can reduce on-farm water use by 25 to 30 percent. Importantly, the conservation practices examined in the research program have been shown to significantly increase crop yield. As such, individual rice producers have a direct economic incentive to adopt the recommended conservation practices. Indications are that a majority of producers have been exposed to the "Less Water, More Rice" conservation practices and that many producers have or intend to adopt recommended practices.

2. Municipal Water Conservation Programs: Overall, urban conservation and re-use are seen as important strategies for mitigating the effects of urban growth on the region's water resources. In addition to reducing future municipal water demands, urban water conservation and re-use can make important contributions toward satisfying the water and wastewater service requirements of growing urban populations and economics.

LCRA is developing a broad range of programs designed to encourage, and where appropriate, require the implementation of urban water conservation and re-use programs. Importantly, LCRA's municipal water conservation programs are predicated on the fact that the implementation of urban conservation and re-use measures must occur largely at the local level. As such,

the focus of LCRA's programs is toward encouraging and supporting initiatives by the more than 300 public water utility systems located in the LCRA 10-county district.

The LCRA municipal water conservation program consists of five major elements:

(a) Direct technical assistance with the development and implementation of local water conservation programs including:

- Public awareness and education;
- Water efficiency standards and guidelines for new construction (e.g., plumbing fixture efficiency standards);
- Retrofit programs to improve water efficiency in existing developments;
- Conservation-oriented water rates and other economic incentives;
- Low-water-use landscaping (i.e., Xeriscape); and
- Water re-use and recycling.

(b) Distribution system audit and leak detection services for local water utilities serving fewer than 10,000 connections.

(c) Integration of water conservation and re-use measures, as appropriate, with other LCRA programs and projects including:

- LCRA water sale contracts;
- Water resource planning and demand forecasting;
- Water and wastewater utility service studies, projects, and service agreements;
- Water rate design;
- Environmental programs; and
- Energy conservation programs.

(d) Public awareness and education on the water conservation opportunities, benefits, and measures. On-going activities include:

- Distribution of brochures, fact sheets, and videos on water conservation;

- Media promotion (e.g., news articles, public service announcements, talk shows, etc.);
- Public school curriculum (i.e., the "Major Rivers" elementary education program);
- Presentations to civic and service organizations; and
- Workshops, seminars, and special events.

(e) Demonstrations of advanced water conservation and re-use technologies and low-water-use landscaping techniques.

The overall effectiveness of municipal water conservation and re-use programs is dependent upon a myriad of location-specific factors (e.g., growth rates and demographic and land use characteristics of a particular community). As such, local programs must be designed in consideration of local conditions, needs and objectives. However, as a general rule, an aggressive urban water conservation program can be expected to reduce long-range water demands by as much as 20 percent. Additionally, the implementation of community-scale wastewater reclamation and re-use (e.g., dual water distribution and direct non-potable re-use) could reduce a community's future freshwater requirements by 50 percent or more.

SECTION 2

CHAPTER 4

DEVELOPMENT OF THE DROUGHT MANAGEMENT PLAN

A. INTRODUCTION

1. Background

On September 20, 1989, the Texas Water Commission issued its Order approving LCRA's Water Management Plan (see Appendix C, Volume I) for the Highland Lakes and the lower Colorado River. The Commission's Order included a requirement for LCRA to submit, within one year, a Drought Management Plan (DMP) with the Commission for its review and approval. Chapter 4 describes the Lower Colorado River Authority's Drought Management Plan for the water rights granted to LCRA. Although the water resources available in the lower Colorado River are considered as a system, only waters used under LCRA's water rights are addressed by this Plan. On December 23, 1991, the Texas Water Commission issued its Order approving the DMP. (see Appendix D, Volume I)

LCRA recognizes that its responsibility and authority under this Plan is subject to and shall not conflict with the authority of any Watermaster operation the Texas Water Commission may establish on the Colorado River. Moreover, LCRA recognizes that the Commission has jurisdiction to resolve any and all disputes regarding the allocation of stored water from Lakes Travis and Buchanan, not withstanding the procedures and guidelines set forth in this Plan.

2. Public Participation

In developing the Drought Management Plan, LCRA sought broad public participation through the work of an Advisory Committee and a series of public information and input meetings in the LCRA district. The Advisory Committee included 28 representatives from varied interests in the river basin. Taking part in the process were State and local officials, rice farmers, representatives of tourism and recreation interests, business and industry and economic development representatives and environmental interest group leaders. The other major water right holders on the Lower Colorado River were also active participants on the Committee.

The purpose of the Advisory Committee was to provide information to LCRA on the attitudes and interests of the major organizations and groups concerned with the allocation and management of LCRA's water resources. The Committee actively participated in the development of the technical studies and the analysis of the policy options. In addition, they aided LCRA by providing information on the plan to the public and the local news

media.

Many of the policy concepts and alternatives found in the Drought Management Plan are the direct result of suggestions made by the advisory group. However, neither the report as a whole, nor any portion thereof, necessarily reflects the views of the Advisory Committee or any member of the Committee.

The LCRA management and staff are appreciative of the commitment of time and energy made by the Advisory Committee.

3. The Lower Colorado River System

The lower Colorado River is considered to be the lower portion of the drainage basin of Colorado River beginning in San Saba County and continuing to Matagorda County on the Texas Gulf Coast (see Figure 1). The river flows through nine of the ten counties which make up the LCRA statutory water district.

The upper portion of LCRA's district is part of the Texas Hill Country. In the Hill Country, the river is largely controlled by a series of five dams and their reservoirs--Buchanan, Inks, Wirtz, Starcke, and Mansfield. Marked by steep slopes and shallow rocky soils with outcroppings of granite and limestone, the Hill Country ends abruptly in the Balcones Fault region near the edges of Austin. At Austin is the Tom Miller Dam which creates Lake Austin. From the eastern edges of Austin the river broadens out, snaking through the dark rich Blackland Prairie soils and then rolls gently downstream through the sand and shale of the coastal plains.

Water from the Colorado River and its tributaries is used for a variety of purposes to support the citizens and economy in the LCRA district. These uses include public water supply, manufacturing, cooling water for electric generating plants, irrigation, agriculture and mining. The water to supply these uses comes largely from the natural runoff into the Colorado River. However, the Colorado River Basin is subject to recurrent, severe droughts and devastating floods resulting in wide ranges of river flows. To provide an assured water supply and to relieve flooding, the LCRA, with the help of the Federal government, constructed the Highland Lakes reservoir system.

The development of LCRA's dams and reservoirs on the Colorado River, accomplished in the years from 1939 through 1951, changed Central Texas in many ways. Beginning by controlling the devastating floods on the river, using the river's power to generate electricity, and creating a secure and reliable water supply, LCRA has helped to stimulate the growth and development of the region. The lower Colorado River's water resources satisfy a wide variety of uses, many of which have changed and will continue to change in concert with the changes in the environment and the growth and development of the region.

4. Major Water Rights Holders

The largest water right holders in the LCRA district also use the majority of the water (Table 3). LCRA holds the largest single right, with the right to use up to 1.5 million acre-feet per year from the Highland Lakes. Other large water right holders downstream of the Highland Lakes have priority dates earlier than that of LCRA's Highland Lakes permits. These rights belong to the City of Austin, Garwood Irrigation Company, Pierce Ranch, and the LCRA's Lakeside and Gulf Coast Irrigation Divisions. These rights are considered as senior in time and superior to LCRA's right to store water in the Highland Lakes. Hence, any inflows to the Highland Lakes which can be diverted for use by these rights must be passed through the Lakes for use downstream.

TABLE (3) MAJOR WATER RIGHTS AND AUTHORIZED RIGHTS IN THE LOWER COLORADO RIVER BASIN (Acre-Feet/Year)

LCRA	1,500,000
CITY OF AUSTIN	296,403
GULF COAST	262,500
GARWOOD	168,000
LAKESIDE	131,250
PIERCE RANCH	55,000
LCRA	55,000
HL&P/LCRA (SOUTH TEXAS PROJECT)	102,000
TOTAL	2,570,153

5. Historic Operation of the Highland Lakes

Lakes Buchanan and Travis serve as the water supply and flood control reservoirs in the Highland Lakes system. Since their construction in the late 1930s and early 1940s, the water storage in these lakes has fluctuated dramatically in response to extreme floods and droughts. The lakes were at their lowest levels in 1952 when Lake Buchanan was at 983 feet mean sea level (msl) and Travis

at 614 feet msl. The highest water surface elevations were in 1991 for Lake Travis (710.4 feet msl) and in 1991 for Buchanan (1021.37 feet msl).

Operational management of the lakes has also changed over time. A major use of the dams in the 1940s and 1950s was for hydroelectric power generation. That use became secondary to water supply purposes when LCRA developed its fossil fuel electric generation stations. As a result of the Final Order and Decree for LCRA's water right holdings, the use of water for hydroelectric generation was formally subordinated to higher uses except under emergency conditions.

6. Purpose and Legal Considerations

The purpose of the DMP is to specify how LCRA will contract and supply firm and interruptible stored water supplies during a repetition of the critical Drought of Record. In managing the stored water from the Highland Lakes, LCRA must

- define the conditions under which water shortages exist and
- specify the actions to be taken by LCRA to mitigate the adverse effects of such shortages.

The overall goals of the Plan are to:

- Extend available water supplies.
- Preserve essential uses of water and protect public health and safety during extreme shortages of supplies.
- Equitably distribute among LCRA's water customers any adverse economic, social and environmental impacts associated with drought-induced water shortages.

The scope of the Drought Management Plan must adhere to the findings of the State District Court's Final Judgment and Decree, adjudicating LCRA's water rights, as well as the Water Commission's Order approving the Water Management Plan. Essentially the scope of the Drought Management Plan is limited to the curtailment of LCRA's interruptible water supplies to insure that there is sufficient firm, uninterruptible water available to meet projected demands for such water through a repetition of the Drought of Record. Firm, uninterruptible water is subject to curtailment only if it is determined that the drought in effect is worse than the Drought of Record.

In times of shortage of supply caused by drought or emergency, LCRA, in accordance with Section 11.039 of the Texas Water Code, will first curtail and distribute the available supply of interruptible water among all of its interruptible water supply customers on a pro rata basis, so that preference is given to no one and all interruptible water supply customers suffer alike.

Projections of firm demands for stored water over the next ten years are significantly less than the firm water supplies available. Thus, curtailment of firm demands is extremely remote in the next decade, even under a recurrence of extreme drought conditions.

If the shortage of supply caused by the drought is worse than the Drought of Record, then LCRA, according to the TWC Order approving the Water Management Plan, must curtail and distribute the available supply of firm water among all of its firm water supply customers on a pro rata basis, so that preference is given to no one and all firm water supply customers suffer alike.

In the annual allocation of interruptible water supplies, LCRA follows the priority order of water use as specified in Section 11.024 of the Texas Water Code and the Water Management Plan.

Similarly, in making additional commitments of firm water supplies, LCRA must also follow the priority order of uses given in Section 11.024 of the Texas Water Code.

As noted above, a goal of the Drought Management Plan is to determine how to allocate available water supplies when there is not sufficient supplies to meet projected water demands even after reasonable, cost-effective water conservation efforts have reduced the water demands. Therefore, the Plan does not emphasize water conservation practices which should occur all the time, not just in drought conditions. LCRA has major programs to encourage conservation in water use. These programs are described in detail in the Water Management Plan. The programs include the water conservation efforts in the LCRA irrigation districts and the "Model Cities" program for municipal water conservation. They are already in operation.

B. WATER USERS AND INTEREST GROUPS

1. LCRA Firm Water Customers

LCRA manages the Highland Lakes for the benefit of all users. LCRA supplies water under its water rights for the Highland Lakes to numerous municipal water supply systems, manufacturers, and power generating plants. Presently, LCRA has over 100 contracts for firm water supplies. The total commitment of firm water, including these contracts, is about 341,660 acre-feet per year, excluding the 91,391 acre-foot commitment for Stacy Reservoir and the 50,000 acre-foot reservation for future uses. Current annual use of firm stored water is less than 20% of the 341,660 acre-foot amount. The largest single customer is the City of Austin, with a contract for approximately 296,000 acre-feet yearly, including water supplied from the City's senior water right.

The major concern of firm water customers is that sufficient supplies be allocated to insure that their demands for water are

fully satisfied even during severe drought conditions. An additional concern for those customers pumping water directly from Lakes Travis and Buchanan is that the lake levels remain sufficiently high for them to continue to use their existing water intake structures. Extending intake facilities further into the lake to follow retreating shorelines can be very expensive. Most of the intakes can accommodate water levels at the historical low lake levels of 614 feet msl on Lake Travis and 983 feet msl on Lake Buchanan.

2. Agricultural Interests -- The Rice Producers

(a) Historic Claims to the Waters of the Colorado

The waters of the Colorado River have served the rice farming industry of the Texas Gulf Coast counties of Colorado, Wharton and Matagorda counties since 1885 when the first rice crops were planted near Eagle Lake, Texas. When legislation creating LCRA was first proposed in the Texas Legislature in 1933,promises were given to the rice producers and other farmers that the waters stored behind the dams proposed for the LCRA system would be available to serve their needs when the natural flow of the river diminishes in dry years.

Rice is the major crop irrigated in the most downstream three counties in the LCRA district. While some rice producers in the region irrigate their crops with pumped groundwater, the major source of water for irrigation is from the waters of the Colorado, either as run-of-river water, or stored water from the Highland Lakes. Approximately 30% of the water used to irrigate in the three counties comes from groundwater. The majority, 70%, is supplied from surface water. Approximately 500,000 acre-feet, which is about 70% of the annual water use of the Colorado River and the Highland Lakes, is used for rice farming. During an average year, about 30% of the total surface water used for irrigation comes from the stored water in the Highland Lakes.

When LCRA purchased two of the irrigation operations (Gulf Coast in 1959 and Lakeside in 1983) and their associated senior water rights from private firms, the promises to provide stored waters from the Highland Lakes as back-up to the run-of-river rights to the rice producers were repeated.

(b) Concerns of the Rice Producers

The primary concern of the rice producers is how LCRA will curtail the interruptible water during times of shortage. The producers understand the interruptible concept because, in essence, the waters were always interruptible. The Water Management Plan formalizes the understanding of how the water supply--both run-of-river and stored water--is managed.

Also of concern to the producers is the impact of any reduction of water and consequent reduction of rice acreage planted on the farmer's participation in the Federal Farm Program, as well as the direct economic impact of reduced income to meet fixed costs. The revised 1990 Farm Program allows a 5% increase of base acreage up to 80% from 75% in the previous years. While one year of reducing the number of acres planted might not affect participation, it is feared that 2 or 3 consecutive years of reduced plantings could reduce the numbers of acres allocated under the Federal Program.

3. Recreation and Tourism Interests

The waters of the Colorado River and the Highland Lakes serve a variety of recreational and tourism interests in Central Texas. In the Water Management Plan, LCRA recognizes the economic interests of the tourism and recreation industry around the Highland Lakes through a commitment to limit its sales of interruptible water, other than for the four irrigation districts' Conservation Base acreage or Priority Allocation acreage, based on the projected volume of water in Lakes Buchanan and Travis , as of January 1 of each year. No such sales would occur if either lake is less than 94% of its maximum conservation capacity. If both lakes are projected to be at their maximum conservation capacity on January 1, then such interruptible water sales would be limited to a total of 80,000 acre-feet for that year. For projected lake volumes between 94% and 100% of conservation capacity, such interruptible water sales would be limited proportionately, based on the storage reservoir with the lowest projected percentage of capacity on January 1.

While the Water Management Plan sets minimum projected reservoir storage levels for Lake Travis and for Lake Buchanan, the lakes will most likely have fallen below these levels during even a brief drought period. Economic hardship on the owners of the many marinas, small recreation businesses (bait stores, fishing camps, restaurants, campgrounds), and larger businesses, such as motels, could last much longer than the drought conditions. Many of the marinas on Lake Travis have the ability to move boat docks further out into deeper water and are willing to bear the added operational costs of such moves in order to stay in business. On Lake Buchanan, the shallow nature of the shoreline allows little flexibility in moving docks and other facilities. Some residents and other lake users have expressed concerns about the lack of access to the lakes during low elevations. Most of the LCRA boat ramp facilities and private boat ramps and launches become unusable when Lake Travis falls below 640 feet msl and Lake Buchanan falls below 1000 feet msl. Additionally, water hazards such as tree stumps and rock areas increase as reservoir levels recede, restricting more of the lake surface available for sail and power boating.

Chambers of Commerce, residents, and representatives of the tourism industry are also concerned about the elevation of the lakes area during low water periods even when a true drought is not in effect. There is a concern that first time visitors will not return to the area having once experienced low water levels in the reservoirs, thus dampening potential future economic growth.

River recreation interests downstream of the Highland Lakes are also concerned that drought conditions will leave stretches of almost dry riverbed and that water quality will deteriorate severely during drought periods.

4. Concerns for Instream Flows and Freshwater Inflows for the Bays and Estuaries

The Colorado River is the largest single source of freshwater flowing into the Lavaca-Tres Palacios estuary through channels in the Colorado River Delta. The Lavaca-Tres Palacios estuary is one of the largest of the seven major and three minor estuaries along the 370 miles of Texas Gulf shoreline. The bays and estuaries of this system provide a rich environment for wildlife, commercial seafood harvest, recreation, and aesthetic opportunities.

The Colorado River contributes freshwater to the estuary directly from the river and indirectly through return flows from rice fields irrigated from the river. An average of 1.3 million acre-feet annually from the Colorado River enters the estuary at the mouth of the river, with about 150,000 acre-feet contributed through irrigation return flows.

Estuaries and their associated wetlands are a transition zone between fresh water and marine environment and serve as the nurseries for over 97% of the fishery species in the Gulf of Mexico. Thus, the levels of salinity, nutrients, and sediments determined by freshwater inflows is critical for high estuarine production. Fluctuation of estuarine conditions from severe droughts, floods, and hurricanes results in a shift of the biological elements of the system and can directly affect the production and survival of many plant and animal species.

In the Water Management Plan, LCRA committed to maintain, on an interim basis and subject to certain limitations, certain levels of flow in the Colorado River and at Bastrop (200 cfs minimum monthly mean flow) and at Bay City (375 cfs minimum seasonal mean flow and 272,121 acre-feet minimum annual flow) for instream flow needs and flows into the bays and estuaries. LCRA committed up to 25,000 acre-feet of stored water per year of its firm water supply to meet these needs.

There are at least two studies which may eventually change the amounts of water--firm or interruptible--which LCRA has committed to instream flows and flows into the bays and estuaries. LCRA

conducted an instream flow study as part of its commitment under a Memorandum of Understanding (MOU) with Texas Parks and Wildlife Department which was completed in March 1992 . The second study was required by Section 16.058 of the Texas Water Code. Pursuant to Section 16.058, the Texas Water Development Board (TWDB) and Texas Parks and Wildlife Department (TPWD) have joint responsibility to establish and maintain a data collection and evaluation program and to conduct studies to analyze the bay conditions necessary to support a sound ecological environment. The reports, studies, and computer models are being completed and will be used by the Texas Water Commission (TWC) to determine the amounts of water necessary to maintain the ecological and environmental systems of the bays and estuaries. No schedule has been set for the proceeding by which the TWC will make this determination.

During the rice irrigation season, even under drought conditions, the instream flow needs should be satisfied as a result of natural inflows and return flows downstream of the Highland Lakes, pass-throughs of inflows to the Highland Lakes required to honor downstream senior water rights, and releases of interruptible stored water flowing downstream to the irrigation operations. Under current water demand conditions, it is in the winter months, when the portions of inflows required to be passed through the reservoirs to honor downstream senior rights are low and when downstream demands for stored water are also low, that it is most likely that instream flows will need to be supplemented with stored water releases. However, should interruptible irrigation water be curtailed or cut off, the periods of low flow in the river would be extended and additional water would be demanded to serve these needs for periods of time.

While it is difficult to estimate the full effect of inadequate instream flows or inadequate inflow to the bays and estuaries, it is clear that many plant and animal species in the food chains would be severely stressed and that productivity would be lessened.

Since the recommendations from TWC and TPWD for freshwater inflows are unknown, it is not possible to estimate the allocations that might be needed to supplement these recommended levels during time of drought.

C. PROJECTED 2000 SURFACE WATER DEMANDS DURING DROUGHTS

1. Introduction

To properly allocate available water supplies, LCRA must project the future water demand on those supplies. The DMP is based on the near future conditions which may occur in the next decade. This ten year planning period was chosen because the critical drought period used to determine the combined firm yield

of the Highland Lakes lasted approximately a decade. Further, the estimates of future water demands are most accurate in the near future. If the critical drought were to repeat itself beginning now, the maximum demands during the drought period would be those in year 2000. Thus, a ten year planning period was used for the development of the DMP.

LCRA supplies water to two general categories of water demands: firm and interruptible. Firm demands presently include the water for municipal, domestic, industrial, steam-electric power generation, non-agricultural irrigation, and some instream flow maintenance purposes. Currently, interruptible water is used almost entirely for agricultural irrigation. Demands for other possible interruptible water uses, such as instream flows and recreation, have not been specified at this time.

Current surface water use in the LCRA ten county statutory district (Figure 2) is approximately 650,000 acre-feet annually. About 70% is used for rice irrigation in the four major irrigation operations located in Colorado, Wharton and Matagorda Counties. The next largest demand for surface water is the City of Austin, which uses approximately 120,000 acre-feet yearly for municipal use.

Surface water demands in the LCRA district over the next decade have been projected by LCRA staff based on drought-condition weather, population growth, water use patterns, and economic development. The major assumptions used in projecting year 2000 demands are described in the following sections.

2. Projected Firm Water Demands

(a) Municipal Water Demand Projections

The LCRA's Economic and Load Forecasting Division has developed drought-case municipal demand projections for the urban and rural populated areas of Burnet, Llano, and Travis Counties. Projections for the City of Cedar Park were obtained from the Texas Water Development Board (TWDB). The City of Cedar Park, located in Williamson County, is served by surface water diversions from Lake Travis in Travis County.

The major assumption in developing municipal drought-case demands is that population growth would occur at a base (or likely) projected rate, but that per capita water use would be high to represent drought weather conditions. The impact of water conservation is anticipated by incorporating an approximate 10% decrease in water demands.

Estimated annual drought-case municipal water demands for surface water, including the City of Austin, are projected to grow to 192,400 acre-feet in 2000. The City of Austin comprises the

majority of this demand. Included in the Austin projection is the water demand within the city for manufacturing and steam-electric power generation.

(b) Manufacturing Water Demands

Manufacturing water demands assume an active petrochemical industry in Matagorda County and moderate manufacturing growth in all other counties in the LCRA district. Manufacturing water demands were assumed to be relatively insensitive to drought conditions. Only manufacturing demands projected to be supplied from stored water are included in these projections.

The annual manufacturing demand on the Highland Lakes is projected to increase to 8,400 acre-feet by the year 2000.

(c) Steam-Electric Water Demands

Steam-electric water demands are based on projections presented in the LCRA 1988 Resource Options Plan and from TWDB estimates. These demands consider dry weather conditions and are not further adjusted for drought conditions.

Water demands for steam-electric generation, both for the South Texas Project (STP) and the LCRA power plants, in 2000 are projected to be 90,500 acre-feet yearly. The demand for STP may be met by using unregulated run-of-river flows, supplemented as necessary with stored water. The arrangements for satisfying these demands at STP and at the LCRA power plants are described in more detail in Finding 58 of the September 7,1989 Order of the Texas Water Commission approving the LCRA's Water Management Plan.

(d) Instream Flow and Bays and Estuaries Freshwater Inflow Demands

The firm water demands projected in 2000 under drought conditions are summarized in Table 4.

3. Projected Interruptible Water Demands

(a) Interruptible Surface Water Suppliers and Their Types of Customers

LCRA presently supplies interruptible stored water to four major irrigation operations. These operations are: Garwood Irrigation Company, Pierce Ranch Irrigation Company, and the LCRA Lakeside and Gulf Coast Irrigation Divisions. These operations have very early rights to divert surface water from the Colorado River, to the extent it is available, to satisfy their needs up to their permitted rights. These run-of-river rights are all senior to LCRA's water rights in the Highland Lakes. Thus, LCRA may

TABLE (4) PROJECTED YEAR 2000 ANNUAL FIRM DEMANDS UNDER DROUGHT CONDITIONS

CATEGORY	2000 DEMAND (Acre-feet/Year)
Highland Lakes Municipal	21,400
Manufacturing	8,400
City of Austin	171,000*
LCRA Power Plants	34,100
South Texas Project (STP)	56,400*
Instream Flow Maintenance	28,700
TOTALS	**320,000**

*Firm water demands for STP and the City of Austin may be met from run-of-river flows, if they are available, under their existing water rights.

impound only that portion of the inflows to the Highland Lakes remaining after passing through inflows to the extent needed to honor these and any other downstream senior water rights.

These four operations are primarily concerned with the growing of rice although there are some turf and row-crops grown within these operations. Virtually all irrigation water is pumped from the Colorado River. Only one operation, Lakeside, has the use of a small amount of ground water for irrigation purposes.

(b) Projected Rice Irrigation Water Demands

Statistical analysis by LCRA staff indicates that agricultural water diversions at these operations is influenced by the number of acres planted, rainfall, and evaporation. Planted acreage is the strongest statistical predictor of agricultural water use, but is also the most difficult to forecast. Each operation's year 2000 acreage forecast, except for Garwood Irrigation Company and Gulf Coast Irrigation Division projected acreage, is the highest first crop levels for the 1982 - 1988 period. The projected acreage for Garwood in 2000 has been provided by Garwood.

The actual use of water for irrigation is likely to be highly variable, with relatively large differences from year to year. Water diversion demands for each district consider rainfall and evaporation conditions during each irrigation season.

For the irrigation operations, the drought case water demands are based on the forecasted acreage levels with Lakeside limited to the Conservation Base acreage. Lakeside Irrigation Division planted acreage is set at 26,000 acres while Gulf Coast is set at 37,000 acres. Each district's acreage is projected to be served through surface water supplies with the exception of 1,000 acres at Lakeside which can be served with groundwater. The projections for planted acreage comply with the Water Management Plan.

Aggressive water conservation efforts are projected to reduce the water diversions at the Gulf Coast Division by 27% in 2000, from historical 1968-1986 period usage levels. The water demands at the Lakeside Division are projected to decline as well, with 5% total cumulative reductions by 2000, from patterns of historical usage. Garwood and Pierce are not projected to have any reductions in water use because of conservation efforts until 2000, when their annual demands are estimated to be 5% less than historical usage rates.

In addition to the senior water right holders and major irrigation operations, there are additional demands for surface water along the Colorado River. These demands, and their water rights, are junior in time to December 1, 1900 but senior to November 1, 1987. The Water Management Plan requires LCRA to treat any of these rights junior to the rights for the Highland Lakes in the same manner as the users of interruptible stored water. The water demand for these rights is modeled as if the total water right could be served by firm water supplies. This demand for interruptible water is about 10,100 acre-feet in 1990 and 4,700 acre-feet in 2000. These demands are not likely to take place each and every year. The difference in the 1990 and 2000 demands is because of term permits expiring prior to 2000.

Table 5 shows the projected acreage for the four major irrigation operations and the minor water rights holders and their associated irrigation water demands for both stored and run-of-river water. The projected demands are based on assumed drought conditions for rainfall and evaporation.

TABLE (5) PROJECTED YEAR 2000 WATER DEMANDS FOR IRRIGATION

DISTRICT	PROJECTED FIRST CROP PLANTED AREA (ACRES)	2000 DEMAND (Acre-Feet/Year)
Gulf Coast	37,000	194,900
Lakeside	25,000	129,200
Garwood	28,000	148,700
Pierce Ranch	4,300	36,000
Other Senior Rights	1,070	2,000
TOTALS	**90,570**	**510,800**

(c) Freshwater Demands for Instream Flows and Bays and Estuaries

LCRA has completed the instream flow needs study. The study identified two sets of instream flow needs: critical flows and target flows. The recommended instream flows for the Colorado River downstream of Austin are in Table 1. .

LCRA will release water from the Highland Lakes to:

1. Maintain the daily river flows at no less than the critical instream flow needs in all years, and

2. Maintain daily river flows at the target instream flow needs in those years when the four major irrigation districts are not curtailed, to the extent of inflows each day to the Highland Lakes as measured at the upstream streamgages.

This recommendation fully meets the most important instream flow needs at all times and meets the desirable (target) flows during periods of normal or above normal streamflow conditions.

To fully honor this recommended commitment, LCRA recommends increasing the present commitment for instream flow and bay and estuary inflows from 25,000 acre-feet per year to an average of 28,700 acre-feet per year during any ten consecutive years, from the Combined Firm Yield of the Highland Lakes. The actual annual releases of stored water will vary from year to year depending of hydrologic conditions. The water demands for maintaining the ecological balance of coastal bays and estuaries are uncertain.

Past studies have estimated freshwater inflow needs come from the Colorado River range from 882,000 to 1,280,000 acre-feet annually, depending on the estuarine conditions desired. Revised studies of the influence of freshwater inflows on the bays and estuaries are due for completion in 1992 .

4. Summary

Projected firm surface water demands during severe droughts total about 320,000 acre-feet annually, in 2000. Surface water demands for irrigated agriculture under drought conditions are estimated to be 510,800 acre-feet annually in 2000. An additional surface water demand of 272,000 acre-feet yearly, in the form of a minimum flow, is required, on an interim basis, at Bay City for bays and estuaries. The projected demands, as well as reported use in years 1986-1988, are indicated in Figure 2.

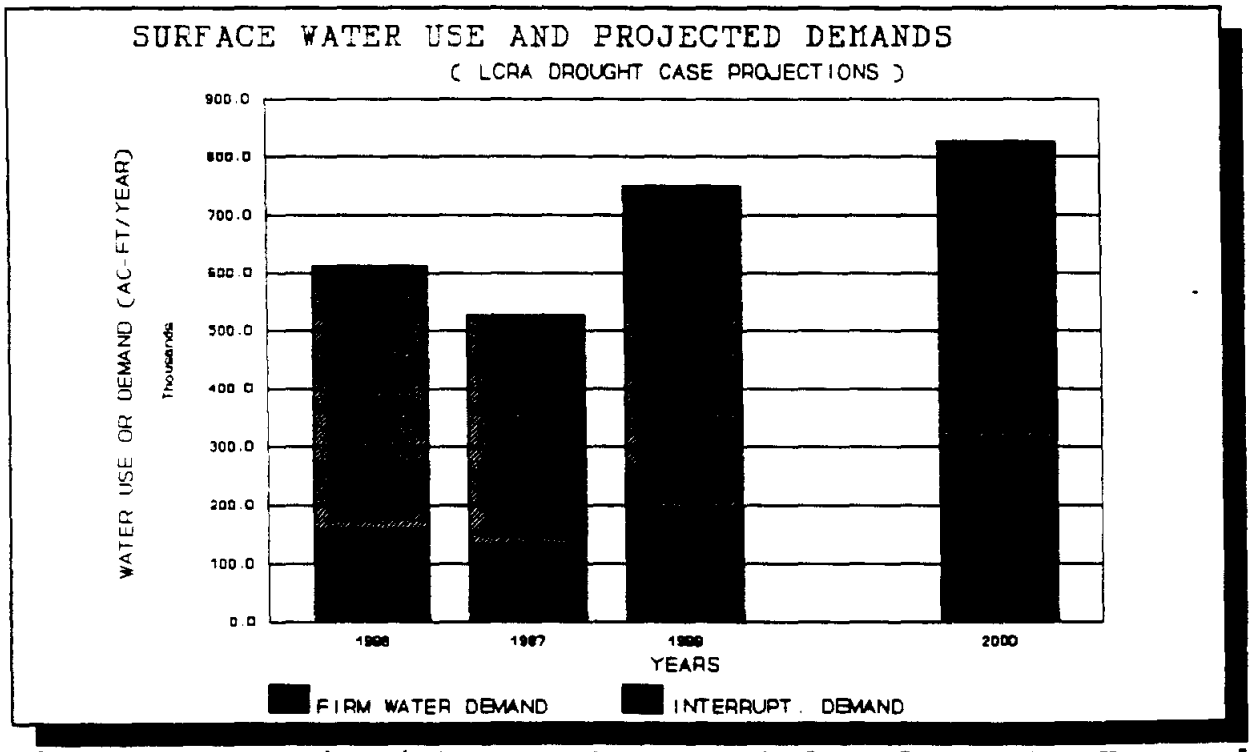


Figure 2. LCRA District 1986-1988 Reported Surface Water Use, and 2000 Drought-Condition Projected Surface Water Demands.

D. PROJECTED WATER SUPPLIES

1. Water Supply Management Procedure

(a) Systems Operation Concept

A fundamental concept of the Water Management Plan is that the Highland Lakes and the lower Colorado River are operated as a combined water supply system. Unregulated inflows entering the river from drainage areas downstream of the Highland Lakes must be used to the maximum extent possible before inflows to the Lakes are released to satisfy downstream water needs.

Such a system concept requires a careful and extensive analysis of the interconnection of hydrologic conditions, water demands, and priority of water rights and uses. The Water Management Plan uses the following general guidelines for the storage and use of water in the Highland Lakes and the lower Colorado River.

(b) Critical Drought Period Concept

A basic assumption in assessing water availability for the Drought Management Plan is that all operational policies must be evaluated as if the worst drought ever recorded for the lower Colorado River were to reoccur. This Drought of Record for the Highland Lakes was the 1947-1956 period.

(c) Procedures For Evaluating Water Availability

LCRA staff developed an automated method for evaluating water availability under a variety of management policies. This program is called "RESPONSE - Lower Colorado River Authority Reservoir System Simulation Computer Program". The evaluation of water availability proceeds on an annual basis. For each year, a three stage process is executed:

(1) water demands are estimated for each user or usage category for the coming year;

(2) the daily flows are allocated among users based on legal priority or seniority; and

(3) the operation of the Highland Lakes is simulated on a monthly basis to reflect the storage of unused inflows, evaporation, and potential spills.

The demands for water in the next year are specified as either fixed annual amounts or demands that vary depending on water in storage. The firm demands are all held constant in each year of simulated hydrologic conditions. The irrigation demands change

from year to year depending on: (1) the acres cultivated in each irrigation operation for first and second crop rice; and (2) weather conditions (rainfall and evaporation) in that year; and (3) water held in storage in the Highland Lakes at the beginning of the year. The water demand for first crop rice occurs only in the months of March through July, while second crop demands are in August, September and October. All annual water demands are distributed on a daily basis using historical water usage information.

The simulated allocation of stored water in the Highland Lakes in the Drought Management Plan follows the same procedure used in developing the Combined Firm Yield of the Lakes for the Water Management Plan.

2. Supplies for Firm Demands

The annual dependable water supply that can be supplied from the Highland Lakes during a repetition of the Drought of Record is referred to as the Combined Firm Yield. Based on the most recent information and studies available to LCRA, the Combined Firm Yield has been calculated by LCRA to be 445,000 acre-feet per year, exclusive of the commitment to Stacy Reservoir. In addition to this Combined Firm Yield, water supplies are also available from the natural flow of the river to meet a major part of the City of Austin's and the South Texas Project's firm water demands.

Adding the other firm water demands to those of the City of Austin gives a projected drought-condition demand in the year 2000 of 320,000 acre-feet annually. Portions of the demands of the City of Austin and of STP can be supplied from run-of-river flows, reducing the projected drought-condition demand for stored water in year 2000 to 152,000 acre-feet annually. Clearly, the firm demands on stored water over the next ten years are low relative to the firm supplies from the Combined Firm Yield. Thus, curtailment of firm demands is extremely remote in the next decade, even under a recurrence of extreme drought conditions. The large surplus in firm stored water supplies is therefore available to meet interruptible water use without placing at risk the stored water needed for firm water users in the next decade.

3. Supplies for Interruptible Demands

As specified by the Water Management Plan, the amount of interruptible stored water available for the next irrigation season is projected by LCRA staff in November of each year. The projected supply depends upon the amount expected to be in the combined storage of Lakes Buchanan and Travis on January 1, anticipated inflows for the subsequent months through the irrigation season, and the current demands for firm water.

Several procedures were evaluated to predict the likely supplies available, during a repetition of the Drought of Record, in the next year for interruptible demand. Historical records of streamflow were examined, but were found to be highly variable and hence not accurate in estimating water availability for the next year. The most accurate indicator of water availability is the combined storage in the Highland Lakes at the beginning of the year. Thus, for the Drought Management Plan, the allocation of stored water supplies to meet interruptible water demands is based solely on the combined reservoir storage in Lakes Travis and Buchanan at the beginning of each year, and decisions to curtail interruptible supplies in annual contracts are keyed to particular total January 1 storage levels.

At relatively full storage levels on January 1, the supply of interruptible water is sufficient to meet all projected firm and interruptible demands. However, at or below some storage levels, there are not sufficient supplies and the annual contracts for interruptible water must be reduced. At lower and lower January 1 storage levels, less and less interruptible stored water is available for allocation through the annual contracts. At some relatively low storage, there will be a total cutoff of water for interruptible use in the coming year. Provisions will be made to revise the water supply estimates during the year to respond to significant changes in projected streamflow and storage due to rainfall in the basin.

The evaluation of expected hydrologic and water demand conditions during a repetition of the Drought of Record can only be simulated based on projected information. This projected information is subject to some uncertainty. LCRA has determined it prudent to designate some minimum storage level serving as a safety factor to insure that all firm demands are fully met during the critical drought. Under this conceptual operating plan, there would be a storage level which, when reached at any time during the year, would require the total cutoff of all water for interruptible use. That storage level defines a Reserve Storage Pool for the system.

E. WATER CURTAILMENT POLICIES

1. Curtailment of Interruptible Water Demands

Given the large demand for interruptible water for rice production, there will likely be a shortage of interruptible stored water at some time during the next decade. The curtailment policies considered in the DMP focus primarily on the reduction in interruptible stored water supplies through the annual contracting process. The impact of reducing supplies in the annual contracts is far less than forcing a curtailment or total cutoff during the year after the rice farmers have made economic commitments based on the assumed availability of the water.

As provided in Finding 25 of the September 7, 1989 Order of the Texas Water Commission approving LCRA's Water Management Plan, "the priority allocation and terms governing the interruption of supply of stored water for Garwood are based upon a contract between Garwood and LCRA."

LCRA has negotiated a contract with Pierce Ranch governing the interruption of the supply of stored water to Pierce Ranch. Interruption of the supply of stored water for other commitments similarly would be governed by contract or LCRA Board resolution.

There are many ways in which interruptible stored water demands may be curtailed through the annual contracts. The two most likely are a gradual curtailment with reductions indexed against beginning of year storage in the Highland Lakes; or an abrupt total cutoff policy where the full demands are supplied if the beginning of year storage level in the Lakes was above a specific level, otherwise totally stop interruptible stored water sales for the next year.

The largest use for interruptible stored water is rice production. Rice producers must plan their crops for the next season based upon the projected interruptible stored water supply, even though more supply may actually be available in future months. The advantages of the gradual approach of curtailment are that the rice industry could use the water allocated to achieve the greatest benefit. Water could be used in first crop on the hope that conditions in the spring would refill the river and lakes. The disadvantage is that some curtailment would occur when it was not really necessary in years when the critical drought was not repeated. The Highland Lakes would refill and spill because the drought ends before conditions become as severe as the critical Drought of Record.

The advantages of the "all or nothing" approach are that there would be more years when the full demands would be met and minor droughts would not affect available supplies. Disadvantages would be that in some years there would be no stored water and most rice producers would risk substantial or total loss of their crops if sufficient run-of-river water was not available throughout the growing season.

In years when there is not sufficient projected stored water available to meet all irrigation needs, the interruptible stored water will be allocated to the irrigation operations so that all operations have the same percentage shortage in their <u>total stored water demand</u>. The calculation of the annual demand of interruptible stored water will be based on a projection of relatively dry weather and low streamflow conditions in the next year. The following example of the distribution procedure illustrates how the process would work.

Example of the Distribution Procedure

To illustrate how the procedure would work in practice, consider the following situation when dry weather conditions are assumed for the next year, and the water demands are for the full projected year 2000 acreage and water usage levels. The dry weather conditions used in this example would be expected to occur approximately one year out of every five. As noted previously, the actual water curtailments may differ from the values in this example depending on the conditions specified in contracts between LCRA and each water user.

- **ASSUMPTIONS:**
  - 200,000 acre-feet of interruptible stored water is available for the coming year based on January 1 storage in the reservoirs.
  - Dry weather diversion demands for the operations for both rice crops are:
    - Gulf Coast = 182,000 acre-feet
    - Lakeside = 126,000 acre-feet
    - Garwood = 135,000 acre-feet
    - Pierce = 40,000 acre-feet
    - Total = 483,000 acre-feet
  - Dry weather run-of-river water available for each operation for both rice crops is:
    - Gulf Coast = 48,000 acre-feet
    - Lakeside = 28,000 acre-feet
    - Garwood = 98,000 acre-feet
    - Pierce = 8,000 acre-feet
    - Total = 182,000 acre-feet
- **CALCULATIONS**
  - Dry weather interruptible stored water diversion demands for each operation for both rice crops are:
    - Gulf Coast = 134,000 acre-feet
    - Lakeside = 98,000 acre-feet
    - Garwood = 37,000 acre-feet
    - Pierce = 32,000 acre-feet
    - Total = 301,000 acre-feet
  - The portion of interruptible stored water available, as a percentage of the maximum stored water demand is about 66%.
  - Dry weather interruptible stored water supply available for each operation for both rice crops is 66% of each operation's

total stored water demand:

- Gulf Coast = 89,000 acre-feet
- Lakeside = 65,100 acre-feet
- Garwood = 24,600 acre-feet
- Pierce = 21,300 acre-feet
- Total = 200,000 acre-feet

- Calculated dry weather water shortages for each operation for both rice crops are:

  - Gulf Coast = 45,000 acre-feet
  - Lakeside = 32,900 acre-feet
  - Garwood = 12,400 acre-feet
  - Pierce = 10,700 acre-feet
  - Total = 101,000 acre-feet

The water shortages are clearly not equal volumes for all operations. However, the shortages in stored water are an equal percentage (34%) of each operation's interruptible stored water demand.

To further illustrate the allocation procedure, consider the Gulf Coast Division water allocation in the above example.

- Dry weather demand for the Division for both rice crops is 182,000 acre-feet.

- Dry weather run-of-river water available is 48,000 acre-feet.

- Dry weather interruptible stored water demand is 134,000 acre-feet.

- Dry weather interruptible stored water supply available is 89,000 acre-feet, or 66% of the interruptible stored demand for the Division.

- Calculated dry weather water shortage is 45,000 acre-feet or 34% of the total stored water demand for the Division.

2. Recommended Interruptible Water Demand Curtailment Policy

LCRA staff examined a number of alternative management policies for the Highland Lakes to meet interruptible water demands. Overall, the recommended alternative best balances the economic benefit to the rice producers, while protecting all firm demands. The principal benefit of this plan is that it protects the full demand for first crop rice in all years of the critical drought. This assurance of supply for full first crop is obtained at the price of reducing supplies of stored water earlier in the critical drought period than other management alternatives.

Policy Recommendation for Interruptible Curtailment and Cutoff

1) Open Supply - If the total January 1 storage in Lakes Travis and Buchanan combined is greater than 1,400,000 acre-feet (67% of the total maximum storage capacity) then LCRA will supply all interruptible water demands.

2) Gradual Curtailment will begin if the total January 1 storage is less than 1,400,000 acre-feet and greater than 325,000 acre-feet. The reduction in interruptible supply will be essentially proportional to the storage content. The interruptible stored water supply available will decrease gradually at a rate of approximately 4% for each 100,000 acre-foot decrease in combined storage on January 1. Examples of the reductions at two specific storage levels are:

- A reduction of approximately 13% in the interruptible water supply will be required when the storage level on January 1 is 1,100,000 acre-feet (52% of the total capacity).

- A reduction of approximately 38% in the interruptible water supply will be required when the storage level on January 1 is 500,000 acre-feet (24% of the total capacity).

3) Cutoff of the interruptible water supply for the coming year will occur when the combined storage level on January 1 is less than or equal to 325,000 acre-feet.

4) Reserve Storage Pool - If at any time during the year the total storage in Lakes Travis and Buchanan, combined, is less than or equal to 200,000 acre-feet then all use of interruptible stored water will be stopped.

5) During periods of curtailment or cutoff instituted on January 1, LCRA will cancel the curtailment of interruptible stored water for the irrigation districts at any time during the year prior to July 31, if the combined storage in Lakes Buchanan and Travis is projected to be equal to or greater than 1.4 million acre-feet anytime in July. Further, the remaining available interruptible supplies for the year may be reallocated, at this time, between irrigation operations if such allocations do not adversely affect any irrigation operation.

6) During periods of curtailments, LCRA will allow each irrigation operation the option of either: (1) using up to a maximum authorized volume of interruptible stored water allocated to that operation, or (2) using sufficient water to cultivate a level of acreage agreed upon by the operation and LCRA.

Figure 3 diagrams the conceptual Lake Management Policy by showing Curtailment Cutoff and Reserve Storage Pool levels relative to the combined storage of Lakes Travis and Buchanan.

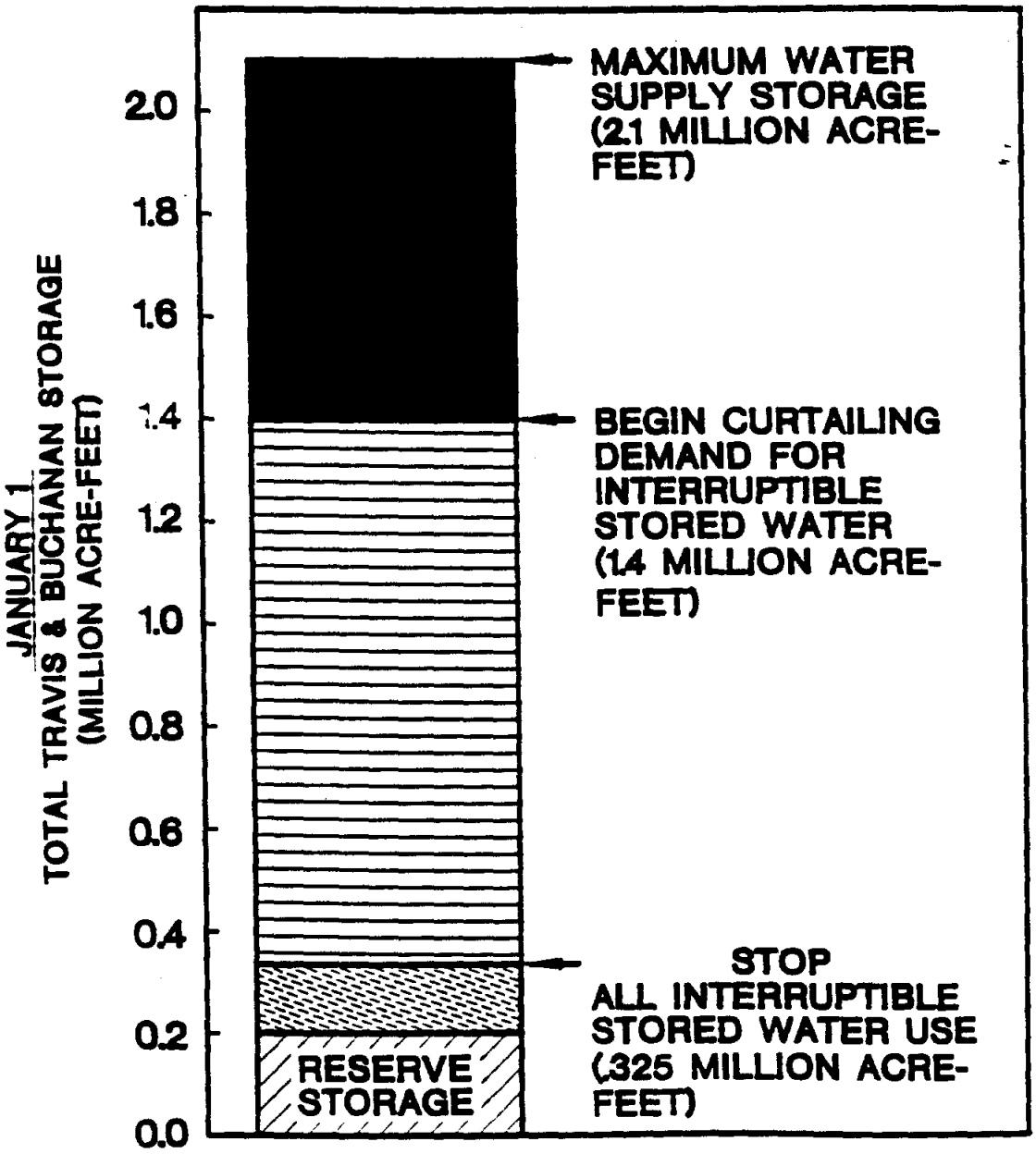
Since the curtailment begins at relatively high water storage levels, curtailment of irrigation water supplies may occur during some relatively mild droughts, however such curtailment would be limited in scope and duration. Further, it is likely that the rice producers will only be tentatively required to curtail second crop rice which is cultivated after first crop rice is harvested in July and August. Thus, the curtailment plan has the added advantage that spring rains and runoff may increase water supplies and reduce demand and thereby allow an increase in the estimate of interruptible stored water available for second crop rice. Rice producers could relatively easily increase their second crop acres if they were aware of any increased water supply by June 15.

To achieve the estimated benefits of the management policy, it is necessary for the irrigation operations to reduce their water demands to correspond to reductions in the estimated stored water supplies, in accordance with the procedures in this Plan or the terms and conditions of contracts between LCRA and stored water users. Close coordination between LCRA and the operations will be needed. Should an operation choose not to reduce the acreage cultivated in response to the projected shortage of interruptible water supply, LCRA will only supply that operation with its estimated portion of the reduced interruptible supply. No additional stored water will be released in that year for that irrigation operation once the diversion limit has been reached.

In addition to the above features, LCRA will require interruptible water customers to prepare and adopt a legally enforceable local drought management plan which specifies the actions to be taken to comply with the LCRA Drought Management Plan regarding the curtailment of interruptible supplies. LCRA staff will provide direct technical assistance with the preparation of required local plans. No local drought management plans have been developed to date by any LCRA customers. However, such plans are required for participation in the State of Texas water infrastructure loan programs administered by the Texas Water Development Board. A drought management plan has been prepared for the Barton Springs-Edwards Aquifer Conservation District located partially within the LCRA ten county statutory district.

FIGURE 3

CONCEPTUAL LAKES MANAGEMENT POLICY



3. Curtailment of Firm Water Demands

LCRA is required by TWC and the Texas Water Code to follow water supply allocation procedures to insure that there is no shortage or deficiency of stored water for firm demands during a repeat of the Drought of Record. Given the relatively small demand on firm water supplies at present, the possibility of a firm water shortage occurring is remote for the foreseeable future.

LCRA cannot determine with absolute certainty whether a particular drought event will be more or less severe than the Drought of Record. Therefore LCRA will request voluntary reduction of firm demands in the early stages of a drought.

LCRA cannot invoke mandatory curtailments of firm water demand unless it can be demonstrated that a particular drought event is more severe than the Drought of Record or some other water emergency that drastically reduces the available firm water supply. LCRA Water Resources staff has developed a simplified "drought monitoring procedure" for identifying a drought worse than the Drought of Record for the Highland Lakes watershed. Historical inflow data for the contributing watershed of the Highland Lakes were used in the development of this procedure.

4. Recommended Firm Water Demand Curtailment Policy

(a) Recommendation 1:

Voluntary water conservation measures will be implemented whenever either:

(1) there is a curtailment in interruptible stored water supplies or

(2) the total storage in Lakes Buchanan and Travis is less than 1.6 million acre-feet.

At such times, LCRA will implement an aggressive public information campaign to provide up-to-date information on water supply conditions and promote voluntary action to conserve water.

(b) Recommendation 2:

LCRA will further encourage the firm water customers to reduce water use by end users whenever the total storage in Lakes Travis and Buchanan is at or below 900,000 acre-feet. To implement end-user water demand reductions may require that mandatory water use restrictions be imposed on end users by the firm water wholesale customers themselves. To encourage such water demand reductions, LCRA will investigate alternative incentive policies, including the use of special water pricing incentives to participating wholesale water customers.

(c) Recommendation 3:

Implementation of the mandatory curtailments of firm water demands will occur whenever the river system is experiencing a drought more severe than the Drought of Record. During a drought more severe than the Drought of Record, LCRA will curtail and distribute the available supply of firm water among all of its firm water supply customers on a pro rata basis according to their demand for stored water. All uses of interruptible stored water will be totally cutoff prior to and during any mandatory curtailment of firm stored water supplies.

In addition to the above features, this curtailment policy for firm water demands includes the following elements:

(1) Required local plans. Each LCRA firm water customer will be required to prepare and adopt a legally enforceable local drought management plan which specifies the actions to be taken to comply with the LCRA Drought Management Plan regarding the curtailment of firm supplies. Such plans should be developed pursuant to LCRA guidelines and submitted for LCRA review and approval within a reasonable time. LCRA staff will provide direct technical assistance with the preparation of required local plans.

(2) Essential and non-essential water uses. To allow a distinction between essential and non-essential water uses during severe droughts, LCRA will petition the Texas Water Commission to determine and adopt definitions for these uses, as appropriate for drought management.

5. Impacts of the Recommended Management Policy

(a) Firm Water Demands and Supplies

All projected year 2000 demands for firm water are fully satisfied under these simulated critical drought conditions. The largest firm water demand is for the City of Austin. The majority of Austin's projected annual demand of 171,000 acre-feet is met from run-of-river flows diverted under its senior water rights. Approximately 63% of the demand during the 1947-1956 critical drought years is estimated to be supplied by these flows with the remainder supplied by firm stored water.

(b) Interruptible Water Demands and Supplies

Under the recommended management policy, all stored interruptible water available during a repetition of the Drought of Record is used by the four downstream irrigation operations, except for a total of 76,500 acre-feet of stored interruptible water released in simulated years 1947 thru 1949 for maintaining the flow

at Bay City. When these releases were made there was no curtailment of interruptible water supplies for the four major irrigation operations. As discussed above, it is assumed that the actual stored water allocation process distributes water by determining an equivalent allocation of acreage for first and second rice crops, by individual irrigation operation. It is assumed that each operation responds to reductions in water demands by following first and second rice cropping practices that maximize the net economic return to the rice producers in each operation . Such practices take into account the net income per acre and water demand for first and second rice crops, and the need for and cost of stored interruptible water. Using a cropping policy which maximizes net producer income, the rice operations would generally use available interruptible supplies to keep first crop acreage at maximum levels and adjust second crop acreage to any remaining interruptible supply available. As discussed previously, the allocation process for Garwood, Pierce Ranch and other users of interruptible water are, or will be, defined by contract or LCRA Board resolution.

Following the recommended curtailment policy during a simulated repetition of the 1941-1965 period, including the Drought of Record, the supplies of interruptible water are estimated to be insufficient to meet all rice irrigation demands. Some curtailment of stored water for rice production would be necessary because of insufficient stored water available at the beginning of 11 of the 25 years simulated to cultivate the full projected acreage. However, in three of these 11 years, the curtailment would be canceled at midyear since the simulated water in storage exceeded 1.4 million acre-feet on July 1. The average cultivated areas each year for total first and second crops over the 25-year simulated period are estimated at 93,600 and 69,900 acres, respectively. All acreage cultivated was supplied all the water needed to complete a successful harvest. This is only possible if the irrigation operations reduce the acres planted in response to reduced water supply estimates. The simulated acreage cultivated in first and second crops are given for all four operations combined and individually in Figures 4 - 8. As noted previously, however, the actual stored water curtailments may differ from the values reflected by the cultivated acreage as shown in this simulation, depending on the facts as they then exist and the terms and conditions of the contracts between LCRA and users.

(c) Lake Storage Levels

For the simulated repetition of the Drought of Record, the combined lake storage was reduced to very low levels in the worst drought years (Figure 9), even with the partial curtailment of interruptible supplies. Approximately 250,000 acre-feet of stored water remains in Lakes Travis and Buchanan combined at the lowest storage content. The simulated lake water surface elevations and storage levels are given in Figures 10 and 11, for Lakes Buchanan

and Travis, respectively. The minimum lake water surface levels during the simulation period are about 963 feet msl on Lake Buchanan and 569 feet msl on Lake Travis. Sufficient water is retained at the minimum storage content in Lake Travis to keep water diversions for all major water systems on Lake Travis, except for Jonestown, Cedar Park, and Lago Vista, which would require major intake extensions. The average for the beginning of August lake water surface elevations (for the repetition of the 1941-1965 period hydrology) are projected to be 1007 feet msl, on Lake Buchanan, and 655 feet msl, on Lake Travis.

The simulated minimum water levels in Lakes Travis and Buchanan are lower than the historical low levels of 614 feet and 983 feet, respectively. The greater drawdown on the lakes in the simulated operation is largely because of greater water demands and lower reservoir inflows than occurred historically. The projected year 2000 water demands are significantly greater than those that occurred in the 1941-1965 historical period. Firm water demands during the actual drought of record were only a small fraction of those projected by year 2000. Additionally, the rice producers only cultivated one crop of rice prior to about 1963. The current practice of producing two crops each year has increased the water demands of irrigation over those of the 1947-1956 critical drought period.

The second factor causing the simulated storage levels to be lower than historical levels is a difference in the reservoir inflows. The simulated operation uses historical inflows adjusted for any flow reductions caused by water diverted for upstream water rights, particularly major reservoirs including Stacy Reservoir. Most of the large reservoirs upstream of the Highland Lakes were not in operation during the critical drought period. During any repetition of the Drought of Record, these upstream reservoirs would likely significantly reduce inflows available for storage.

d. Flows in the Colorado River

For a repetition of the hydrologic conditions in the 1947-1956 critical drought years, the estimated average flow of the Colorado River at Bay City is about 460,000 acre-feet annually. For a repetition of the 1941-1965 period, the simulated annual flow at Bay City averages 1.2 million acre-feet. Of this total, a portion of the flow consists of dedicated stored water releases required by the TWC Order approving the Water Management Plan to satisfy the interim minimum flow requirements at the USGS Bay City stream flow gaging station.

In many of the years in the 1947-1956 critical drought period, the simulated flows do not fully meet the interim minimum flow requirements at Bay City. During this period, the simulated average annual deficiency in meeting the minimum flow levels is about 35,000 acre-feet. The dedicated firm and interruptible

stored water releases for the 1947-1956 critical period amount to an average of 28,000 acre-feet per year.

F. IMPLEMENTATION OF DROUGHT MANAGEMENT PLAN

1. Annual Review and Revisions

As part of the Water Management Plan, the DMP is subject to review each year. The TWC order approving the Water Management Plan stated that the priorities in the Water Management Plan are subject to change after the completion of the instream flow studies. The DMP may be revised at any time subject to approval by the LCRA Board and the TWC. Changing water supply and demand conditions on the Lower Colorado River will be reflected as necessary in future plans.

2. Administration

The curtailment of interruptible water supply will occur through the annual contracting process in November through January of each year. The curtailment of firm water will depend on storage levels and will be monitored continuously. Curtailment of interruptible water supply for Garwood and other entities supplied pursuant to long-term contracts will be accomplished pursuant to the terms of those contracts.

LCRA will monitor customer compliance with the required demand reduction goals and take enforcement action as necessary against noncompliant customers. Monitoring and enforcement of water use restrictions at the end-user level generally will be the customer's responsibility. At present, LCRA's ability to enforce curtailments of firm water demands is uncertain and may be limited to taking civil action to enjoin a non-compliant customer for breach-of-contract.

FIGURE 4

SIMULATED IRRIGATED ACREAGE (4 IRRIGATION DISTRICTS COMBINED)

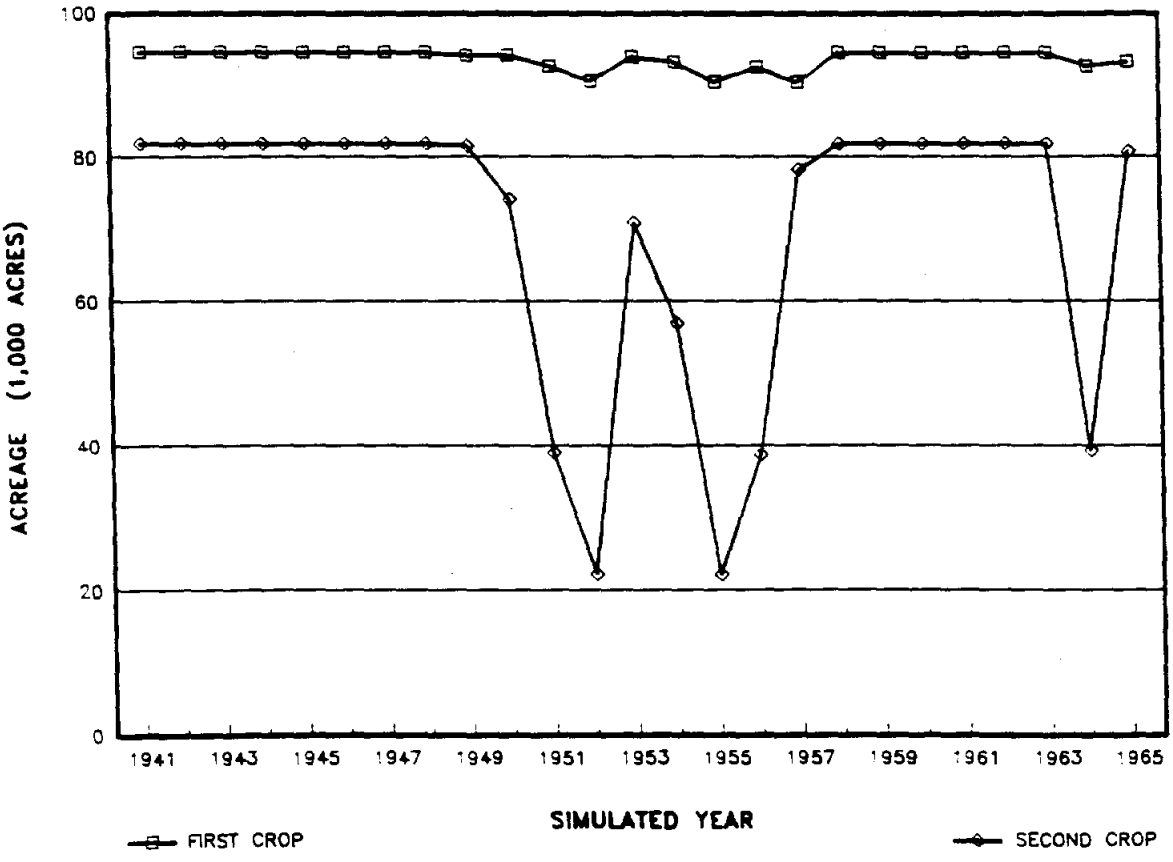


FIGURE 5

SIMULATED GULF COAST PLANTED ACREAGE

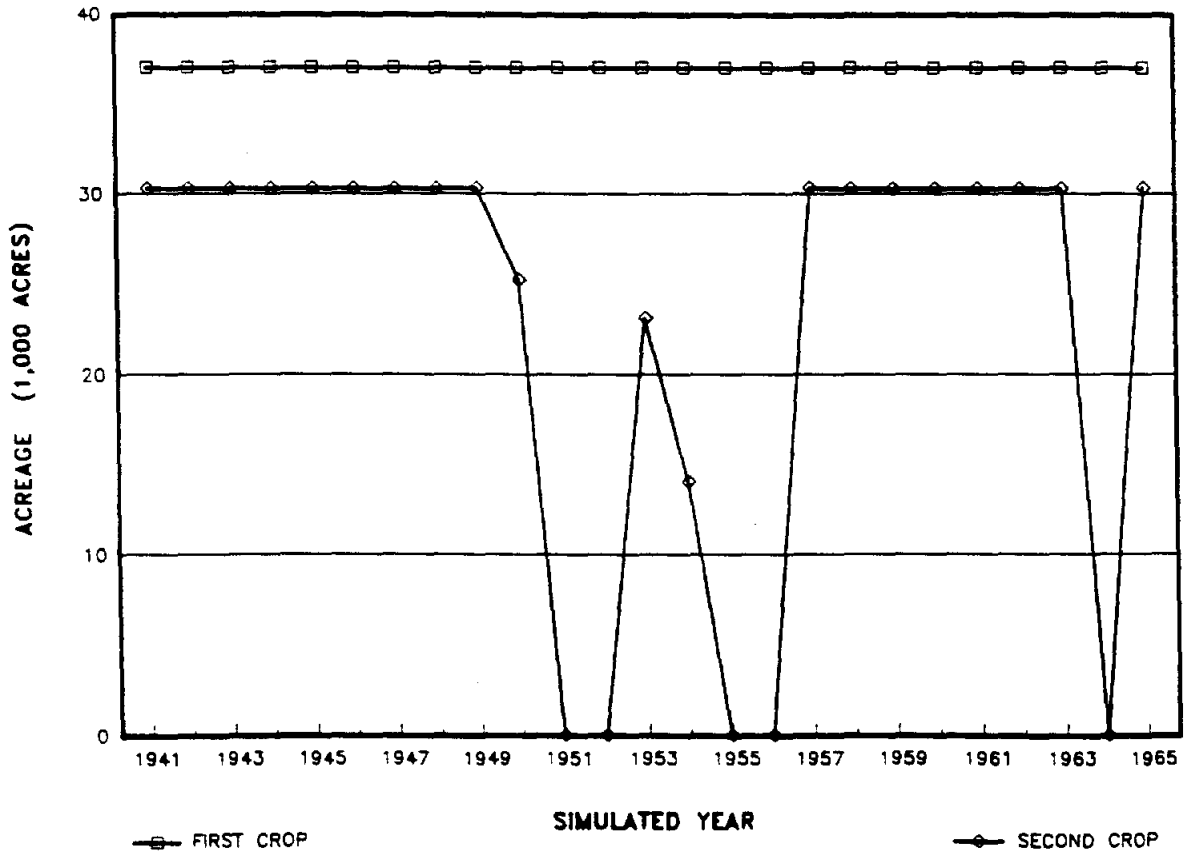


FIGURE 6

SIMULATED LAKESIDE PLANTED ACREAGE

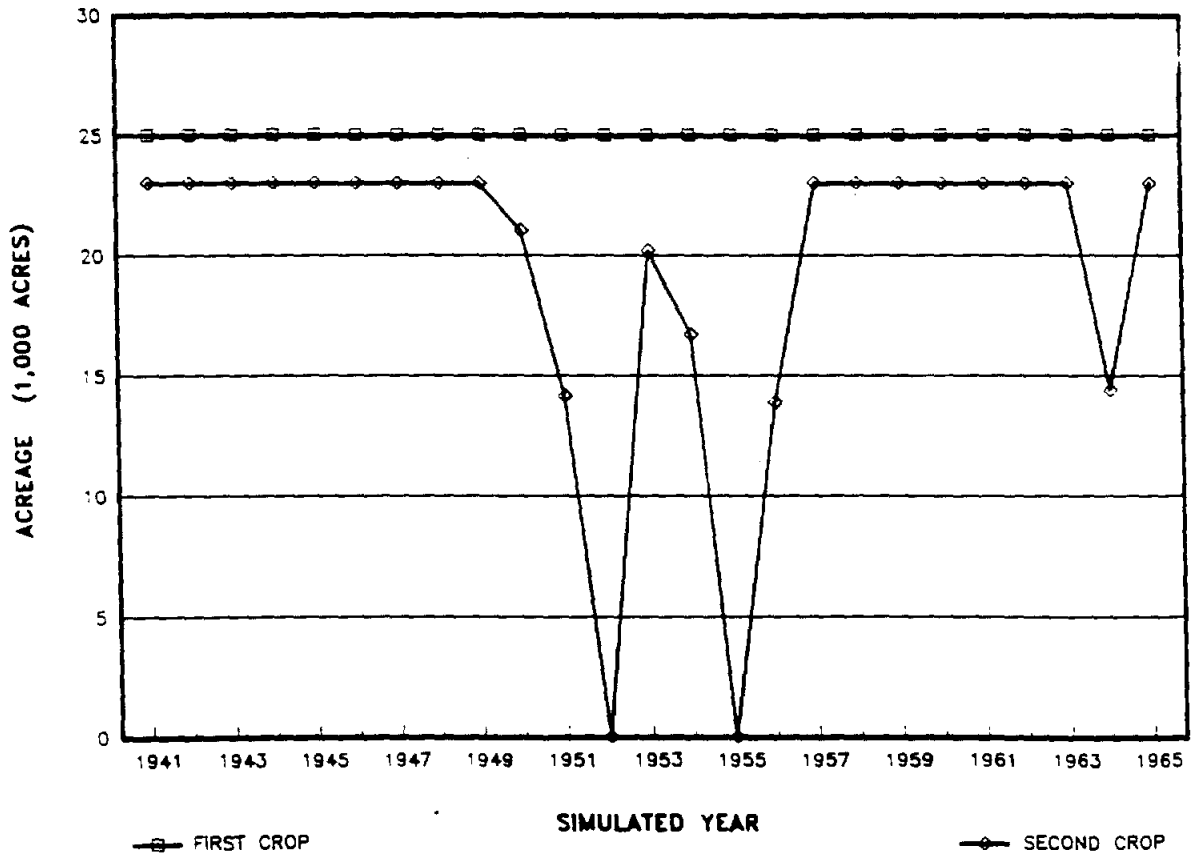


FIGURE 7

SIMULATED GARWOOD PLANTED ACREAGE

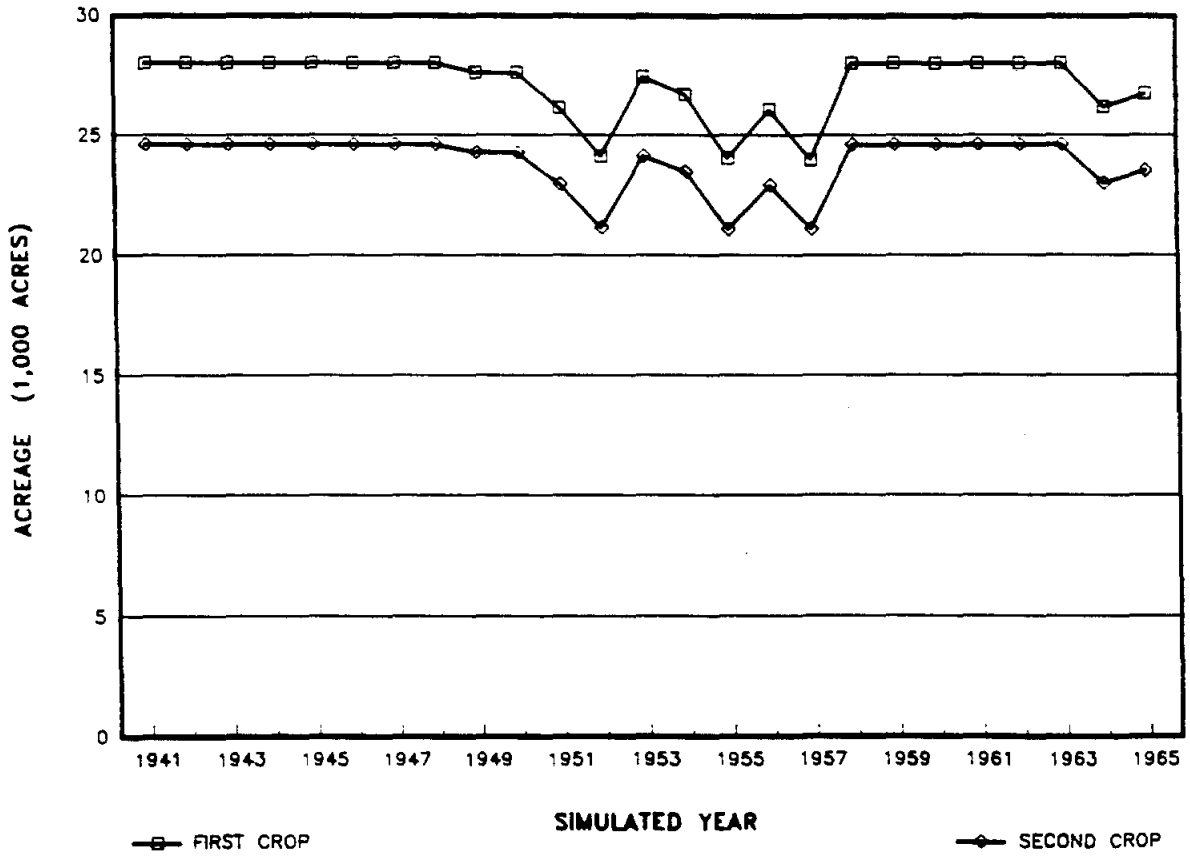


FIGURE 8

SIMULATED PIERCE RANCH PLANTED ACREAGE

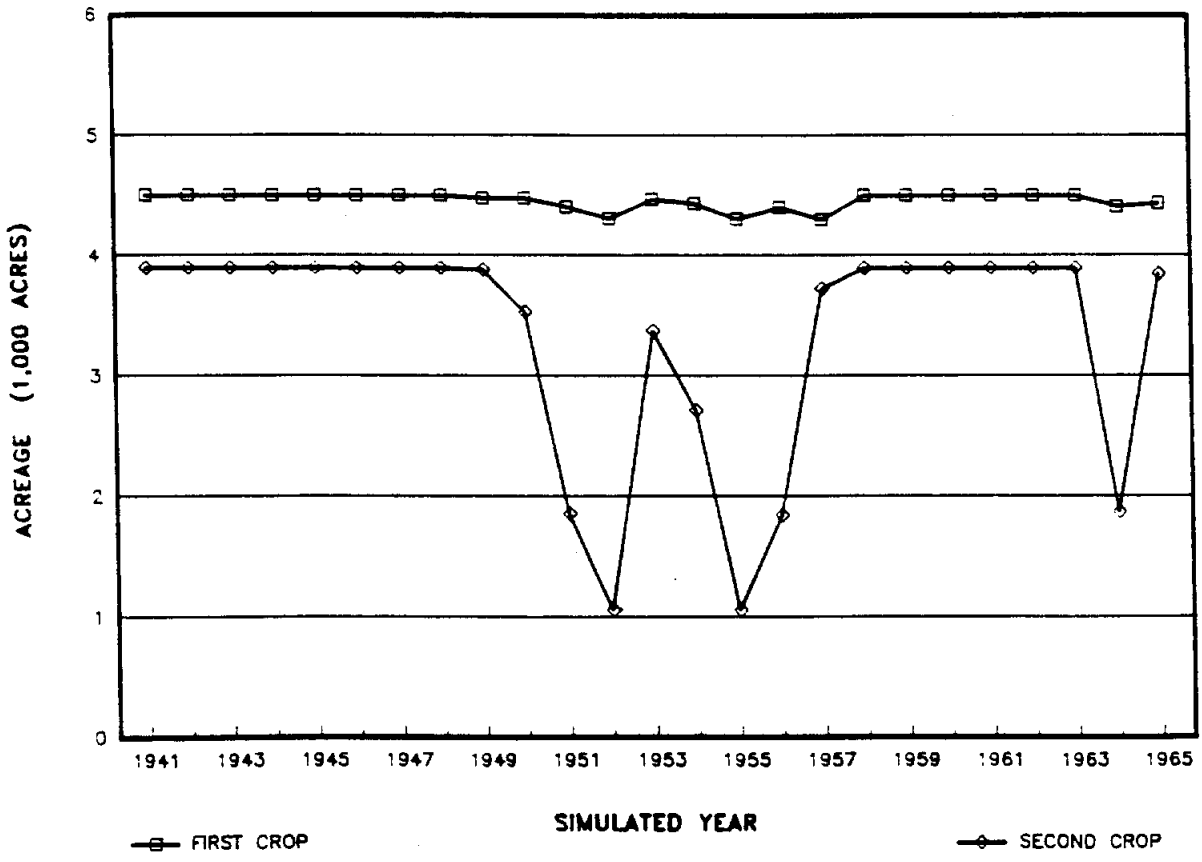


FIGURE 9

SIMULATED TRAVIS AND BUCHANAN STORAGE CONDITIONS

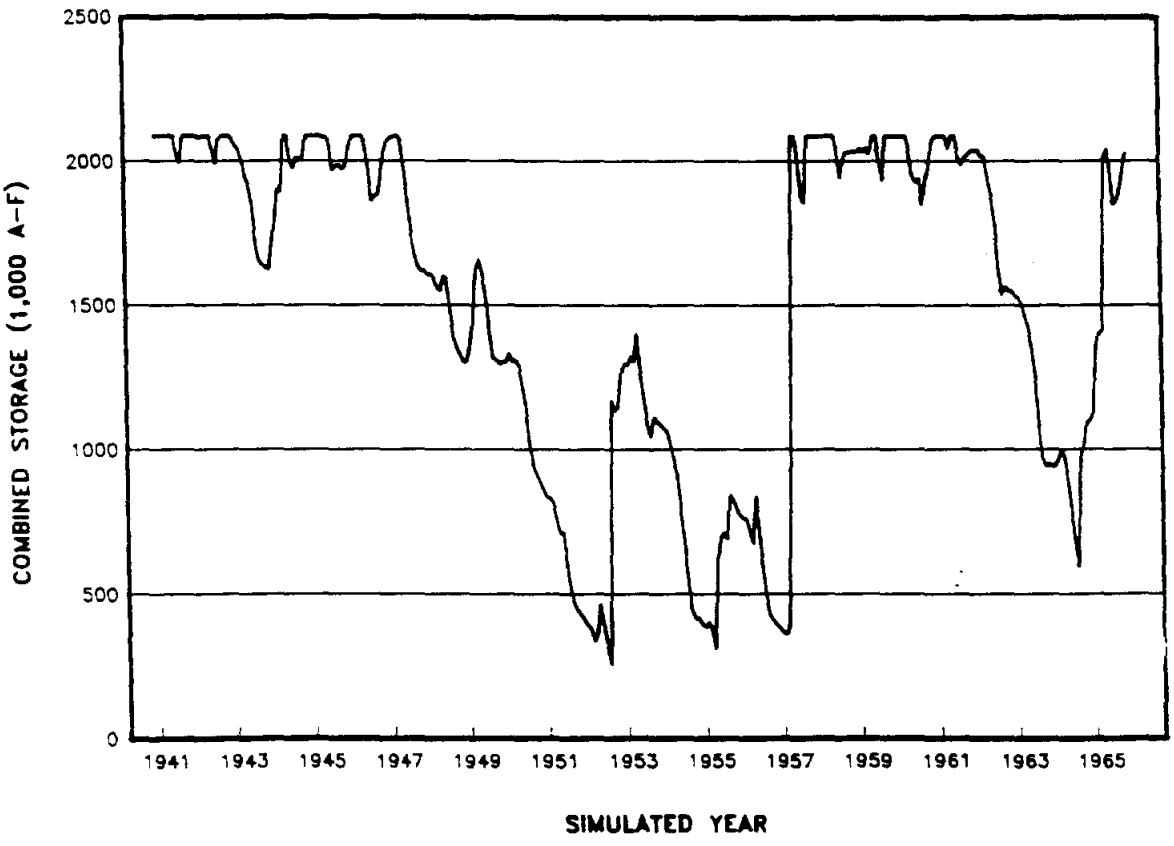
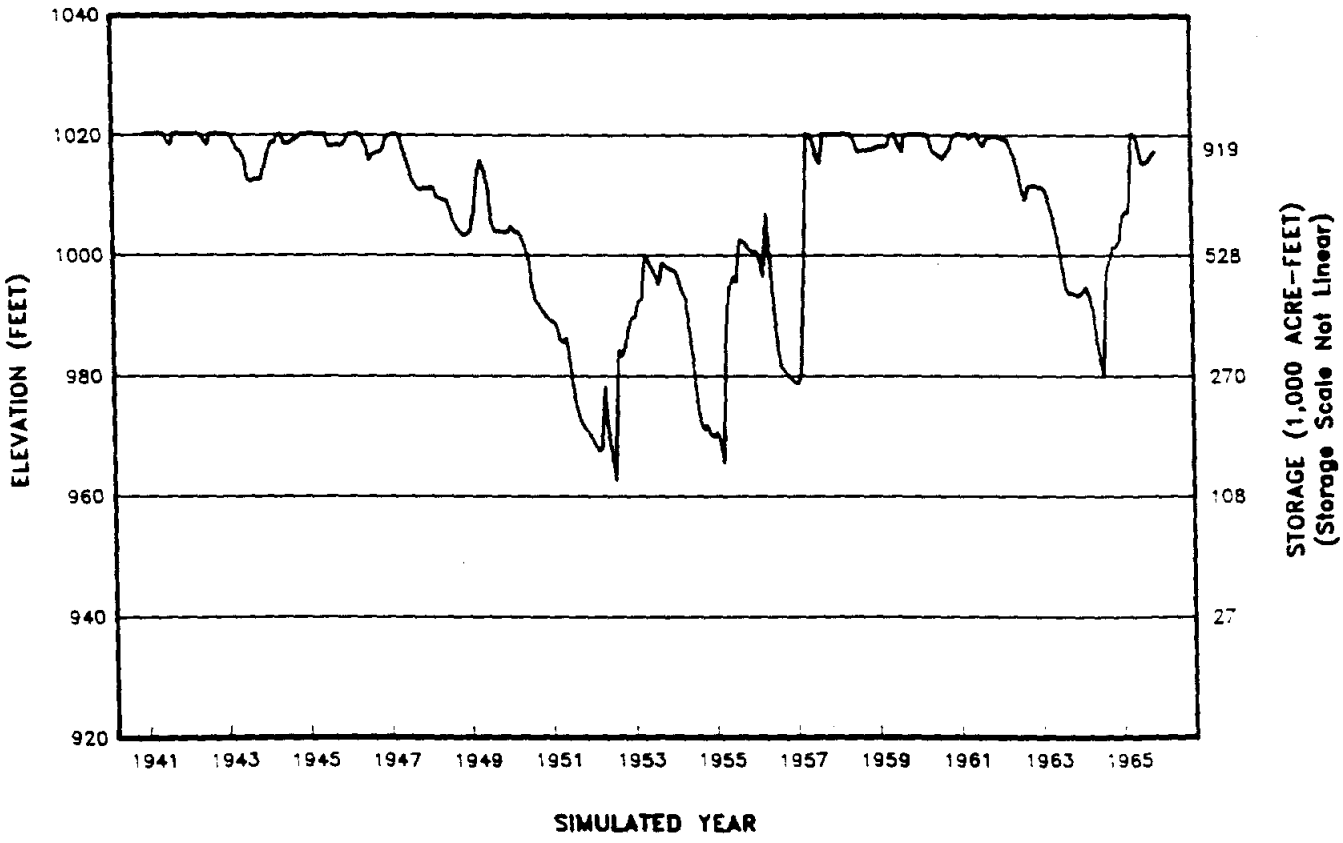


FIGURE 10

LAKE BUCHANAN SIMULATED ELEVATION AND STORAGE




LCRA
THE POWER TO MAKE A DIFFERENCE.

Lower Colorado River Authority

WATER MANAGEMENT PLAN

FOR THE

LOWER COLORADO RIVER BASIN

Prepared By

The Lower Colorado River Authority

May 29, 1992

TABLE OF CONTENTS

VOLUME I

WATER MANAGEMENT PLAN FOR THE LOWER COLORADO RIVER BASIN

PREFACE

The "business" of water resources management in Texas, and throughout the nation, is in the midst of transition and transformation. The transition is largely the result of ever increasing demands and competition for renewable but limited water supplies and a growing awareness of the limits of "traditional" water supply management strategies. Additionally, the spectra of long-range shifts in global climatic patterns have injected a new element of uncertainty in water resources planning and management. Clearly, the past may no longer be a valid guide to the future.

In response to new challenges and uncertainties, it is imperative that water management institutions, at all levels, adopt a balanced, flexible, and feasible approach that gives due weight to all the conflicting demands on the water, including the heavy economic dependence of the rice farmers on historic uses of irrigation water, rapidly emerging public interest in recreation, and environmental values. The challenge is to recognize both the historic uses and the forces of change, transform emerging problems into new opportunities, and guide the institutions of water resources management toward a new era where clean water in Central Texas is recognized as a scarce commodity.

The purpose of this document, Water Management Plan for the Lower Colorado River Basin, is to define LCRA's water management programs and policies. This plan, it should be noted, is not the final word on LCRA's water management activities. LCRA's Water Management Plan will evolve over the years in response to changing conditions, new information, and emerging issues and opportunities.

LEGAL AUTHORITY

The legal authority underlying the development of the Water Management Plan is derived from four principal sources:

(1) The final order of adjudication of the water rights of the Lower Colorado River Authority;
(2) The enabling act of the Lower Colorado River Authority;
(3) General law of the State of Texas, particularly the Texas Water Code; and
(4) The water policies of the Lower Colorado River Authority Board of Directors.

In combination, the authorities establish and define LCRA's responsibility to develop and implement a Water Management Plan. In particular, the final adjudication of LCRA's water rights

includes provisions relating to the manner in which LCRA will manage the Highland Lakes and the Colorado River above and below the Highland Lakes and directs the LCRA to prepare and submit a proposed Water Management Plan to the Texas Water Commission. This document was developed by the LCRA pursuant to that directive.

LCRA's Water Resources Management

It is important to consider the historical context in which this Water Management Plan has evolved. In the early years of LCRA's existence the predominant priorities in water resources management were to moderate and control the floods and droughts in the Lower Colorado River Basin. This was accomplished, appropriately, through the construction of dams in the Hill Country west of Austin which created the Highland Lakes.

The results have been impressive. The ravages of flood waters have largely been controlled. These same dams have also provided a dependable source of water supply for municipal, industrial, agricultural, and mining uses. Additionally, the Highland Lakes provided the source of inexpensive, renewable electrical energy, and recreational opportunities for the citizens and communities of Central Texas. In sum, the work of the LCRA in its early years provided the foundation on which the present day population and economy of Central Texas depend.

Notwithstanding the successes of the past, in developing a Water Management Plan for the river, LCRA today faces an array of water management issues and opportunities that were scarcely envisioned a half century ago. Recreation has emerged as a major use, both on the lakes and the river. Maintaining the aquatic habitat in the river channel and in the bays and estuaries is a major use, as is water quality and the use of the river to sustain a growing population and economy. This intensified competition among the various users of the water resource is placing increasing stress on the ecologic and environmental resources supported by the Colorado River. LCRA, in partnership with the State of Texas, local governments, and private interests, must confront these challenges as we develop a meaningful Water Management Plan.

LCRA's Water Management Plan is grounded in these key principles:

(1) LCRA recognizes the supremacy of the State of Texas, acting through the Texas Water Commission, as the ultimate authority for water resources management and as the arbiter of disputes involving the allocation of water from the Colorado River and its tributaries. LCRA, within the intent and meaning of its legal authority, is the steward of the water rights granted to it by the State of Texas. Further, LCRA recognizes the responsibilities and prerogatives conferred upon local political subdivisions of the State and the rights of private citizens and corporations.

(2) Many water management issues and opportunities are regional in scope and effect. Solutions and strategies must be built upon regional consensus and action. LCRA considers its role as one of consensus-building among competing users of Colorado River water and among the public and private interests concerned with the management of the Colorado River.

(3) LCRA, in exercising its responsibilities as a steward of the water resources of the Colorado River and its tributaries, will strive to maximize the beneficial use of Colorado River water and achieve a sustainable balance among the competing demands on the system. In pursuing this objective, LCRA will implement management procedures and programs addressing:

   (A) The efficient management of available water supplies as an integrated system;
   (B) Water demand management measures including long-term conservation measures and short-term drought contingency measures;
   (C) Protection and, where possible, enhancement of water-related environmental values; and
   (D) Future water supply development and augmentation.

DEFINITIONS

To understand the Water Management Plan, it is important to know the definitions of the key legal and hydrologic terms used in this plan . The major terms are defined below and should be considered specific to LCRA.

adjudication - a court proceeding to determine all rights to the use of water on a particular stream system.

beneficial use of water - Use of the amount of water which is economically necessary for a purpose authorized by law, when reasonable intelligence and reasonable diligence are used in applying the water to that purpose. Such uses include domestic use, municipal uses, industrial use, agricultural use, hydroelectric power, navigation, fish and wildlife, etc. The benefit may vary from one location to another and by custom. Beneficial uses are defined by statute in the Texas Water Code.

combined firm yield - a specific amount or quantity of water usually stated in acre-feet or millions of gallons per year which represents the maximum average annual demand that can be met through storage in a reservoir during a simulation of a repetition of the system's Drought of Record.

curtail (water)-to reduce the supply being provided through a diversion by reducing the amount served under the contract for a specific period of time. Curtailment may occur during drought or other emergency conditions.

critical drought period - the period of time during which the reservoir system was last full and refilled, and the storage content was at its minimum value.

cutoff (water) - to discontinue, or to terminate completely, the supply of water provided under contracts for diversion for a certain period of time. Cutoff may occur during drought or other emergency conditions.

diversion demand - the water pumped from a water body for beneficial use.

domestic water use - water used for household purposes such as bathing, food preparation, waste removal, and landscape irrigation.

drawdown - the lowering of the water level in a water body by diversion, pumping, or release.

drought - a prolonged period of dryness or lack of rainfall that has a significant effect on water or water-related uses.

drought of record - the drought which occurred during the critical drought period.

firm water - a supply of stored water that is drawn from the combined firm yield of the reservoir system. Such supplies are diverted under a contract or resolution issued by the LCRA Board.

firm yield - the maximum annual supply of water which can be supplied from a water source without shortages during a repetition of the critical drought period.

gaging station - particular site on a stream, canal, or lake where systematic observations of hydrological data are obtained.

interruptible water- stored water supplied pursuant to contract or resolution, where the contract, resolution or special conditions defining the commitment specifically provides that such commitment is "subject to interruption or curtailment."

irrigation - The use of water for the irrigation of crops, trees, and pasture land, including, but not limited to, golf courses and parks, which do not receive water through a municipal distribution system.

minimum streamflow - the specific amount of water reserved to flow in a stream or river to support aquatics life, minimize pollution, or for recreational use.

run-of-river flows - the natural flow in the river that is available under law at a given point on the river at a given instant in time to honor a right with a given priority date. This

flow is determined by hydrologic studies that assume that all reservoirs and diversions under upstream junior rights do not exist. Rights to use run-of-river flows for beneficial uses, rights to store inflows in reservoirs, and pass-through of inflows and releases from reservoirs, are regulated by the Texas Water Commission.

storage capacity - the quantity of water that can be contained in a reservoir.

streamflow - rate of flow of water that occurs in a natural channel.

water conservation - those practices, techniques, and technologies that will: (1) reduce the consumption, loss or waste of water, (2) improve the efficiency in the use of water, or (3) increase the recycling and reuse of water, so that a water supply is made available for future or alternative uses.

water permit - a legal document which grants authority to take unused water and put it to beneficial use.

water right - a legally protected right, granted by law, to take possession of water occurring in a water supply and to divert the water and put it to beneficial use.

SUMMARY OF WATER MANAGEMENT PLAN

A. KEY ELEMENTS OF THE WATER MANAGEMENT PLAN

The key elements of the WMP include the following:

- The Highland Lakes and the Colorado River will be managed together as a single system for water supply purposes.
- LCRA will manage the system to maximize the beneficial use of water derived from inflows below the Highland Lakes.
- LCRA will manage the system to stretch and conserve the waters stored in the Highland Lakes.
- All demands for water from the Colorado River downstream of the Highland Lakes should be satisfied to the extent possible by run-of-river flows of the Colorado River.
- Inflows should be passed through the Highland Lakes to honor downstream senior water rights only when those rights cannot be satisfied by the flow in the river below the Highland Lakes.
- The firm, uninterruptible commitments of water from Lakes Travis and Buchanan should not exceed the Combined Firm Yield.
- The water from Lakes Travis and Buchanan will be available on an interruptible basis as long as LCRA's ability to meet the demand for uninterruptible water is not impaired.
- Water shall not be released through any dam solely for hydroelectric generation, except during emergency shortages of electricity, and during other times that such releases will be needed for another beneficial purpose.
- Competing demands on the system include water quality matters, flood control, water supply, recreation and tourism, hydroelectric power, instream flows and bays and estuaries.
- The Combined Firm Yield of Lakes Buchanan and Travis is determined to be 535,812 acre-feet.
- To supply existing firm water demands during a repetition of the critical drought would require an average of 421,919 acre-feet per year to be released or diverted from storage in Lakes Buchanan and Travis.

- 50,000 acre-feet of the remaining Combined Firm Yield of Lakes Buchanan and Travis has been placed in reserve for the future needs of many areas within the LCRA 10-county district that are now using ground water supplies which are becoming depleted or are of poor water quality.

- The four downstream irrigation operations (Gulf Coast, Lakeside, Garwood and Pierce Ranch) will have first priority for all the interruptible stored water in the annual allocation process to the extent of their Conservation Base acreage or Priority Allocation acreage.

- In recognition of the importance of recreation and tourism demands, additional sales of interruptible stored water, other than for the four irrigation operations, will be limited based on the projected volume of water in Lakes Buchanan and Travis, as of January 1 of each year. No sales will occur if either lake is less that 94% of its maximum conservation capacity. If both lakes are projected to be at their maximum conservation capacity on January 1, then such interruptible water sales will be limited to a total of 80,000 acre-feet for that year. For projected lake volumes between 94% and 100% of conservation capacity, such interruptible water sales will be limited proportionately, based on the storage reservoirs with the lowest projected percentage of capacity on January 1.

- Instream flow needs will be met by the release of stored water from the Highland Lakes to maintain the daily river flows at no less than the critical instream flow needs in all years and maintain daily river flows at the target instream flow needs in those years when the four major irrigation districts are not curtailed, to the extent of inflows each day to the Highland Lakes as measured at the upstream streamgages. An average of 28,700 acre-feet per year during any ten consecutive years from the Combined Firm Yield of the Highland Lakes is committed for instream flow and bay and estuary needs.

B. KEY ELEMENTS OF THE DROUGHT MANAGEMENT PLAN

The key elements of the DMP include the following:

- A 10 year time period from 1990 - 2000 is the time frame for the Plan.
- The Plan establishes criteria for the curtailment of stored water that is committed through contract or by LCRA Board resolution.
- Establishes a criteria for interruptible water supply curtailments which protects firm demands, establishes a Reserve Storage Pool, and provides for gradual curtailment in order to protect the full demand of first crop rice in all years of the critical drought.
  - Open Supply occurs when January 1 storage levels are greater than 1.4 million acre-feet.
  - Gradual Curtailment occurs in stages between 1.4 million acre-feet and 325,000 acre-feet.
  - Cutoff of interruptible supply for the coming year occurs when storage is less than 325,000 acre-feet on January 1.
  - Review and cancel the curtailment of interruptible stored water for the irrigation districts at any time during the year prior to July 31, if the combined storage of Lakes Buchanan and Travis is projected to be equal to or greater than 1.4 million acre-feet anytime in July.
  - Reserve Storage Pool cutoff of all interruptible supplies when storage levels are less than or equal to 200,000 acre-feet.
  - Allow each irrigation operation the option of a fixed maximum amount of interruptible stored water or all the water necessary to cultivate a maximum acreage agreed upon by the operation and LCRA.
  - LCRA will request voluntary curtailment of firm water demands when there is a curtailment of interruptible water supplies and/or the total storage in Lakes Buchanan and Travis is less than 1.6 million acre feet.
  - LCRA will request that all LCRA firm water customers reduce water use by their end users when the combined storage for Lakes Travis and Buchanan

is at or below 900,000 acre-feet.

- During a drought more severe than the Drought of Record, LCRA will curtail and distribute the available supply of firm water among all of its firm water supply customers on a pro rata basis according to their demand for stored water. All uses of interruptible stored water will be totally cutoff prior to and during any mandatory curtailment of firm stored water supplies.

- Petition TWC to adopt definitions of essential and non-essential water uses.

- Require legally enforceable local drought management plans for LCRA firm water customers and the four major irrigation operations.

SECTION 1

CHAPTER 1

INTRODUCTION TO THE WATER MANAGEMENT PLAN

On April 20, 1988 Judge J. F. Clawson of the 264th Judicial District of Bell County, Texas, signed the Final Judgement and Decree relating to LCRA's and City of Austin's respective water rights. (see Appendix 1A, Volume II) This settlement was the product of a long series of negotiations among LCRA, the City of Austin, and the Texas Water Commission (TWC).

Under the Final Judgement and Decree, LCRA was granted the right to use 1,500,000 acre-feet annually from the Highland Lakes. As part of this settlement LCRA was required to determine the Combined Firm Yield of both Buchanan and Travis Reservoirs. An interim level of Combined Firm Yield of 500,000 acre-feet was established by the TWC with an understanding the LCRA would establish the basis for the Combined Firm Yield calculation and submit it to the TWC. The amount of water above the firm yield is considered interruptible water and may be sold only on a interruptible basis subject to annual availability and certain rules and conditions required by the TWC.

A. Goals of the Water Management Plan

The Final Judgement and Decree required LCRA to submit a reservoir operations plan describing how LCRA would determine the amount of firm and interruptible waters and how LCRA would manage the waters in the Highland Lakes and the Colorado River. The Water Management Plan for the Lower Colorado River Basin was developed using the following goals and guidelines as provided in the Final Judgement and Decree:

1. The Highland Lakes and the Colorado River will be managed together as a single system for water supply purposes.

2. LCRA will manage the system to maximize the beneficial use of water derived from inflows below the Highland Lakes.

3. LCRA will manage the system to stretch and conserve the waters stored in the Highland Lakes.

To achieve the goals stated above, LCRA will manage the system according to the following guidelines:

(a) All demands for water from the Colorado River downstream of the Highland Lakes should be satisfied to the extent possible by run-of-river

flows of the Colorado River;

(b) Inflows should be passed through the Highland Lakes to honor downstream senior water rights only when those rights cannot be satisfied by the flow in the river below the Highland Lakes;

(c) The firm, uninterruptible commitments of water from Lakes Travis and Buchanan should not exceed the Combined Firm Yield;

(d) The water from Lakes Travis and Buchanan will be available on an interruptible basis as long as LCRA's ability to meet the demand for uninterruptible water is not impaired;

(e) Water shall not be released through any dam solely for hydroelectric generation, except during emergency shortages of electricity, and during other times that such releases will be needed for another beneficial purpose.

B. LCRA Act

Through the passage of the LCRA Act by the Texas Legislature in 1934, LCRA was established as a "conservation and reclamation district" consisting of ten counties which comprise the watershed of the lower Colorado River. Those ten counties are Blanco, Burnet, Fayette, Colorado, Llano, Travis, Bastrop, Wharton, San Saba, and Matagorda. (see Figure 1) LCRA was delegated the responsibility of harnessing the Colorado River and its tributaries and making them productive for the people of the 10-county district.

The Act establishes LCRA's mission in four areas--water, electric energy, conservation and lands. In water, LCRA is empowered to control floods and control, store, sell, preserve and distribute the waters of the Colorado River and its tributaries. The waters are to be used for beneficial purposes including irrigation, generation of electric energy, reclamation of arid lands and the creation of lakes for water storage. LCRA is required to prevent flood damage to people and property by the Colorado River and to control the uses of the surface of the lakes it created.

Consistent with the control of the waters, LCRA is empowered to develop, distribute, and sell the energy created through hydroelectric generation both inside and outside the 10-county district. Later legislation allowed LCRA to expand its electric generation capabilities beyond hydropower through developing fossil fuel generation facilities.

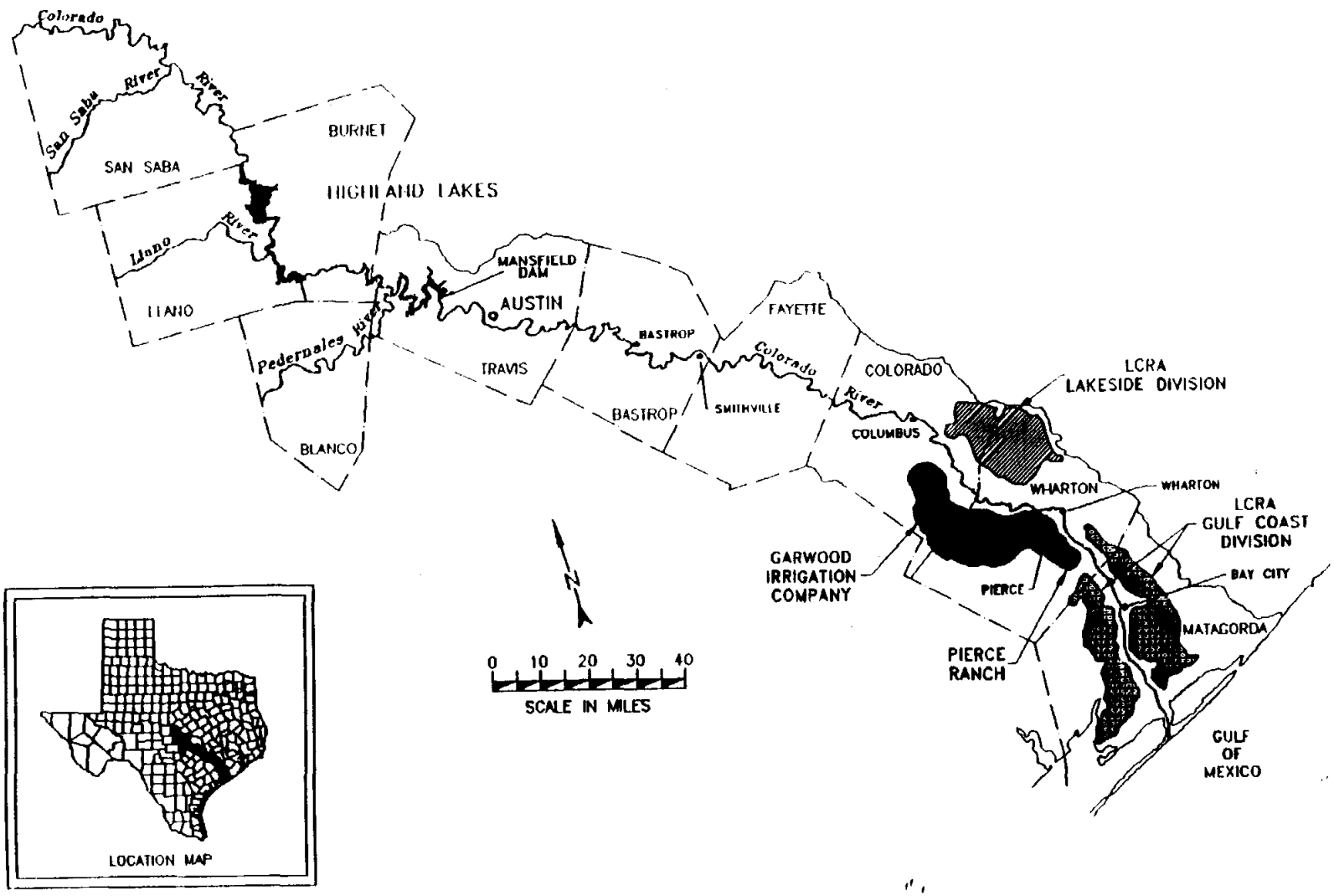


FIGURE 1. LOWER COLORADO RIVER AUTHORITY DISTRICT

As a conservation and reclamation district, LCRA is to conserve and develop the lands, forests and water of the district and to study and correct both artificial and natural sources of pollution which may affect the ground and surface waters within the district. LCRA is also empowered to provide water and wastewater treatment services within the district.

During the construction of the dams and development of the Highland Lakes system LCRA acquired large tracts of land which surround the reservoir system. The Act authorizes LCRA to develop, manage, and promote the use of these lands for parks, recreational facilities and natural science laboratories and to promote the preservation of fish and wildlife. LCRA must also provide public access to, and use of, its lakes and lands for recreation.

Each of the many purposes, functions, and uses of the elements of the river--the lakes, the lands, the ground and surface waters, the bays and estuaries--must be considered as parts of an integrated system.

The Water Management Plan will describe the issues and conflicts which LCRA must recognize and, where possible, resolve.

C. LCRA's Comprehensive Water Policy Review

As a foundation for the Water Management Plan, LCRA began a comprehensive review of the policies and programs that guide and shape the way LCRA manages the river system. This review was conducted as a series of meetings held as joint public meetings of the LCRA Board's Planning and Public Policy and Natural Resources Committees. The meetings were designed to use staff expertise and information from outside experts to analyze the environmental, social, economic and legal factors that shape the issues which LCRA faces in managing the Colorado River system.

An important part of these public meetings was the involvement of the State agencies, environmental groups, business, industry and agricultural interests, wholesale electric customers and other constituencies whose interests are affected by LCRA policies.

The process was designed to assure that participation was effective in informing LCRA of public views and also so that these constituencies would be better informed about the issues involved in the policy decisions. An issues inventory was developed and briefing papers were prepared for each of the meetings. Summaries of the meetings elements were developed and distributed to the LCRA Board and members of the public.

As a result of the Board and the public review, LCRA has adopted a set of water and flood control policies to address many of the issues in water quality and water supply that face LCRA today and will continue to face the agency well into the future. (see Appendix A, Volume I) . They form the foundation of this Water Management Plan.

D. Scope of Water Management Plan

LCRA approached the development of the Water Management Plan as much more than a set of complex engineering tools to serve as guidelines for operating the structures on the Colorado River system. The development of the Water Management Plan stimulated a comprehensive review of how LCRA has developed and operated the Highland Lakes and the lower Colorado River system for almost 50 years to meet the needs of the area it serves.

Volume I of the Water Management Plan is organized as follows:

(1) Section 1 of the Water Management Plan describes the issues and conflicts in the demands on the Colorado River system and lays out the policies and management actions LCRA will use to accommodate the variety of demands on the system.

(2) Section 2 of the Water Management Plan describes the issues and conflicts in the demands on the Colorado River system during drought periods and sets forth the policies and management actions LCRA will use to address the competing demands for water in times of shortage.

(3) Section 3 of the Water Management Plan describes the engineering and hydrological models and data sources and the process for the determination of the Combined Firm Yield.

Volume II of the Water Management Plan is a compilation of several technical appendices used to develop the Water Management Plan.

E. Annual Review

The Water Management Plan will be reviewed on an annual basis by LCRA. A compliance report will be provided to the Texas Water Commission each year on or before March 1.

CHAPTER 2

MANAGING THE SYSTEM AMONG COMPETING DEMANDS

Demands on the Highland Lakes and the lower Colorado River system are many, varied, and often are in competition with one another. These demands are dynamic and will evolve as the population grows.

LCRA's reservoir system is designed to store waters from winter and spring rains and make that water available for use during the summer months for hydroelectric generation, water supply and irrigation needs downstream of the reservoirs. During the summer months these releases cause a decline in the reservoir levels thus providing storage for the next year winter and spring rains. This type of operating pattern enables LCRA to serve a variety of functions with its reservoir system. It can also create conflicts among these functions. If the system's ability to meet all of these demands is to be maximized, compromises must be made among the competing demands.

LCRA must continually re-evaluate its Water Management Plan to assure that the competing demands are being met according to their priority within the framework of legal and financial constraints on the system. This chapter states the measures LCRA is taking to accommodate the demands on the system and identifies those areas where continued analysis is needed.

A. Water Quality Issues and Demands

Everyone favors "clean water," but achieving an understanding of the value of water quality so that the necessary investments and efforts are made is a major challenge to LCRA's management responsibility. This is an issue in which every user of the river has a stake. LCRA will need every concerned citizen's help in taking the actions to make cleaner water a reality. The problem areas are as follows:

1. Point Source Pollution: In managing the river system LCRA must consider the impact of point sources of pollution entering the tributaries and the river, even though we recognize that the TWC is the agency that establishes regulatory standards to control point sources of pollution. But even if a point source of pollution is lawful, the assimilation of sewage treatment plant wastes is a function and use of the lakes and the river for which no one pays in dollars and everyone pays in quality. During the low flow periods of the year when LCRA is not releasing water for the irrigation operations downstream the body of the Colorado River below Austin may be as much as 70-80 percent effluent on a given day. This condition is exacerbated during periods of low rainfall or drought that affect not only the quality of the river but also its aesthetic value. Downstream residents complain about the smell

of the river and its loss of use for recreation, fishing, and as a water supply for grazing livestock.

During the policy and issue review process for the Water Management Plan, LCRA received numerous comments and letters regarding LCRA's role in monitoring and reducing the volume and concentration of point source pollution. The Protect the Lakes organizations for Lakes Buchanan, Inks, LBJ, Marble Falls, and Travis have been particularly concerned about this issue. LCRA has also received requests from communities upstream and downstream for assistance in planning for new and expanded wastewater treatment plants which would have higher treatment standards.

Point source discharges into the Highland Lakes present a much more serious problem due to the reduced assimilative capacity of the lakes. LCRA is working with the communities which currently discharge into the lakes to develop land application and irrigation projects to eliminate such discharges.

2. Nonpoint Source Pollution: Runoff from urban and agricultural areas, soil erosion, and leakages from faulty septic tank and waste dumps all represent nonpoint sources (NPS) of pollution. The EPA estimates that approximately 73 percent of the pollution in the nation's rivers is caused by nonpoint sources.

Due to the high quality of water in the Highland Lakes chain there is great concern for preventing NPS pollution and maintaining this high quality water for the future. The lakes serve as a source of drinking water for over a million citizens of the Austin-Travis County metropolitan area and all of their uses are enhanced by maintaining a high degree of purity.

While LCRA is encouraging and supporting economic development, tourism, and recreation activities in the Highland Lakes and the Colorado River downstream, there is the awareness that increased usage and development will result in more nonpoint source pollution unless effective controls are put in place.

The causes and sources of NPS pollution are dispersed and difficult to manage without broad public awareness and support. LCRA's Water Quality Leadership Policy requires effective implementation to control NPS pollution through research, monitoring, education and the use of LCRA's ordinance making powers to prevent and control sources of nonpoint pollution within the 10-county district.

LCRA has received comments and letters of support regarding its efforts in nonpoint source pollution abatement from the Protect the Lakes Groups, Clear Clean Colorado Association and the Lone Star Chapter of the Sierra Club and Travis County.

3. Soil Erosion and Sedimentation: Soil Erosion and the resulting sedimentation in the Highland Lakes, the Colorado River and its streams and tributaries is a cross cutting issue in water quality and water supply. The sedimentation in the lakes causes problems for boating and fishing. The build up of silt also reduces the storage capacity of the lakes for water supply and for holding flood waters. Siltation downstream of the Highland Lakes in the river channel reduces the capacity of the river for holding flood releases. Both in the lakes and in the river the silt in the water causes problems of turbidity or cloudiness thus reducing the aesthetics of the water and may cause higher water treatment costs. This factor often shows up in LCRA's Water Quality Index and causes lower ratings for many areas. Beyond increased turbidity, soil erosion can contribute to water quality problems by carrying pesticides, herbicides and other pollutants into the water along with the soil particles.

4. Dissolved Oxygen Problems: The dissolved oxygen content of LCRA's releases of stored water through the hydroelectric turbines in the dams has caused water quality problems in the summer months. The deep lakes stratify during the warmer months of the year which prevents replenishment of oxygen at the levels from which the turbines draw water. The passage of water with low levels of dissolved oxygen from one reservoir into another or into the river system can cause fish kills and reduce the assimilative capacity of the river system. LCRA has concluded its research and has determined that there is no benefit to changing current management practices.

5. Upstream Pollutants: Pollutants from the watershed upstream of the Highland Lakes and outside of LCRA's district can also affect the resources for which LCRA is responsible. An example of this is the inflows of high concentrations of salts in the water from seepage from natural springs and highly concentrated bodies of salty water in the upper watershed combined with high rainfall in the "salt water" basin. Abandoned unplugged oil wells may also be a cause of this problem. Remedial action has been taken by the Colorado River Municipal Water District, but the problem persists.

B. Flood Control Responsibilities

Flood control is one of the primary reasons for LCRA's existence. The series of dams and reservoirs from Buchanan, through Mansfield, contribute to the control of the lower Colorado River and the protection of lands and communities within the basin . While all the dams and reservoirs aid in controlling and storing the waters of the Colorado, Mansfield Dam is the only designated flood control structure. Mansfield Dam flood storage space is between the elevation of 681 feet mean sea level (msl) and the spillway crest elevation of 714 feet msl providing 800,000 acre-feet of dedicated flood control storage. During flood control operations, Mansfield Dam is operated in accordance with regulations specifically

developed for that facility by the U.S. Corps of Engineers, the U.S. Bureau of Reclamation, and LCRA and published in the Code of Federal Regulations (see Appendix B, Volume 1).

Over the years, as the floods no longer ravaged the river basin washing out river banks and clearing away vegetation, the capacity of the channel to contain water releases, especially during flood conditions has been reduced. LCRA must limit the rates of releases during flood events if it is to minimize downstream damage. This reduction in outflow causes increases in water levels upstream of Mansfield Dam which results in more frequent damages to properties around Lake Travis. This balancing problem is compounded by encroachments on the floodplains both upstream and downstream. Lake and river residents have built boat houses and structures into the floodplain and suffer property losses during flood occurrences. LCRA's management requires renewed efforts to remove encroachments and put people on clear notice that they are at risk.

The extent of potential damages to areas downstream of Mansfield Dam, including the City of Austin, from various flood levels resulting from releases from Mansfield Dam and other inflow is being evaluated by the U. S. Army Corps of Engineers. LCRA is cooperating in this study and its results will be used to inform the public as well as provide direction for any necessary modifications to the flood control operations.

LCRA is cooperating with the U.S. Army Corps of Engineers in a reconnaissance study of possible additional flood control and water supply in a new reservoir on the Llano River or the Pedernales River upstream of Lake Travis, or on the San Saba or Colorado River upstream of Lake Buchanan.

One alternative is to create additional flood control space in Lake Travis by reducing the conservation capacity to some level below 681 feet msl. However, this would have an adverse impact on LCRA's ability to meet its commitment for water supply during a critical drought situation. It would also reduce lake levels and thus have a negative impact on recreational interests around Lake Travis.

The schedule by which floodwaters must be released from the flood control storage space between elevations 681 feet msl and 714 feet msl in Lake Travis is governed by the U. S. Army Corps of Engineers' Water Control Manual for Mansfield Dam. This release schedule was designed to minimize damages both downstream and upstream of the dam without endangering the safety of the dam. A brief description of this schedule is as follows:

RESERVOIR ELEVATIONS feet msl	RELEASE cfs	
681 to 683	3,000	
683 to 685	5,000	
685 to 691	5,000	during Jan/Feb/ Mar/Apr/July/Aug/ Nov/Dec
	30,000	during May/June/ Sept/Oct
691 to 710	30,000	
710 to 714	50,000	
714 to 722	90,000	

While public interests were carefully considered in developing the schedule, a continuous public information program is necessary to assure that everyone who may be at risk from flooding, either upstream or downstream, is made aware of the risks. LCRA will initiate a program of notices and public forums to assure that the affected public is informed.

LCRA believes that the existing policy of delicately balancing the adverse impacts of rising flood waters in the reservoir against the damages resulting from downstream flood releases is the best option.

C. Water Supply

Under the constraints specified in the Final Judgement and Decree, LCRA has determined the Combined Firm Yield of Lakes Travis and Buchanan to be 535,812 acre-feet per year. Of that amount, 90,546 acre-feet are committed to Owen Ivie Reservoir. The remaining 445,266 acre-feet are available to supply LCRA's current and future contractual commitments and agreements for firm water supply.

Currently LCRA estimates that 85 percent of the Combined Firm Yield available for sale (445,266 acre-feet per year) is under contract or held in reserve to back up existing or new contracts for firm water such as those held by the City of Austin and Houston Lighting and Power Company.

All of the municipalities downstream of Austin currently draw their water supplies from ground water sources. Ground water also supplies 40 percent of the agricultural irrigation in the LCRA service area. Two counties--Matagorda and Colorado--have areas on the Texas Water Development Board's list of critically depleting ground water resources. Upstream of Austin the municipalities use a mixture of ground and surface waters.

As economic and industrial development increase the demand for water, and as other uses such as the fresh water needs in the bays and estuaries are determined, more demands will be made upon surface water resources. One of the greatest demands will be due

to ground water sources degrading, depleting, and becoming more expensive to use due to higher pumping costs. LCRA is thus faced with the conflict between near-term demands and holding some remaining amount of the firm waters in reserve for future users. This conflict may be partially resolved by the LCRA Board reserving 50,000 acre-feet of firm water for uses authorized under LCRA's certificates of adjudication within the 10-county district until water supply and demand assessments of the individual counties within the district are completed or three years, whichever is sooner.

1. Municipal Water Use: Municipal use includes water used by private residences, commercial establishments, public offices, industries and institutions to the extent that such uses are included in the definition of municipal use as provided by the rules of the Texas Water Commission. Eighty percent of the municipal use in LCRA's service area is in Travis County. The Austin area experienced rapid population growth during the early and mid 1980's. This growth has slowed over the last 2-3 years, but, the Austin area is expected to show a steady growth over the long-term with the normal cycles of advances and pauses associated with economic growth.

The City of Austin's total diversion from Lake Austin and Town Lake for 1988 was 118,750 acre-feet. Approximately 75 percent of this was served through their own senior water rights. While at present the City of Austin's water is supplied from the Colorado River under its own rights, LCRA provides stored water from the Highland Lakes to back-up Austin's water rights. Also, some portion of the growth in the Austin area will be in municipal utility districts and other communities in Travis County and may use stored water from the lakes.

Over the long-term, Bastrop and Burnet Counties are forecasted to be the other two counties with the greatest gains in municipal use. This is due to their proximity to Travis County and the associated spillover of population growth and related services.

LCRA currently supplies water to 43 Municipal Utility Districts (MUDs), communities, and cities within LCRA's 10-county district, exclusive of Austin. The current annual demand of all these contracts is approximately 14,200 acre-feet per year.

At present, no communities below Austin are supplied water from the firm yield for potable water use.

LCRA currently requires an approved conservation plan of its new water customers through its water sale contracts.

2. Industrial Demands: Industrial demands include both water for manufacturing use and cooling water for electric power production other than hydroelectric generation.

a. Manufacturing Use: LCRA supplies water for various industrial uses within its 10-county statutory district. The water supply for these industrial uses is considered a firm demand on the system. The largest current and projected manufacturing water users are located in Travis and Matagorda counties and account for slightly more than 80 percent of total manufacturing water use. Most of the manufacturing in Travis County is served by treated water from the City of Austin which is considered to be municipal use by the rules of the Texas Water Commission. Growth in demand in this sector is expected to increase, particularly in microelectronic manufacturing--a high water demand industry. Downstream, Matagorda County is experiencing growth in the petrochemical industry. Overall manufacturing is projected to increase from about 2 to 6 percent of the total base case water use during the period from 1990 to 2030.

LCRA has established programs for industrial water conservation and encourages existing and new industrial users to consider efficiency and re-use strategies for industrial processes.

b. Steam Electric Use: Much of the demand for steam electric use is from electric generating plants in Bastrop, Fayette, Llano, Matagorda, and Travis Counties. LCRA's own system of power plants makes up the largest demand for this sector at an average of about 50,000 acre-feet per year. Uses include total evaporative use, plant use and the addition of a reservoir at the Fayette Power Project (FPP). The second largest user, the South Texas Project demand is served by run-of-river contract rights jointly owned by LCRA and Houston Lighting and Power. These run-of-river rights are backed-up by a firm contract for LCRA stored waters. The City of Austin serves its generating plants under its own rights, also firmed up by LCRA stored water pursuant to the LCRA-City of Austin December 10, 1987 Comprehensive Water Settlement Agreement.

Most of the current industrial users are located downstream of the Highland Lakes thus allowing a portion of their demand to be supplied from the run-of-river water originating below Lake Travis. LCRA's system under the Water Management Plan allows for full utilization of the water in the river before calling for releases from storage in the reservoirs.

The demand for use in this sector is projected to increase from 4 to over 7 percent of the total base case water use by the year 2020. LCRA is committed to the most efficient and beneficial uses of water for cooling purposes at it power plants and will encourage implementation of similar programs in other plants served by water from the LCRA system.

3. Demands for Interruptible Water: Under the Final Judgement and Decree LCRA is permitted to develop contractual commitments with water users whose demands do not have to be met 100 percent of the time. Such demands for interruptible water would be met to the

extent water is available each year after firm demands are satisfied. At the present time the contracts for the firm yield of the system are not using their full commitment. By applying an "overdraft" concept the portion of the firm yield that is not yet committed and the water that is committed but not yet being used increases the interruptible water that is available each year. The water that is captured and stored from flood flows also adds to the amount of interruptible water that is available. Over time, as the current firm contracts draw fully on their commitments and the remainder of the firm yield is contracted for, there will be less interruptible water available on an annual basis.

a. Irrigation Demands: Currently the vast majority of LCRA's commitments for interruptible water are for irrigation downstream. Most of the irrigation is for rice farming, although other crops such as pecans and turf grass as well as golf courses also use irrigation. As the rice farmers have an historic use of the waters that are now considered interruptible, one way of mitigating the potential future conflicts is to assure the rice farmers a priority on a portion of the interruptible waters that will be allocated on an annual basis.

In good years with adequate rainfall there is an abundance of interruptible water compared to the current demand, which is largely for growing rice. The real conflict would occur during a drought in the years ahead as other demands compete.

Irrigation water represents the largest demand of any user on the lower Colorado River system with rice irrigation in the lower basin constituting about 70 percent of the total annual use. The demand for water to irrigate rice varies greatly from year to year based upon the number of acres irrigated and weather conditions throughout the irrigation season. The number of acres irrigated is highly dependent upon the federal allocation program for rice as well as the world market for rice. Currently, about 95 percent of the rice farmers in the LCRA service area participate in government support programs.

Most of the rice irrigated by water from the Colorado River is concentrated in four irrigation operations whose annual demand on the system is about 500,000 acre-feet of water. These operations include Lakeside and Gulf Coast, which are owned and operated by LCRA, and Garwood and Pierce Ranch Irrigation Companies. These irrigation operations represent about 60 percent of total irrigated agriculture for water use in the three counties. The remaining 40 percent comes from pumped ground water.

The four irrigation operations hold their own senior water rights for direct diversion from the Colorado River. These water rights allow the operations to pump water from the river as it is available without calling upon LCRA to release water from storage. However, often in the height of the irrigation season, rainfall

inflows are insufficient to supply these needs. During these periods LCRA is called upon to release water from storage to make up the deficit. The demand on the Highland Lakes System for the release of stored water for the rice irrigation season varies greatly from year to year. During an average year, about 30 percent of the total water needed for irrigation comes from water released from storage in the Highland Lakes.

Because a very large percentage of the overall demand on the system is related to irrigated agriculture that demand must be met in the most efficient way possible. LCRA's ability to constantly monitor the amount of water in the river available to meet these demands through the Hydromet System allows full utilization of the flows originating below Lake Travis prior to making any releases from storage. The operational goal for the system is to reduce the amount of flow passing the last diversion point to a level compatible with the instream flow needs and requirements for the bays and estuaries.

Under the Water Management Plan the four downstream irrigation operations (Gulf Coast, Lakeside, Garwood, and Pierce Ranch) will have first priority for the interruptible stored water in the annual allocation process. This priority will be set by establishing a Conservation Base for LCRA's two irrigation districts.The Conservation Base acreage will be the historical 10-year average acres irrigated (see Table 2 "Allocation Table for Interruptible Water") at a total of 5.25 acre-feet of water per acre irrigated. LCRA currently has a contract dated December 1987 to supply interruptible water to Garwood to the extent necessary to firm up Garwood's 168,000 acre-foot-per-year independent run-of-river water right. This contractual commitment to Garwood is not based on a "Conservation Base acreage" calculation, but the 5.25 acre-foot-per-acre duty will apply to the acreage irrigated. LCRA has also entered into an agreement with Pierce Ranch to firm up 55,000 acre-feet of Pierce Ranch's independent run-of-river water right at an annual rate of 20,000 acre-feet based on a five year average with a 30,000 acre-feet one year maximum.

b. Agriculture Conservation: As the largest user of water from the lower Colorado River system, irrigated agriculture also provides the best opportunity for reduction of the overall demand through conservation programs. LCRA currently has underway a water conservation program with its two irrigation companies, Lakeside and Gulf Coast. These conservation activities are directed at improving the efficiency of the water delivery systems and improving water use efficiency on the individual farms served by the companies.

Historical data shows that as much as seven acre-feet of water had to be pumped from the river to irrigate one acre of rice. The Texas Water Commission, in its Final Adjudication order of all of the irrigation rights in the lower Colorado River stated that the

use of more than 5.25 acre-feet of water for the irrigation of an acre of rice constituted a waste of water. This goal can be achieved and, in fact, recent results indicate that the overall irrigation demand can be reduced by as much as 25 to 30 percent, thus bringing water use per acre to well within the Commission's required 5.25 acre-feet. A reduction of this magnitude could have a major impact on the reservoir system's ability to meet other competing demands.

Currently, LCRA provides water to individual customers of the irrigation districts on a per acre of rice irrigated basis. A major goal for LCRA's irrigation operations is to move toward selling water on a per acre-foot basis if this can be done effectively and efficiently. To accomplish this goal will require individual meters for each major diversion point in the irrigation system. The initial capital cost for such a system is very high and would have to be recovered in the rates for irrigation water. Also, the meters available in the market have data retrieval problems and are subject to tampering in the field. LCRA is working with Texas A & M University Agricultural Extension Service, The U.S. Bureau of Reclamation, the other irrigation districts, and equipment manufacturers to analyze the technical and economic feasibility of metering water use in the district.

4. Recreation and Tourism Demands: The use of water for recreation and tourism is closely linked to the population of an area, nearness of the recreation, and the value of the resource to recreational users. Recreational users are interested in qualities including: full lakes, flowing rivers, clean water, and aesthetics.

In many areas recreational uses of the waterways are increasing steadily. The entire Highland Lakes area, from Lake Austin to Lake Buchanan, receives a great deal of recreational use from boaters, park visitors, swimmers and windsurfers from all over Texas and the Southwestern United States.

Recreation and tourism demands in the Highland Lakes area is an important contributor to the local area economies. Recreation is not just fun, it is a critical economic factor in the life of citizens of the Hill Country.

a. Managing Lake Levels for Recreation and Tourism: The recreation industry associated with the Highland Lakes has experienced a phenomenal growth over the past decade and is currently the major economic stability factor in many of the counties surrounding the Highland Lakes. The viability of this recreational industry is strongly tied to the level of water in the reservoirs. In the pass through lakes--Inks, LBJ, Marble Falls, and Austin--little impact is felt from variations in the levels of Lake Travis and Buchanan.

The original purposes of flood control and water supply for the rice farmers and others for which Lake Travis and Buchanan were constructed dictate that the lake levels will follow an annual cycle--that of filling the conservation storage space in the winter and spring months of the year to be drawn down by water uses during the summer months. The recreational users of these reservoirs are accustomed to a certain amount of variation in the lake levels. However, two or more consecutive years of below normal streamflow into the reservoirs results in some extreme variations which have an adverse impact on recreational interests.

Because these multiple purpose reservoirs were not constructed to maximize the recreational use of the reservoirs, the demands for stability in the reservoir levels by these incidental beneficiaries (the recreation interests) present conflicts which are extremely difficult to accommodate. If limits are to be placed on how far down the reservoirs' water levels are allowed to decline, a corresponding limitation on the amount of water that is available to supply the other demands on the reservoir system must also be agreed to.

It is neither practical, nor in the public interest, to limit drawdown from demands for essential uses for water, such as municipal, industrial, and historic irrigation demands or existing irrigation commitments. To the extent that the annual analysis of the amount of water in storage reveals that there are interruptible water supplies available after meeting the demands of the irrigation operations, interruptible water may be held in the reservoirs to maintain lake levels.

LCRA recognizes the importance of the recreational economy of the region by limiting additional sales of interruptible stored water, other than for the four irrigation districts' Conservation Base acreage or Priority Allocation acreage, based on the projected volume of water in Lakes Buchanan and Travis, as of January 1 of each year. No such sales would occur if either lake is less than 94% of its maximum conservation capacity. If both lakes are projected to be at their maximum conservation capacity on January 1, then such interruptible water sales would be limited to a total of 80,000 acre-feet for that year. For projected lake volumes between 94% and 100% of conservation capacity, such interruptible water sales would be limited proportionately, based on the storage reservoir with the lowest projected percentage of capacity on January 1.

The consideration for the use of interruptible water and the projections for water availability would occur during the annual allocation process.

b. Downstream Recreation: The river downstream of the Highland Lakes is a potential source of recreation of vast importance to the people who live along its shores. Unfortunately, pollution has

degraded the river to the point that it is often considered a dangerous place to swim or fish. Furthermore, water levels are very low, especially in the winter months when the river below Austin is primarily wastewater which further reduces access for canoeing and boating. LCRA's commitment to maintain instream flows may partially ameliorate this condition. However, as with many rivers, the Colorado has many broad low areas where the flow is not sufficient for boating.

The more fundamental conflict is between people who want LCRA to keep the Highland Lakes full for recreation upstream and people who live along the river who want LCRA to release water to improve the downstream recreation potential. Crucial to improving downstream recreation are better controls on both wastewater treatment plants and nonpoint pollution from Austin, the downstream communities, and other users.

Gaining access to the river downstream of Austin is often difficult because there are few boat ramps and riverside parks. LCRA is developing additional boat launches and recreation areas to the river throughout the 10-county district in order to give the public better access to the Colorado River.

5. Hydroelectric Power Demand: Hydroelectric power plants located in each of the dams owned and operated by LCRA total 242 megawatts of capacity. Until the 1960s the hydro plants represented LCRA's total capability for generating electric energy. These plants still represent the cheapest power produced. The Final Judgement and Decree recognizes the competing needs for the stored water in the reservoirs, and as a result hydropower has been subordinated to be a by-product of the release of water for other purposes. To the maximum extent possible, releases of water through all of the structures are made to take maximum advantage of the energy produced by those releases. LCRA retains the right to make releases solely for hydropower production in times of emergency as part of the Water Management Plan operating policies.

6. Mining Demand: There presently is very little demand for water for mining purposes, and LCRA does not anticipate any major increases in these demands.

7. Instream Flow Requirements: The amount of water flowing within the river channel supports the strengths and diversity of the aquatic life in the system. As flows decrease, the river ecosystem can be depleted and some species destroyed.

LCRA entered into a memorandum of understanding (MOU) with the Texas Parks and Wildlife Department which provides that LCRA and TPWD will cooperate in developing a Water Management Plan with a goal of maintaining and, where reasonably possible, improving fish and wildlife resources in the lower Colorado River basin.

Pending completion of the studies which will serve as a basis for defining the flow regime necessary to sustain or enhance the aquatic life in the river, LCRA committed to maintaining a minimum monthly mean flow of 200 cfs throughout the lower basin. This flow may, at times be satisfied from inflows into the river channel and releases made by LCRA to satisfy the demands of downstream users. To assure that sufficient water will be available to satisfy this instream flow requirements, LCRA allocated 25,000 acre-feet of firm water supply to back-up both this demand on the system and the demand for inflows into the bays and estuaries.

LCRA has completed this instream flow needs study. The results of that study are two sets of instream flow needs: critical flows and target flows. The following schedule of flows takes into consideration the water quality and physical habitat requirements of the fish community native to the Colorado River.

Subsistence and critical flows: Since all City of Austin wastewater plants discharge into the Colorado River downstream of Highway 183, return flows of treated effluent bypass the Austin gage, effectively dewatering parts of the river immediately downstream of Longhorn Dam when no releases are being made from the dam. Flows of less than ten cfs have been common at this gage during the non-irrigation season although flows are substantially higher immediately downstream. Although this segment does not have the capacity to support a balanced, natural community due to its proximity to the dam, a minimum flow should be maintained in this reach. A review of historical flow records indicate that flow seldom fell below 50 cfs during dry periods before impoundment by the Highland Lakes. It is recommended that a flow of at least **46 cfs** be maintained at the Austin gage at all times. This is the 7Q10 (the seven-day average low flow expected to occur every ten years) for the Austin gage based on the period of record prior to impoundment by the Highland Lakes (1898 to 1940). Maintenance of low flows at the Austin gage will require the City of Austin to alter operational procedures at Longhorn Dam to avoid pulsed discharges from the dam's automatic gates.

A mean daily discharge of greater than **120 cubic feet per second** as measured at the Bastrop Gage should be maintained at all times except March, April, and May (critical flow months) in order to provide adequate water quality conditions in the Colorado River. This is a minimum flow based on the Texas Water Commission's standard of a daily average of greater than five milligrams per liter dissolved oxygen and meets the criteria for the high quality aquatic habitat designation in segment 1402 and 1428. Model simulations indicate that this discharge will provide a minimum daily average of greater than six mg/l dissolved oxygen throughout most of segment 1428. This recommendation is based on the assumption that the City of Austin will maintain an effluent quality at or above current levels and amend their TWC permits to require that they meet those standards in the future. Minimum flow

recommendations should be considered subject to revision as predictive capabilities are improved.

The seasonally adjusted target flow recommendations given below are largely adequate to meet the critical flow requirements for the target species during the spawning season. However, until more information on the flow requirements of the Blue Sucker (Cycleptus elongatus) during critical periods are available, it is recommended that flow be maintained at or above **500 cfs** at Bastrop for a continuous period of not less than six weeks during the months of March, April, and May. Further studies on the life history of the Blue Sucker in the Colorado River are needed.

Target flows: A schedule of flows that provides an optimal range of habitat complexity to support a well balanced, native aquatic community was determined for each study reach. These flow regimes are considered an optimal range and should be maintained whenever water resources are adequate but should be classified as an interruptible demand subject to curtailment when water resources become limited during drought periods. Since native fish species are adapted to normal seasonal variations in flow regimes, target flows were adjusted monthly to emulate the annual cycle. It is interesting to note that the composite optimal flows are roughly equivalent to the historic median flows prior to impoundment. The following recommended target flows are based on the Bastrop study reach since this segment contains suitable habitat for the Blue Sucker (Cycleptus elongatus), listed as a threatened (protected nongame) species by the Texas Parks and Wildlife Department. Since diversions for irrigation have the potential to reduce flows significantly in the lower reaches, flows should be monitored at Eagle Lake and Egypt to assure that target flows for those reaches are also met.

Maintenance flows: Periodic spates of high flows are needed to prevent siltation and dense macrophyte growth. It is presumed that these flows would be provided by natural rainfall events but may occasionally require dam releases in excess of generation capacity for short periods. Frequency and duration of maintenance flows will be determined by examination of historical data on flow regimes and macrophyte growth patterns. Macrophyte studies are in progress.

These recommendations as shown on Table 1, below, represent a balanced approach to instream flow requirements that take into account both natural flow regimes and water quality conditions needed to support a healthy, diverse native fish community downstream of Austin and should provide a strong technical foundation for the development of instream flow policy for the Lower Colorado River.

TABLE 1
Schedule of recommended flows for the Colorado River Downstream of Austin:

Month	Subsitence/Critical Flows (cfs)		Target Flows (cfs)		
	Austin	Bastrop	Bastrop	Eagle Lake	Egypt
January	46	120	370	300	240
February	46	120	430	340	280
March	46	500[b]	560	500[a]	360
April	46	500[b]	600	500[a]	390
May	46	500[b]	1030	820	670
June	46	120	830	660	540
July	46	120	370	300	240
August	46	120	240	200	160
September	46	120	400	320	260
October	46	120	470	380	310
November	46	120	370	290	240
December	46	120	340	270	220

[a]Since target flow at Eagle Lake (based on overall community habitat availability) were insufficient to meet Blue Sucker (Cycleptus elongatus) spawning requirements during March and April, target flows were superseded by critical flow recommendations for this reach.

[b]This flow should be maintained for a continuous period of not less than six weeks during these months.

LCRA will release water from the Highland Lakes to:

1. Maintain the daily river flows at no less than the critical instream flow needs in all years, and

2. Maintain daily river flows at the target instream flow needs in those years when the four major irrigation districts are not curtailed, to the extent of inflows each day to the Highland Lakes as measured at the upstream streamgages.

This recommendation fully meets the most important instream flow needs at all times and meets the desirable (target) flows during periods of normal or above normal streamflow conditions.

To fully honor this recommended commitment, LCRA recommends increasing the present commitment for instream flow and bay and estuary inflows from 25,000 acre-feet per year to an average of 28,700 acre-feet per year during any ten consecutive years, from the Combined Firm Yield of the Highland Lakes. The actual annual releases of stored water will vary from year to year depending of hydrologic conditions.

8. Bay and Estuary Requirements: LCRA recognizes the importance of fresh water inflows to the productivity of the bays and estuaries to which the Colorado River contributes. A study is now underway by the Texas Parks and Wildlife Department and the Texas Water Development Board, that hopefully, will provide a resolution as to how much fresh water is necessary to maintain the productivity of the bays. The current schedule for completion of this study is by the end of 1992 . Earlier studies indicate that this requirement has the potential for establishing a demand far greater than any other category of use on the system. The mechanism for meeting this demand is one which will require very careful analysis and consideration.

The TWC's Order, dated September 20, 1989, approving the Water Management Plan (see Appendix C) establishes a schedule of interim minimum freshwater inflows to the Lavaca-Tres Palacios estarine system. The schedule calls for a minimum monthly mean flow of 200 cfs, a minimum seasonal mean flow of 375 cfs, and a minimum annual flow of 272,000 acre-feet measured at the USGS gage at Bay City. While the source of this flow may be made of inflows into the river system downstream of Austin and runoff or tailwaters from the rice irrigation districts, it will be backed up with the firm commitment of an average of 28,700 acre-feet per annum during any ten consecutive years from the Combined Firm Yield of the Highland Lakes.

CHAPTER 3

DEVELOPMENT OF THE WATER MANAGEMENT PLAN

A. Highland Lakes Operations Procedures

The Highland Lakes system is comprised of two water storage reservoirs, Lake Buchanan and Travis and three intermediate pass-through reservoirs, Lakes Inks, LBJ and Marble Falls. Lake Austin, the last of the lakes in the chain is owned by the City of Austin, but operated by LCRA under agreement and may be referred to as part of the system from time to time. Technical data on each of the dams and lakes in included in Appendix 2A of Volume II.

The Highland Lakes operations procedures discussed in Chapter 5 define how the storage water from Lakes Buchanan and Travis is used to meet downstream demands. Buchanan has a large surface area when it is at or near conservation storage, thus it has large losses due to evaporation. Lake Travis generally receives more inflow than Lake Buchanan and is more susceptible to spilling during normal operations. The Highland Lakes operations procedures were developed to minimize the impacts of the losses due to evaporation and spills and thus maximizes the beneficial use of waters in the system. Chapter 5 describes the data, methodology, and models used to develop this policy including information on reservoir inflows, junior and senior water rights priorities and demands, reservoir evaporation data, return flows and other critical information.

B. Determination of Combined Firm Yield of Lakes Buchanan and Travis

One of the primary assumptions for the Highland Lakes operations procedures is the Combined Firm Yield for Lakes Buchanan and Travis. This amount was determined in accordance with the Final Judgement and Decree. The Combined Firm Yield of Lakes Buchanan and Travis is determined to be 535,812 acre-feet. An essential criteria specified in the Final Judgement and Decree for the determination of the Combined Firm Yield was that all senior downstream water rights must be honored by LCRA by passing through inflows necessary to meet those senior water rights to their fullest extent. The senior water rights include those belonging to the City of Austin, Garwood and Pierce Ranch Irrigation Companies, and Lakeside and Gulf Coast Irrigation operations owned by LCRA.

A full description of those water rights and the method used to determine their demand on a daily pass through basis is found in Chapter 5. The upstream reservoir demand for Owen Ivie Reservoir (90,546 acre-feet) is considered in the calculation of the Combined Firm Yield based on the commitment for these upstream inflows to be withdrawn from the inflows prior to their flows into Lake Buchanan.

Honoring these senior water rights at their fully authorized diversion rate and annual demand has a major impact on the firm yield determination of Lakes Travis and Buchanan. The current annual demand of these senior downstream rights is about 65 percent.

Streamflows into the Highland Lakes will be passed through on the basis of the senior right holder's actual demands. At the present time, and for the next several years, the actual demands can be expected to be less than the maximum authorized rights. This system of operation allows LCRA to conserve the stored waters and increases the water supply available from the existing reservoirs by stretching their yield.

C. Commitments Against Combined Firm Yield of Lakes Buchanan and Travis

The Combined Firm Yield of Lakes Travis and Buchanan represents the maximum average annual demand that could be met by these two lakes during a repetition of the most critical drought of record on the lower Colorado River. That drought period was from 1947 to 1957, an eleven year period that was identified as the most severe occurring during the 90 years since data collection started in February 1898. The Combined Firm Yield was calculated while honoring all senior water rights to their fullest extent granted by the Texas Water Commission.

A question of primary interest is how much of this firm supply of 535,812 acre-feet is LCRA committed to supply and how much is remaining that can be devoted to future needs for firm water. Currently, there are six groups of commitments that are considered firm demand:

1) Owen Ivie Reservoir: Permit No. 3676 authorizes Owen Ivie Reservoir. Operation of the reservoir will be under an operating agreement between LCRA and the Colorado River Municipal Water District (CRMWD) which calls for a gradual filling of Owen Ivie Reservoir. (see Appendix 1B, Volume II) This will allow an incremental increase in Owen Ivie Reservoir's firm demand as CRMWD's contractual commitments increase. The maximum impact of Owen Ivie Reservoir on the firm yield of Lakes Travis and Buchanan is 90,546 acre-feet per year.

2) City of Austin: Under the Comprehensive Water Settlement Agreement between the City of Austin and the Lower Colorado River Authority, LCRA agrees to make available to the City stored water from Lakes Travis and Buchanan as may be required from time to time to firm up or supplement the City's independent water rights to the extent of 290,156 acre-feet per year. In order to fulfill this agreement, present studies by LCRA show that a commitment of approximately 148,300 acre-

feet per year from the Combined Firm Yield of Lakes Travis and Buchanan will be required.

3) Contracts for use from Highland Lakes: As of May 1, 1992, LCRA has committed through contracts for the diversion of water either directly from the Highland Lakes or releases a total of 84,842 acre-feet per year. These contracts are for municipal and industrial purposes and because they call for a designated quantity of water each and every year with no other independent water rights available, they are considered to be a firm commitment for the supply of water.

4) Cooling Water for LCRA Power Plants: LCRA's power plants have a demand for cooling water and other plant uses which is considered to be a commitment against the Combined Firm Yield. By LCRA Board Resolution on January 22, 1987, the following commitments were made to each of the power plants:

Ferguson	15,000	
Sim Gideon	10,750	
Fayette	38,101	
TOTAL	63,851	acre-feet per year

5) South Texas Project (STP): LCRA currently has a contract in effect with Houston Lighting and Power (HL&P) to serve the South Texas Project (STP). HL&P as project manager of STP acts on behalf of, and for the benefit of, itself and the other participants in STP, which presently are: 1) the City Public Service Board of the City of San Antonio; 2) Central Power and Light Company; and 3) the City of Austin, to supply cooling water for the South Texas Project in an amount up to 102,000 acre-feet per year. This water is to be made up of run-of-river water available and back-up stored water from Lakes Travis and Buchanan. To the extent that stored water is required to fulfill this commitment, it is considered a commitment against the Combined Firm Yield of Lakes Travis and Buchanan.

In order to determine what impact this commitment would have on the commitment of firm yield water, a simulated operation was conducted through the critical drought period with a demand for cooling water generated by four units at the South Texas Project with a combined generating capacity of approximately 5,000 megawatts. This simulation showed that the South Texas Project would not require any water from storage to be released during most of the critical drought period.

However, the simulation through the critical drought period indicated a demand for stored water in one year of 51,700 acre-feet, the average of 5,680 acre-feet per year could be accumulated over the eleven year critical period to provide

for this larger annual demand.

6) Instream Flows and Bays and Estuaries:

As previously discussed, LCRA is recommending to increase the present commitment for instream flow and bay and estuary inflows from 25,000 acre-feet to an average of 28,700 acre-feet per year during any ten consecutive years.

7) Summary: To supply the demands of the preceding commitments for firm water existing during a repetition of the critical drought would require an average of 421,919 acre-feet per year to be released or diverted from storage in Lakes Buchanan and Travis. This commitment is comprised of:

Owen Ivie Reservoir	90,546	
City of Austin	148,300	
Contracts from Highland Lakes	84,842	
LCRA Power Plants	63,851	
South Texas Project	5,680	
Instream Flows/ Bays and Estuaries	28,700	(annual average during any ten consecutive years)
TOTAL	421,919	acre-feet/year

Out of concern for the future needs of the many areas in the LCRA 10-county district that are now using ground water supplies which are becoming depleted or are of poor water quality, the LCRA Board committed to reserving 50,000 acre-feet of the remaining Combined Firm Yield. In the future this reservation of the firm yield will be available for uses authorized under LCRA's certificates of adjudication. This interim reservation was to be in effect until water supply and demand assessments for the 10-county district were completed by LCRA staff or three years, whichever was sooner. The evaluation of projected new water demands on the firm water supplies of the Highland Lakes has been completed. A high population and economic growth and irrigation demand scenario was used in evaluating future demands. These demands were allocated to surface and groundwater sources in determining areas of water shortage. A twenty year (2013) time horizon was used in estimating likely new firm water demands.

The year 2013 projected new surface water need was estimated to be approximately 39,000 acre-feet annually. Since this amount is close to the current reservation of 50,000 acre-feet LCRA does not recommend a change in the reservation amount at this time. However, the demand projections were developed in 1988 and are currently being revised. Therefore, the reservation of 50,000 acre-feet will be reevaluated in 1993.

This leaves an uncommitted balance of the Combined Firm Yield of 63,893 acre-feet per year.

D. Annual Allocation of Firm and Interruptible Water

Each year LCRA will determine the amount of water that is available for interruptible commitments to supply the uses authorized under LCRA's certificates of adjudication.

No interruptible water will be supplied to cities or other industries which should be served on a firm basis. Interruptible water will be limited to irrigation or other similar uses where the value of water is well below firm water rates and the purchase is for one year only. New contracts for firm and interruptible water are subject to the Administrative Procedures and Rules for Water Contracts as specified in Appendix 4C of Volume II.

In November of each year LCRA will determine the amount of water which is available in the following year to meet firm and interruptible demands in the system. LCRA manages the conservation storage of the reservoirs by using the interruptible waters to increase the average yield of the system.

Should an emergency occur which causes a demand for additional allocations of water to either firm or interruptible water contract holders, any interested party will be able to petition the LCRA Board for such additional purchases.

1. Allocation of Firm Water

The amount of water required to meet the firm demand within the system for the preceding year will be calculated in early October. This amount will be compared to the projections for that year, and any variations will be noted and documented. LCRA will solicit information and projections of use from all of its firm supply contract holders and other firm uses provided for by resolution of the LCRA Board. This information will be used to develop a projection of firm demands for the coming year.

LCRA will assess the contents of Lakes Buchanan and Travis as of November 1 to project the storage levels for January 1 of the next year. Inflows into Lakes Buchanan and Travis from the upstream tributaries will be added to this preliminary storage level based on the minimum annual inflow from the period of drought.

This process will allow LCRA to reserve sufficient water in the system to meet all firm demands for one year beyond the year being considered for allocation.

Estimates for firm demand commitments for the next year will be subtracted from the total water supply available. The amount of water remaining will then be available for interruptible allocation for that year.

2. Allocation of Interruptible Water

As part of the overall allocation process, in November LCRA will determine the amount of water that is available in the following year for interruptible contracts. LCRA may make commitments for interruptible water for terms in excess of one year. However, the allocation of interruptible water to be supplied under such commitments will be determined on an annual basis. All interruptible commitments are subject to full or partial curtailment.

3. Priority Uses in the Allocation of Interruptible Water

In the allocation process, priority will be given to the irrigation operations (Lakeside, Gulf Coast, Garwood, and Pierce Ranch) in order to firm-up the independent water rights associated with individual irrigation operations. The LCRA Board will establish, by resolution, a Conservation Base number of acres determined by the historical (10-year) average acres that have been irrigated by its two irrigation operations. The amount of surface water to be used for irrigation under this Conservation Base is based upon a limit of 5.25 acre-feet of water per acre irrigated (see Table 2). The priority allocation for Garwood Irrigation Company is based on a contract which defines LCRA's commitment to supply interruptible stored water to Garwood to the extent necessary to firm up Garwood's 168,000 acre-foot-per-year independent run-of-river water right. The priority allocation for Pierce Ranch is based on a contract which defines LCRA's committment to supply interruptible stored water to Pierce Ranch to firm up Pierce Ranch's 55,000 acre-foot-per-year independent run-of-river water right. These contractual commitments to Garwood and Pierce Ranch are not based on a "Conservation Base acreage" calculation, but the 5.25 acre-foot-per-acre duty will apply to the acreage irrigated.

The Conservation Base acreage will be served without charge for the amount of water designated under each operations' run-of-river rights. In years when the amount of run-of-river water is projected to be insufficient to serve the Conservation Base and the priority allocations for Garwood and Pierce Ranch, the annual allocation of interruptible water will provide back-up for those rights. The charge for the allocation of interruptible stored water shall be at the prevailing interruptible water rate set by the LCRA Board or in the case of Garwood and Pierce Ranch, in accordance with their respective contracts with LCRA.

TABLE 2

RICE IRRIGATION
CONSERVATION BASE ACREAGE OR OTHER PRIORITY ALLOCATION OF INTERRUPTIBLE WATER

	LAKESIDE	GULF COAST	GARWOOD[1]	PIERCE[3]
Acres x Duty[2] = Ac. Ft.	25,000 x 5.25 = 131,250	50,000 x 5.25 = 262,500	32,000 x 5.25 = 168,000	25,000 with 55,000
Conservation Base[6] Or other Priority Allocation	26,000 x 5.25 = 136,500	50,000 x 5.25 = 262,500	32,000 x 5.25 = 168,000	10,476 x 5.25 = 55,000
% R-O-R Rts.[4]	53.5%	76.5%[7]	93.4%	46.8%[8]
% Stored Int.[5]	46.5%	23.5%[7]	6.6%	53.2%[8]

1) Garwood Irrigation Company and LCRA entered into a contract dated December 10, 1987, which defines LCRA's commitment to supply interruptible water to Garwood and the terms for curtailment during periods of shortages. This contractual commitment to Garwood is not based on a "Conservation Base Acreage" calculation, but the 5.25 acre-foot-per-acre duty will apply to the acreage irrigated.

2) Duty set by Texas Water Commission (5.25 Ac.Ft./Ac.) for rice irrigation. Pierce Ranch's current water rights are 55,000 acre feet to irrigate 25,000 acres.

3) LCRA has entered into a contract with Pierce Ranch regarding LCRA's commitment to supply interruptible stored water to Pierce Ranch and the terms for curtailment during periods of shortage. This contractual commitment to Pierce Ranch is not based on a "Conservation Base Average" calculation, but the 5.25 acre-foot-per-acre duty will apply to the acreage irrigated.

4) % of Conservation Base or other priority Allocation Supplied by Run-of-River Rights.

5) % of Conservation Base or other Priority Allocation Supplied by Stored Interruptible Water.

6) Limit on Surface Water for Lakeside is 131,250 acre-feet; the additional acres in the Conservation Base (1000 acres) and under the maximum allocation (2,300 acres) can be served by an alternate source.

7) % based on water used for 37,000 acres (194,250 acre-feet)

8) % based on water use for 7,200 acres (37,800 acre-feet)

There are two exceptions to the amounts of water to be provided to the Conservation Base acres for the two LCRA operations. The first concerns the Lakeside Irrigation Division's Conservation Base acres (26,000) which exceeds the number of acres (25,000) that can be irrigated from the Lakeside Division under the surface water rights set by the Final Judgement and Decree. This additional 1,000 acres of land in the Conservation Base acres will be supplied, as needed, by one of the six ground water wells owned and operated by the Lakeside Division.

The second exception to the Conservation Base allocation of interruptible water is a provision for supplying water to the Lakeside Division in years when the federal allocation for the number of acres of rice that can be grown exceeds the Conservation Base. The federal allocation is set each year by the U. S. Department of Agriculture and is a percentage of the acres of farmable land established as a historic base for each individual tract of land.

There are limits that must apply when considering any expansion of the Conservation Base to serve a greater number of acres as allocated under all governmental programs. The amount of surface water, either stored or run-of-river, which may be used for irrigation is set by the water rights for each district as established by the Final Judgement and Decree. As stated above, for Lakeside the limit is 25,000 acres, to be supplied at a limit of 5.25 acre-feet of water per acre irrigated. In years when the federal allocation for acres of rice planted is greater than the Conservation Base for Lakeside LCRA will provide back up stored water for up to 28,300 acres at Lakeside. These limits represent the maximum number of acres served by the Lakeside during the 10 year historic period that was used to establish the Conservation Base. For the Lakeside Division, any acreage over 25,000 and up to 28,300 can be served from an alternate source.

4. Use of Interruptible Water for Recreation

Interest groups around the Highland Lakes such as marina owners and other tourist and recreation industry members represented by the Highland Lakes Tourist Association expressed the need for recreation to be given some priority in the allocation of interruptible water.

In developing the annual interruptible allocation process, LCRA has considered the needs of the recreation industry around the lakes and proposes establishing some use of the interruptible waters to maintain lake levels in Lake Travis and Buchanan. These levels would be above the possible minimal drawdowns of the lakes under the operating rule curve and would be established in recognition of LCRA's public

interest responsibilities.

The conflict between supplies of interruptible water being held in the lakes for recreation or being released and sent downstream for rice irrigation, and public recreation downstream, is one of the most difficult issues for LCRA to balance. The rice farmers have a historic claim to a "first call" on the water used for rice farming as shown in Table 1. However, LCRA believes that the needs and interests of the recreation industry that has developed around the Highland Lakes must be heard and given due consideration.

Once the first priority allocation of interruptible stored water has been made to supply the Conservation Base of the Lakeside and Gulf Coast irrigation operations and LCRA's contractual commitments to Garwood and Pierce Ranch, LCRA staff will make recommendations to the LCRA Board for the remainder of the interruptible water available for supplying other authorized uses under LCRA's water rights. In recognition of the economic benefits to the recreation industry in the Highland Lakes region the Water Management Plan establishes a process to consider the levels of Lakes Travis and Buchanan.

LCRA will limit additional sales of interruptible water other than for the four irrigation districts' Conservation Base or Priority Allocation acreage, based on the projected volume of water in Lakes Buchanan and Travis, as of January 1 of each year. No such sales would occur if either lake is less than 94% of its maximum conservation capacity. If both lakes are projected to be at their maximum conservation capacity on January 1, then such interruptible water sales would be limited to a total of 80,000 acre-feet for that year. For projected lake volumes between 94% and 100% of conservation capacity, such interruptible water sales would be limited proportionately, based on the storage reservoir with the lowest projected percentage of capacity on January 1. This use of a portion of the interruptible water for recreation does not preclude the recreation industry groups from making purchases of interruptible water after the priority needs of the irrigation operations are satisfied. Such purchases would be on a basis equal to other contractual customers if the supply is available and they are willing to bear the market price for interruptible water.

No maintenance, except for emergencies which would require the lowering of Lakes LBJ, Marble Falls, and Inks,will be permitted if the refilling of those lakes would result in Lakes Travis or Buchanan being less than 80% full . Periodic lowering and refilling of Lake Austin will be done pursuant to the Settlement Agreement (December 10, 1988) between LCRA and the City of Austin.

5. Publication of Annual Allocation of Firm and Interruptible Water

LCRA will publish the results of the allocation process and notify the LCRA Board, the firm supply contract holders, and any existing or potential interruptible contract holders of the results in November . During the November LCRA Board meeting, the firm and interruptible supply and demand estimates will be provided to the Board, and any significant issues presented for discussion.

Prior to developing a final recommendation, the LCRA staff will consider public comments on the recommended Annual Allocation Plan published in November and take into account any significant water events that may have occurred up to the date of publication. At this time, the Annual Allocation plan for firm and interruptible waters will be prepared and submitted as a recommendation for Board approval and adoption in November.

6. Monthly and Quarterly Operations

The operational rule curve will be applied to the system on a monthly basis to determine how the system is responding to current conditions as compared to historical operations. This will allow LCRA to optimize reservoir operations on a real time basis and to determine if adjustments to the amount of interruptible water should be considered. The monthly allocation model serves to continually evaluate inflows into the system, to evaluate risks, and to assess system reliability. The monthly analysis would detect early signs of drought and allow LCRA to develop and implement contingency measures in a timely fashion.

A quarterly system operations report showing inflows to the system, monthly releases for firm and interruptible commitments, and important operating characteristics will be provided to the LCRA Board.

E. Water Conservation Plan and Programs

Increasing competition for available water supplies can be moderated, to some degree, by the implementation of water conservation programs. While not a panacea, water conservation can provide a potentially large and inexpensive source of "new" water supply and reduce the risk of disruptive water shortages. Additionally, water conservation can favorably effect the timing and amount of future capital investments in new supply development and water and wastewater utility infrastructure, as well as reduce utility operating costs. Water conservation will also help preserve environmental and recreational values by preventing the

overuse of limited water supplies and by reducing both point and non-point sources of water pollution.

Recognizing these and other benefits, the LCRA Board of Directors has adopted water conservation policies intended to place the agency in a leadership role in encouraging, and where appropriate, requiring the conservation of ground and surface water within the 10-county district. The goal is to promote the development and application of practices and technologies that will improve water use efficiency, increase the beneficial re-use of water, and minimize the waste of water. Consistent with this policy, LCRA has initiated a comprehensive water conservation plan targeted at the two largest water use sectors within the 10-county district; that is, irrigated agriculture and municipal water use which together account for more than 90 percent of total water use.

1. Agricultural Water Conservation Programs: LCRA's agricultural water conservation effort is focused on reducing total water use associated with rice production in Colorado, Wharton, and Matagorda counties. Specific goals are to reduce agricultural demands for stored water from the Highland Lakes and reduce costs associated with the operation of LCRA-owned irrigation water delivery systems. LCRA's agricultural water conservation programs are also intended to strengthen the long-term economic viability of the rice industry in Colorado, Wharton, and Matagorda counties.

   LCRA's agricultural water conservation programs currently consist of activities aimed at improving the operating efficiency of irrigation water delivery systems, and improving on-farm water use efficiency. At present, LCRA is implementing an irrigation canal rehabilitation program designed to "re-capture" distribution system efficiencies within the Gulf Coast canal system. The major elements of this program are:

   - Improved operational control and management of the system;
   - Vegetation removal and control;
   - Improved hydraulic characteristics of canals;
   - Installation of water control and measurement structures; and
   - Automation of water diversion facilities.

   The canal rehabilitation program is expected to reduce water use by 30 percent within the Gulf Coast canal system. Routine preventative maintenance is expected to maintain existing

canal operations efficiencies within the Lakeside canal system.

LCRA's efforts to promote on-farm water conservation in Colorado, Wharton, and Matagorda counties began in 1986. To date, the program has focused on accelerating the development of new cultural and irrigation water management practices that will improve on-farm water use efficiency and reduce waste. Key elements of the on-farm water conservation program include:

- Direct support (funding and staff) for the Cooperative Rice Water Management Research Program (i.e., "Less Water, More Rice");
- Assistance with the transfer of information from the research arena to the rice producer;
- Conservation demonstrations (e.g., development and testing of an automated levee gate); and
- Inclusion of water conservation stipulations in LCRA's standard irrigation water service contract.

Based on the preliminary results of the "Less Water, More Rice" research program, improved cultivation and management practices (e.g., precision land leveling, multiple inlet systems, etc.) can reduce on-farm water use by 25 to 30 percent. Importantly, the conservation practices examined in the research program have been shown to significantly increase crop yield. As such, individual rice producers have a direct economic incentive to adopt the recommended conservation practices. Indications are that a majority of producers have been exposed to the "Less Water, More Rice" conservation practices and that many producers have or intend to adopt recommended practices.

2. Municipal Water Conservation Programs: Overall, urban conservation and re-use are seen as important strategies for mitigating the effects of urban growth on the region's water resources. In addition to reducing future municipal water demands, urban water conservation and re-use can make important contributions toward satisfying the water and wastewater service requirements of growing urban populations and economics.

LCRA is developing a broad range of programs designed to encourage, and where appropriate, require the implementation of urban water conservation and re-use programs. Importantly, LCRA's municipal water conservation programs are predicated on the fact that the implementation of urban conservation and re-use measures must occur largely at the local level. As such,

the focus of LCRA's programs is toward encouraging and supporting initiatives by the more than 300 public water utility systems located in the LCRA 10-county district.

The LCRA municipal water conservation program consists of five major elements:

(a) Direct technical assistance with the development and implementation of local water conservation programs including:

- Public awareness and education;
- Water efficiency standards and guidelines for new construction (e.g., plumbing fixture efficiency standards);
- Retrofit programs to improve water efficiency in existing developments;
- Conservation-oriented water rates and other economic incentives;
- Low-water-use landscaping (i.e., Xeriscape); and
- Water re-use and recycling.

(b) Distribution system audit and leak detection services for local water utilities serving fewer than 10,000 connections.

(c) Integration of water conservation and re-use measures, as appropriate, with other LCRA programs and projects including:

- LCRA water sale contracts;
- Water resource planning and demand forecasting;
- Water and wastewater utility service studies, projects, and service agreements;
- Water rate design;
- Environmental programs; and
- Energy conservation programs.

(d) Public awareness and education on the water conservation opportunities, benefits, and measures. On-going activities include:

- Distribution of brochures, fact sheets, and videos on water conservation;

- Media promotion (e.g., news articles, public service announcements, talk shows, etc.);
- Public school curriculum (i.e., the "Major Rivers" elementary education program);
- Presentations to civic and service organizations; and
- Workshops, seminars, and special events.

(e) Demonstrations of advanced water conservation and re-use technologies and low-water-use landscaping techniques.

The overall effectiveness of municipal water conservation and re-use programs is dependent upon a myriad of location-specific factors (e.g., growth rates and demographic and land use characteristics of a particular community). As such, local programs must be designed in consideration of local conditions, needs and objectives. However, as a general rule, an aggressive urban water conservation program can be expected to reduce long-range water demands by as much as 20 percent. Additionally, the implementation of community-scale wastewater reclamation and re-use (e.g., dual water distribution and direct non-potable re-use) could reduce a community's future freshwater requirements by 50 percent or more.

SECTION 2

CHAPTER 4

DEVELOPMENT OF THE DROUGHT MANAGEMENT PLAN

A. INTRODUCTION

1. Background

On September 20, 1989, the Texas Water Commission issued its Order approving LCRA's Water Management Plan (see Appendix C, Volume I) for the Highland Lakes and the lower Colorado River. The Commission's Order included a requirement for LCRA to submit, within one year, a Drought Management Plan (DMP) with the Commission for its review and approval. Chapter 4 describes the Lower Colorado River Authority's Drought Management Plan for the water rights granted to LCRA. Although the water resources available in the lower Colorado River are considered as a system, only waters used under LCRA's water rights are addressed by this Plan. On December 23, 1991, the Texas Water Commission issued its Order approving the DMP. (see Appendix D, Volume I)

LCRA recognizes that its responsibility and authority under this Plan is subject to and shall not conflict with the authority of any Watermaster operation the Texas Water Commission may establish on the Colorado River. Moreover, LCRA recognizes that the Commission has jurisdiction to resolve any and all disputes regarding the allocation of stored water from Lakes Travis and Buchanan, not withstanding the procedures and guidelines set forth in this Plan.

2. Public Participation

In developing the Drought Management Plan, LCRA sought broad public participation through the work of an Advisory Committee and a series of public information and input meetings in the LCRA district. The Advisory Committee included 28 representatives from varied interests in the river basin. Taking part in the process were State and local officials, rice farmers, representatives of tourism and recreation interests, business and industry and economic development representatives and environmental interest group leaders. The other major water right holders on the Lower Colorado River were also active participants on the Committee.

The purpose of the Advisory Committee was to provide information to LCRA on the attitudes and interests of the major organizations and groups concerned with the allocation and management of LCRA's water resources. The Committee actively participated in the development of the technical studies and the analysis of the policy options. In addition, they aided LCRA by providing information on the plan to the public and the local news

media.

Many of the policy concepts and alternatives found in the Drought Management Plan are the direct result of suggestions made by the advisory group. However, neither the report as a whole, nor any portion thereof, necessarily reflects the views of the Advisory Committee or any member of the Committee.

The LCRA management and staff are appreciative of the commitment of time and energy made by the Advisory Committee.

3. The Lower Colorado River System

The lower Colorado River is considered to be the lower portion of the drainage basin of Colorado River beginning in San Saba County and continuing to Matagorda County on the Texas Gulf Coast (see Figure 1). The river flows through nine of the ten counties which make up the LCRA statutory water district.

The upper portion of LCRA's district is part of the Texas Hill Country. In the Hill Country, the river is largely controlled by a series of five dams and their reservoirs--Buchanan, Inks, Wirtz, Starcke, and Mansfield. Marked by steep slopes and shallow rocky soils with outcroppings of granite and limestone, the Hill Country ends abruptly in the Balcones Fault region near the edges of Austin. At Austin is the Tom Miller Dam which creates Lake Austin. From the eastern edges of Austin the river broadens out, snaking through the dark rich Blackland Prairie soils and then rolls gently downstream through the sand and shale of the coastal plains.

Water from the Colorado River and its tributaries is used for a variety of purposes to support the citizens and economy in the LCRA district. These uses include public water supply, manufacturing, cooling water for electric generating plants, irrigation, agriculture and mining. The water to supply these uses comes largely from the natural runoff into the Colorado River. However, the Colorado River Basin is subject to recurrent, severe droughts and devastating floods resulting in wide ranges of river flows. To provide an assured water supply and to relieve flooding, the LCRA, with the help of the Federal government, constructed the Highland Lakes reservoir system.

The development of LCRA's dams and reservoirs on the Colorado River, accomplished in the years from 1939 through 1951, changed Central Texas in many ways. Beginning by controlling the devastating floods on the river, using the river's power to generate electricity, and creating a secure and reliable water supply, LCRA has helped to stimulate the growth and development of the region. The lower Colorado River's water resources satisfy a wide variety of uses, many of which have changed and will continue to change in concert with the changes in the environment and the growth and development of the region.

4. Major Water Rights Holders

The largest water right holders in the LCRA district also use the majority of the water (Table 3). LCRA holds the largest single right, with the right to use up to 1.5 million acre-feet per year from the Highland Lakes. Other large water right holders downstream of the Highland Lakes have priority dates earlier than that of LCRA's Highland Lakes permits. These rights belong to the City of Austin, Garwood Irrigation Company, Pierce Ranch, and the LCRA's Lakeside and Gulf Coast Irrigation Divisions. These rights are considered as senior in time and superior to LCRA's right to store water in the Highland Lakes. Hence, any inflows to the Highland Lakes which can be diverted for use by these rights must be passed through the Lakes for use downstream.

TABLE (3) MAJOR WATER RIGHTS AND AUTHORIZED RIGHTS IN THE LOWER COLORADO RIVER BASIN (Acre-Feet/Year)

LCRA	1,500,000
CITY OF AUSTIN	296,403
GULF COAST	262,500
GARWOOD	168,000
LAKESIDE	131,250
PIERCE RANCH	55,000
LCRA	55,000
HL&P/LCRA (SOUTH TEXAS PROJECT)	102,000
TOTAL	2,570,153

5. Historic Operation of the Highland Lakes

Lakes Buchanan and Travis serve as the water supply and flood control reservoirs in the Highland Lakes system. Since their construction in the late 1930s and early 1940s, the water storage in these lakes has fluctuated dramatically in response to extreme floods and droughts. The lakes were at their lowest levels in 1952 when Lake Buchanan was at 983 feet mean sea level (msl) and Travis

at 614 feet msl. The highest water surface elevations were in 1991 for Lake Travis (710.4 feet msl) and in 1991 for Buchanan (1021.37 feet msl).

Operational management of the lakes has also changed over time. A major use of the dams in the 1940s and 1950s was for hydroelectric power generation. That use became secondary to water supply purposes when LCRA developed its fossil fuel electric generation stations. As a result of the Final Order and Decree for LCRA's water right holdings, the use of water for hydroelectric generation was formally subordinated to higher uses except under emergency conditions.

6. Purpose and Legal Considerations

The purpose of the DMP is to specify how LCRA will contract and supply firm and interruptible stored water supplies during a repetition of the critical Drought of Record. In managing the stored water from the Highland Lakes, LCRA must

- define the conditions under which water shortages exist and
- specify the actions to be taken by LCRA to mitigate the adverse effects of such shortages.

The overall goals of the Plan are to:

- Extend available water supplies.
- Preserve essential uses of water and protect public health and safety during extreme shortages of supplies.
- Equitably distribute among LCRA's water customers any adverse economic, social and environmental impacts associated with drought-induced water shortages.

The scope of the Drought Management Plan must adhere to the findings of the State District Court's Final Judgment and Decree, adjudicating LCRA's water rights, as well as the Water Commission's Order approving the Water Management Plan. Essentially the scope of the Drought Management Plan is limited to the curtailment of LCRA's interruptible water supplies to insure that there is sufficient firm, uninterruptible water available to meet projected demands for such water through a repetition of the Drought of Record. Firm, uninterruptible water is subject to curtailment only if it is determined that the drought in effect is worse than the Drought of Record.

In times of shortage of supply caused by drought or emergency, LCRA, in accordance with Section 11.039 of the Texas Water Code, will first curtail and distribute the available supply of interruptible water among all of its interruptible water supply customers on a pro rata basis, so that preference is given to no one and all interruptible water supply customers suffer alike.

Projections of firm demands for stored water over the next ten years are significantly less than the firm water supplies available. Thus, curtailment of firm demands is extremely remote in the next decade, even under a recurrence of extreme drought conditions.

If the shortage of supply caused by the drought is worse than the Drought of Record, then LCRA, according to the TWC Order approving the Water Management Plan, must curtail and distribute the available supply of firm water among all of its firm water supply customers on a pro rata basis, so that preference is given to no one and all firm water supply customers suffer alike.

In the annual allocation of interruptible water supplies, LCRA follows the priority order of water use as specified in Section 11.024 of the Texas Water Code and the Water Management Plan.

Similarly, in making additional commitments of firm water supplies, LCRA must also follow the priority order of uses given in Section 11.024 of the Texas Water Code.

As noted above, a goal of the Drought Management Plan is to determine how to allocate available water supplies when there is not sufficient supplies to meet projected water demands even after reasonable, cost-effective water conservation efforts have reduced the water demands. Therefore, the Plan does not emphasize water conservation practices which should occur all the time, not just in drought conditions. LCRA has major programs to encourage conservation in water use. These programs are described in detail in the Water Management Plan. The programs include the water conservation efforts in the LCRA irrigation districts and the "Model Cities" program for municipal water conservation. They are already in operation.

B. WATER USERS AND INTEREST GROUPS

1. LCRA Firm Water Customers

LCRA manages the Highland Lakes for the benefit of all users. LCRA supplies water under its water rights for the Highland Lakes to numerous municipal water supply systems, manufacturers, and power generating plants. Presently, LCRA has over 100 contracts for firm water supplies. The total commitment of firm water, including these contracts, is about 341,660 acre-feet per year, excluding the 91,391 acre-foot commitment for Stacy Reservoir and the 50,000 acre-foot reservation for future uses. Current annual use of firm stored water is less than 20% of the 341,660 acre-foot amount. The largest single customer is the City of Austin, with a contract for approximately 296,000 acre-feet yearly, including water supplied from the City's senior water right.

The major concern of firm water customers is that sufficient supplies be allocated to insure that their demands for water are

fully satisfied even during severe drought conditions. An additional concern for those customers pumping water directly from Lakes Travis and Buchanan is that the lake levels remain sufficiently high for them to continue to use their existing water intake structures. Extending intake facilities further into the lake to follow retreating shorelines can be very expensive. Most of the intakes can accommodate water levels at the historical low lake levels of 614 feet msl on Lake Travis and 983 feet msl on Lake Buchanan.

2. Agricultural Interests -- The Rice Producers

(a) Historic Claims to the Waters of the Colorado

The waters of the Colorado River have served the rice farming industry of the Texas Gulf Coast counties of Colorado, Wharton and Matagorda counties since 1885 when the first rice crops were planted near Eagle Lake, Texas. When legislation creating LCRA was first proposed in the Texas Legislature in 1933,promises were given to the rice producers and other farmers that the waters stored behind the dams proposed for the LCRA system would be available to serve their needs when the natural flow of the river diminishes in dry years.

Rice is the major crop irrigated in the most downstream three counties in the LCRA district. While some rice producers in the region irrigate their crops with pumped groundwater, the major source of water for irrigation is from the waters of the Colorado, either as run-of-river water, or stored water from the Highland Lakes. Approximately 30% of the water used to irrigate in the three counties comes from groundwater. The majority, 70%, is supplied from surface water. Approximately 500,000 acre-feet, which is about 70% of the annual water use of the Colorado River and the Highland Lakes, is used for rice farming. During an average year, about 30% of the total surface water used for irrigation comes from the stored water in the Highland Lakes.

When LCRA purchased two of the irrigation operations (Gulf Coast in 1959 and Lakeside in 1983) and their associated senior water rights from private firms, the promises to provide stored waters from the Highland Lakes as back-up to the run-of-river rights to the rice producers were repeated.

(b) Concerns of the Rice Producers

The primary concern of the rice producers is how LCRA will curtail the interruptible water during times of shortage. The producers understand the interruptible concept because, in essence, the waters were always interruptible. The Water Management Plan formalizes the understanding of how the water supply--both run-of-river and stored water--is managed.

Also of concern to the producers is the impact of any reduction of water and consequent reduction of rice acreage planted on the farmer's participation in the Federal Farm Program, as well as the direct economic impact of reduced income to meet fixed costs. The revised 1990 Farm Program allows a 5% increase of base acreage up to 80% from 75% in the previous years. While one year of reducing the number of acres planted might not affect participation, it is feared that 2 or 3 consecutive years of reduced plantings could reduce the numbers of acres allocated under the Federal Program.

3. Recreation and Tourism Interests

The waters of the Colorado River and the Highland Lakes serve a variety of recreational and tourism interests in Central Texas. In the Water Management Plan, LCRA recognizes the economic interests of the tourism and recreation industry around the Highland Lakes through a commitment to limit its sales of interruptible water, other than for the four irrigation districts' Conservation Base acreage or Priority Allocation acreage, based on the projected volume of water in Lakes Buchanan and Travis , as of January 1 of each year. No such sales would occur if either lake is less than 94% of its maximum conservation capacity. If both lakes are projected to be at their maximum conservation capacity on January 1, then such interruptible water sales would be limited to a total of 80,000 acre-feet for that year. For projected lake volumes between 94% and 100% of conservation capacity, such interruptible water sales would be limited proportionately, based on the storage reservoir with the lowest projected percentage of capacity on January 1.

While the Water Management Plan sets minimum projected reservoir storage levels for Lake Travis and for Lake Buchanan, the lakes will most likely have fallen below these levels during even a brief drought period. Economic hardship on the owners of the many marinas, small recreation businesses (bait stores, fishing camps, restaurants, campgrounds), and larger businesses, such as motels, could last much longer than the drought conditions. Many of the marinas on Lake Travis have the ability to move boat docks further out into deeper water and are willing to bear the added operational costs of such moves in order to stay in business. On Lake Buchanan, the shallow nature of the shoreline allows little flexibility in moving docks and other facilities. Some residents and other lake users have expressed concerns about the lack of access to the lakes during low elevations. Most of the LCRA boat ramp facilities and private boat ramps and launches become unusable when Lake Travis falls below 640 feet msl and Lake Buchanan falls below 1000 feet msl. Additionally, water hazards such as tree stumps and rock areas increase as reservoir levels recede, restricting more of the lake surface available for sail and power boating.

Chambers of Commerce, residents, and representatives of the tourism industry are also concerned about the elevation of the lakes area during low water periods even when a true drought is not in effect. There is a concern that first time visitors will not return to the area having once experienced low water levels in the reservoirs, thus dampening potential future economic growth.

River recreation interests downstream of the Highland Lakes are also concerned that drought conditions will leave stretches of almost dry riverbed and that water quality will deteriorate severely during drought periods.

4. Concerns for Instream Flows and Freshwater Inflows for the Bays and Estuaries

The Colorado River is the largest single source of freshwater flowing into the Lavaca-Tres Palacios estuary through channels in the Colorado River Delta. The Lavaca-Tres Palacios estuary is one of the largest of the seven major and three minor estuaries along the 370 miles of Texas Gulf shoreline. The bays and estuaries of this system provide a rich environment for wildlife, commercial seafood harvest, recreation, and aesthetic opportunities.

The Colorado River contributes freshwater to the estuary directly from the river and indirectly through return flows from rice fields irrigated from the river. An average of 1.3 million acre-feet annually from the Colorado River enters the estuary at the mouth of the river, with about 150,000 acre-feet contributed through irrigation return flows.

Estuaries and their associated wetlands are a transition zone between fresh water and marine environment and serve as the nurseries for over 97% of the fishery species in the Gulf of Mexico. Thus, the levels of salinity, nutrients, and sediments determined by freshwater inflows is critical for high estuarine production. Fluctuation of estuarine conditions from severe droughts, floods, and hurricanes results in a shift of the biological elements of the system and can directly affect the production and survival of many plant and animal species.

In the Water Management Plan, LCRA committed to maintain, on an interim basis and subject to certain limitations, certain levels of flow in the Colorado River and at Bastrop (200 cfs minimum monthly mean flow) and at Bay City (375 cfs minimum seasonal mean flow and 272,121 acre-feet minimum annual flow) for instream flow needs and flows into the bays and estuaries. LCRA committed up to 25,000 acre-feet of stored water per year of its firm water supply to meet these needs.

There are at least two studies which may eventually change the amounts of water--firm or interruptible--which LCRA has committed to instream flows and flows into the bays and estuaries. LCRA

conducted an instream flow study as part of its commitment under a Memorandum of Understanding (MOU) with Texas Parks and Wildlife Department which was completed in March 1992 . The second study was required by Section 16.058 of the Texas Water Code. Pursuant to Section 16.058, the Texas Water Development Board (TWDB) and Texas Parks and Wildlife Department (TPWD) have joint responsibility to establish and maintain a data collection and evaluation program and to conduct studies to analyze the bay conditions necessary to support a sound ecological environment. The reports, studies, and computer models are being completed and will be used by the Texas Water Commission (TWC) to determine the amounts of water necessary to maintain the ecological and environmental systems of the bays and estuaries. No schedule has been set for the proceeding by which the TWC will make this determination.

During the rice irrigation season, even under drought conditions, the instream flow needs should be satisfied as a result of natural inflows and return flows downstream of the Highland Lakes, pass-throughs of inflows to the Highland Lakes required to honor downstream senior water rights, and releases of interruptible stored water flowing downstream to the irrigation operations. Under current water demand conditions, it is in the winter months, when the portions of inflows required to be passed through the reservoirs to honor downstream senior rights are low and when downstream demands for stored water are also low, that it is most likely that instream flows will need to be supplemented with stored water releases. However, should interruptible irrigation water be curtailed or cut off, the periods of low flow in the river would be extended and additional water would be demanded to serve these needs for periods of time.

While it is difficult to estimate the full effect of inadequate instream flows or inadequate inflow to the bays and estuaries, it is clear that many plant and animal species in the food chains would be severely stressed and that productivity would be lessened.

Since the recommendations from TWC and TPWD for freshwater inflows are unknown, it is not possible to estimate the allocations that might be needed to supplement these recommended levels during time of drought.

C. PROJECTED 2000 SURFACE WATER DEMANDS DURING DROUGHTS

1. Introduction

To properly allocate available water supplies, LCRA must project the future water demand on those supplies. The DMP is based on the near future conditions which may occur in the next decade. This ten year planning period was chosen because the critical drought period used to determine the combined firm yield

of the Highland Lakes lasted approximately a decade. Further, the estimates of future water demands are most accurate in the near future. If the critical drought were to repeat itself beginning now, the maximum demands during the drought period would be those in year 2000. Thus, a ten year planning period was used for the development of the DMP.

LCRA supplies water to two general categories of water demands: firm and interruptible. Firm demands presently include the water for municipal, domestic, industrial, steam-electric power generation, non-agricultural irrigation, and some instream flow maintenance purposes. Currently, interruptible water is used almost entirely for agricultural irrigation. Demands for other possible interruptible water uses, such as instream flows and recreation, have not been specified at this time.

Current surface water use in the LCRA ten county statutory district (Figure 2) is approximately 650,000 acre-feet annually. About 70% is used for rice irrigation in the four major irrigation operations located in Colorado, Wharton and Matagorda Counties. The next largest demand for surface water is the City of Austin, which uses approximately 120,000 acre-feet yearly for municipal use.

Surface water demands in the LCRA district over the next decade have been projected by LCRA staff based on drought-condition weather, population growth, water use patterns, and economic development. The major assumptions used in projecting year 2000 demands are described in the following sections.

2. Projected Firm Water Demands

(a) Municipal Water Demand Projections

The LCRA's Economic and Load Forecasting Division has developed drought-case municipal demand projections for the urban and rural populated areas of Burnet, Llano, and Travis Counties. Projections for the City of Cedar Park were obtained from the Texas Water Development Board (TWDB). The City of Cedar Park, located in Williamson County, is served by surface water diversions from Lake Travis in Travis County.

The major assumption in developing municipal drought-case demands is that population growth would occur at a base (or likely) projected rate, but that per capita water use would be high to represent drought weather conditions. The impact of water conservation is anticipated by incorporating an approximate 10% decrease in water demands.

Estimated annual drought-case municipal water demands for surface water, including the City of Austin, are projected to grow to 192,400 acre-feet in 2000. The City of Austin comprises the

majority of this demand. Included in the Austin projection is the water demand within the city for manufacturing and steam-electric power generation.

(b) Manufacturing Water Demands

Manufacturing water demands assume an active petrochemical industry in Matagorda County and moderate manufacturing growth in all other counties in the LCRA district. Manufacturing water demands were assumed to be relatively insensitive to drought conditions. Only manufacturing demands projected to be supplied from stored water are included in these projections.

The annual manufacturing demand on the Highland Lakes is projected to increase to 8,400 acre-feet by the year 2000.

(c) Steam-Electric Water Demands

Steam-electric water demands are based on projections presented in the LCRA 1988 Resource Options Plan and from TWDB estimates. These demands consider dry weather conditions and are not further adjusted for drought conditions.

Water demands for steam-electric generation, both for the South Texas Project (STP) and the LCRA power plants, in 2000 are projected to be 90,500 acre-feet yearly. The demand for STP may be met by using unregulated run-of-river flows, supplemented as necessary with stored water. The arrangements for satisfying these demands at STP and at the LCRA power plants are described in more detail in Finding 58 of the September 7,1989 Order of the Texas Water Commission approving the LCRA's Water Management Plan.

(d) Instream Flow and Bays and Estuaries Freshwater Inflow Demands

The firm water demands projected in 2000 under drought conditions are summarized in Table 4.

3. Projected Interruptible Water Demands

(a) Interruptible Surface Water Suppliers and Their Types of Customers

LCRA presently supplies interruptible stored water to four major irrigation operations. These operations are: Garwood Irrigation Company, Pierce Ranch Irrigation Company, and the LCRA Lakeside and Gulf Coast Irrigation Divisions. These operations have very early rights to divert surface water from the Colorado River, to the extent it is available, to satisfy their needs up to their permitted rights. These run-of-river rights are all senior to LCRA's water rights in the Highland Lakes. Thus, LCRA may

TABLE (4) PROJECTED YEAR 2000 ANNUAL FIRM DEMANDS UNDER DROUGHT CONDITIONS

CATEGORY	2000 DEMAND (Acre-feet/Year)
Highland Lakes Municipal	21,400
Manufacturing	8,400
City of Austin	171,000*
LCRA Power Plants	34,100
South Texas Project (STP)	56,400*
Instream Flow Maintenance	28,700
TOTALS	**320,000**

*Firm water demands for STP and the City of Austin may be met from run-of-river flows, if they are available, under their existing water rights.

impound only that portion of the inflows to the Highland Lakes remaining after passing through inflows to the extent needed to honor these and any other downstream senior water rights.

These four operations are primarily concerned with the growing of rice although there are some turf and row-crops grown within these operations. Virtually all irrigation water is pumped from the Colorado River. Only one operation, Lakeside, has the use of a small amount of ground water for irrigation purposes.

(b) Projected Rice Irrigation Water Demands

Statistical analysis by LCRA staff indicates that agricultural water diversions at these operations is influenced by the number of acres planted, rainfall, and evaporation. Planted acreage is the strongest statistical predictor of agricultural water use, but is also the most difficult to forecast. Each operation's year 2000 acreage forecast, except for Garwood Irrigation Company and Gulf Coast Irrigation Division projected acreage, is the highest first crop levels for the 1982 - 1988 period. The projected acreage for Garwood in 2000 has been provided by Garwood.

The actual use of water for irrigation is likely to be highly variable, with relatively large differences from year to year. Water diversion demands for each district consider rainfall and evaporation conditions during each irrigation season.

For the irrigation operations, the drought case water demands are based on the forecasted acreage levels with Lakeside limited to the Conservation Base acreage. Lakeside Irrigation Division planted acreage is set at 26,000 acres while Gulf Coast is set at 37,000 acres. Each district's acreage is projected to be served through surface water supplies with the exception of 1,000 acres at Lakeside which can be served with groundwater. The projections for planted acreage comply with the Water Management Plan.

Aggressive water conservation efforts are projected to reduce the water diversions at the Gulf Coast Division by 27% in 2000, from historical 1968-1986 period usage levels. The water demands at the Lakeside Division are projected to decline as well, with 5% total cumulative reductions by 2000, from patterns of historical usage. Garwood and Pierce are not projected to have any reductions in water use because of conservation efforts until 2000, when their annual demands are estimated to be 5% less than historical usage rates.

In addition to the senior water right holders and major irrigation operations, there are additional demands for surface water along the Colorado River. These demands, and their water rights, are junior in time to December 1, 1900 but senior to November 1, 1987. The Water Management Plan requires LCRA to treat any of these rights junior to the rights for the Highland Lakes in the same manner as the users of interruptible stored water. The water demand for these rights is modeled as if the total water right could be served by firm water supplies. This demand for interruptible water is about 10,100 acre-feet in 1990 and 4,700 acre-feet in 2000. These demands are not likely to take place each and every year. The difference in the 1990 and 2000 demands is because of term permits expiring prior to 2000.

Table 5 shows the projected acreage for the four major irrigation operations and the minor water rights holders and their associated irrigation water demands for both stored and run-of-river water. The projected demands are based on assumed drought conditions for rainfall and evaporation.

TABLE (5) PROJECTED YEAR 2000 WATER DEMANDS FOR IRRIGATION

DISTRICT	PROJECTED FIRST CROP PLANTED AREA (ACRES)	2000 DEMAND (Acre-Feet/Year)
Gulf Coast	37,000	194,900
Lakeside	25,000	129,200
Garwood	28,000	148,700
Pierce Ranch	4,300	36,000
Other Senior Rights	1,070	2,000
TOTALS	**90,570**	**510,800**

(c) Freshwater Demands for Instream Flows and Bays and Estuaries

LCRA has completed the instream flow needs study. The study identified two sets of instream flow needs: critical flows and target flows. The recommended instream flows for the Colorado River downstream of Austin are in Table 1. .

LCRA will release water from the Highland Lakes to:

1. Maintain the daily river flows at no less than the critical instream flow needs in all years, and

2. Maintain daily river flows at the target instream flow needs in those years when the four major irrigation districts are not curtailed, to the extent of inflows each day to the Highland Lakes as measured at the upstream streamgages.

This recommendation fully meets the most important instream flow needs at all times and meets the desirable (target) flows during periods of normal or above normal streamflow conditions.

To fully honor this recommended commitment, LCRA recommends increasing the present commitment for instream flow and bay and estuary inflows from 25,000 acre-feet per year to an average of 28,700 acre-feet per year during any ten consecutive years, from the Combined Firm Yield of the Highland Lakes. The actual annual releases of stored water will vary from year to year depending of hydrologic conditions. The water demands for maintaining the ecological balance of coastal bays and estuaries are uncertain.

Past studies have estimated freshwater inflow needs come from the Colorado River range from 882,000 to 1,280,000 acre-feet annually, depending on the estuarine conditions desired. Revised studies of the influence of freshwater inflows on the bays and estuaries are due for completion in 1992 .

4. Summary

Projected firm surface water demands during severe droughts total about 320,000 acre-feet annually, in 2000. Surface water demands for irrigated agriculture under drought conditions are estimated to be 510,800 acre-feet annually in 2000. An additional surface water demand of 272,000 acre-feet yearly, in the form of a minimum flow, is required, on an interim basis, at Bay City for bays and estuaries. The projected demands, as well as reported use in years 1986-1988, are indicated in Figure 2.

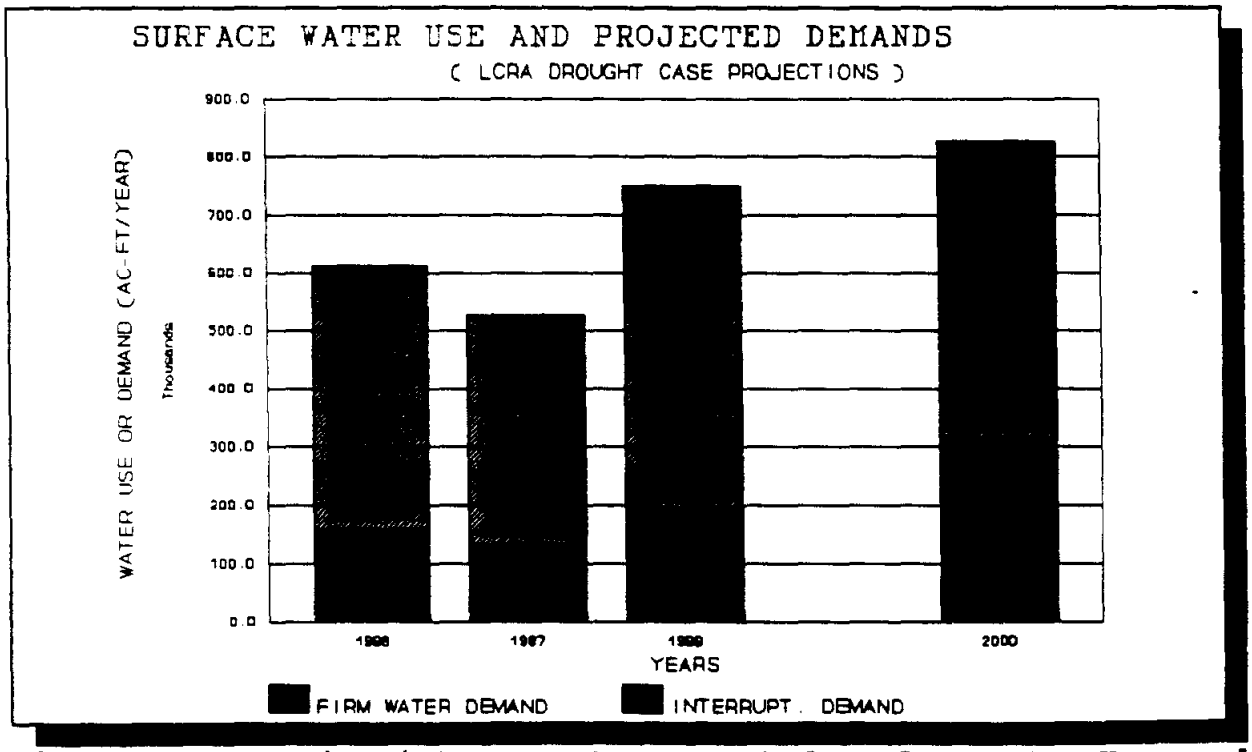


Figure 2. LCRA District 1986-1988 Reported Surface Water Use, and 2000 Drought-Condition Projected Surface Water Demands.

D. PROJECTED WATER SUPPLIES

1. Water Supply Management Procedure

(a) Systems Operation Concept

A fundamental concept of the Water Management Plan is that the Highland Lakes and the lower Colorado River are operated as a combined water supply system. Unregulated inflows entering the river from drainage areas downstream of the Highland Lakes must be used to the maximum extent possible before inflows to the Lakes are released to satisfy downstream water needs.

Such a system concept requires a careful and extensive analysis of the interconnection of hydrologic conditions, water demands, and priority of water rights and uses. The Water Management Plan uses the following general guidelines for the storage and use of water in the Highland Lakes and the lower Colorado River.

(b) Critical Drought Period Concept

A basic assumption in assessing water availability for the Drought Management Plan is that all operational policies must be evaluated as if the worst drought ever recorded for the lower Colorado River were to reoccur. This Drought of Record for the Highland Lakes was the 1947-1956 period.

(c) Procedures For Evaluating Water Availability

LCRA staff developed an automated method for evaluating water availability under a variety of management policies. This program is called "RESPONSE - Lower Colorado River Authority Reservoir System Simulation Computer Program". The evaluation of water availability proceeds on an annual basis. For each year, a three stage process is executed:

(1) water demands are estimated for each user or usage category for the coming year;

(2) the daily flows are allocated among users based on legal priority or seniority; and

(3) the operation of the Highland Lakes is simulated on a monthly basis to reflect the storage of unused inflows, evaporation, and potential spills.

The demands for water in the next year are specified as either fixed annual amounts or demands that vary depending on water in storage. The firm demands are all held constant in each year of simulated hydrologic conditions. The irrigation demands change

from year to year depending on: (1) the acres cultivated in each irrigation operation for first and second crop rice; and (2) weather conditions (rainfall and evaporation) in that year; and (3) water held in storage in the Highland Lakes at the beginning of the year. The water demand for first crop rice occurs only in the months of March through July, while second crop demands are in August, September and October. All annual water demands are distributed on a daily basis using historical water usage information.

The simulated allocation of stored water in the Highland Lakes in the Drought Management Plan follows the same procedure used in developing the Combined Firm Yield of the Lakes for the Water Management Plan.

2. Supplies for Firm Demands

The annual dependable water supply that can be supplied from the Highland Lakes during a repetition of the Drought of Record is referred to as the Combined Firm Yield. Based on the most recent information and studies available to LCRA, the Combined Firm Yield has been calculated by LCRA to be 445,000 acre-feet per year, exclusive of the commitment to Stacy Reservoir. In addition to this Combined Firm Yield, water supplies are also available from the natural flow of the river to meet a major part of the City of Austin's and the South Texas Project's firm water demands.

Adding the other firm water demands to those of the City of Austin gives a projected drought-condition demand in the year 2000 of 320,000 acre-feet annually. Portions of the demands of the City of Austin and of STP can be supplied from run-of-river flows, reducing the projected drought-condition demand for stored water in year 2000 to 152,000 acre-feet annually. Clearly, the firm demands on stored water over the next ten years are low relative to the firm supplies from the Combined Firm Yield. Thus, curtailment of firm demands is extremely remote in the next decade, even under a recurrence of extreme drought conditions. The large surplus in firm stored water supplies is therefore available to meet interruptible water use without placing at risk the stored water needed for firm water users in the next decade.

3. Supplies for Interruptible Demands

As specified by the Water Management Plan, the amount of interruptible stored water available for the next irrigation season is projected by LCRA staff in November of each year. The projected supply depends upon the amount expected to be in the combined storage of Lakes Buchanan and Travis on January 1, anticipated inflows for the subsequent months through the irrigation season, and the current demands for firm water.

Several procedures were evaluated to predict the likely supplies available, during a repetition of the Drought of Record, in the next year for interruptible demand. Historical records of streamflow were examined, but were found to be highly variable and hence not accurate in estimating water availability for the next year. The most accurate indicator of water availability is the combined storage in the Highland Lakes at the beginning of the year. Thus, for the Drought Management Plan, the allocation of stored water supplies to meet interruptible water demands is based solely on the combined reservoir storage in Lakes Travis and Buchanan at the beginning of each year, and decisions to curtail interruptible supplies in annual contracts are keyed to particular total January 1 storage levels.

At relatively full storage levels on January 1, the supply of interruptible water is sufficient to meet all projected firm and interruptible demands. However, at or below some storage levels, there are not sufficient supplies and the annual contracts for interruptible water must be reduced. At lower and lower January 1 storage levels, less and less interruptible stored water is available for allocation through the annual contracts. At some relatively low storage, there will be a total cutoff of water for interruptible use in the coming year. Provisions will be made to revise the water supply estimates during the year to respond to significant changes in projected streamflow and storage due to rainfall in the basin.

The evaluation of expected hydrologic and water demand conditions during a repetition of the Drought of Record can only be simulated based on projected information. This projected information is subject to some uncertainty. LCRA has determined it prudent to designate some minimum storage level serving as a safety factor to insure that all firm demands are fully met during the critical drought. Under this conceptual operating plan, there would be a storage level which, when reached at any time during the year, would require the total cutoff of all water for interruptible use. That storage level defines a Reserve Storage Pool for the system.

E. WATER CURTAILMENT POLICIES

1. Curtailment of Interruptible Water Demands

Given the large demand for interruptible water for rice production, there will likely be a shortage of interruptible stored water at some time during the next decade. The curtailment policies considered in the DMP focus primarily on the reduction in interruptible stored water supplies through the annual contracting process. The impact of reducing supplies in the annual contracts is far less than forcing a curtailment or total cutoff during the year after the rice farmers have made economic commitments based on the assumed availability of the water.

As provided in Finding 25 of the September 7, 1989 Order of the Texas Water Commission approving LCRA's Water Management Plan, "the priority allocation and terms governing the interruption of supply of stored water for Garwood are based upon a contract between Garwood and LCRA."

LCRA has negotiated a contract with Pierce Ranch governing the interruption of the supply of stored water to Pierce Ranch. Interruption of the supply of stored water for other commitments similarly would be governed by contract or LCRA Board resolution.

There are many ways in which interruptible stored water demands may be curtailed through the annual contracts. The two most likely are a gradual curtailment with reductions indexed against beginning of year storage in the Highland Lakes; or an abrupt total cutoff policy where the full demands are supplied if the beginning of year storage level in the Lakes was above a specific level, otherwise totally stop interruptible stored water sales for the next year.

The largest use for interruptible stored water is rice production. Rice producers must plan their crops for the next season based upon the projected interruptible stored water supply, even though more supply may actually be available in future months. The advantages of the gradual approach of curtailment are that the rice industry could use the water allocated to achieve the greatest benefit. Water could be used in first crop on the hope that conditions in the spring would refill the river and lakes. The disadvantage is that some curtailment would occur when it was not really necessary in years when the critical drought was not repeated. The Highland Lakes would refill and spill because the drought ends before conditions become as severe as the critical Drought of Record.

The advantages of the "all or nothing" approach are that there would be more years when the full demands would be met and minor droughts would not affect available supplies. Disadvantages would be that in some years there would be no stored water and most rice producers would risk substantial or total loss of their crops if sufficient run-of-river water was not available throughout the growing season.

In years when there is not sufficient projected stored water available to meet all irrigation needs, the interruptible stored water will be allocated to the irrigation operations so that all operations have the same percentage shortage in their <u>total stored water demand</u>. The calculation of the annual demand of interruptible stored water will be based on a projection of relatively dry weather and low streamflow conditions in the next year. The following example of the distribution procedure illustrates how the process would work.

Example of the Distribution Procedure

To illustrate how the procedure would work in practice, consider the following situation when dry weather conditions are assumed for the next year, and the water demands are for the full projected year 2000 acreage and water usage levels. The dry weather conditions used in this example would be expected to occur approximately one year out of every five. As noted previously, the actual water curtailments may differ from the values in this example depending on the conditions specified in contracts between LCRA and each water user.

- **ASSUMPTIONS:**
  - 200,000 acre-feet of interruptible stored water is available for the coming year based on January 1 storage in the reservoirs.
  - Dry weather diversion demands for the operations for both rice crops are:
    - Gulf Coast = 182,000 acre-feet
    - Lakeside = 126,000 acre-feet
    - Garwood = 135,000 acre-feet
    - Pierce = 40,000 acre-feet
    - Total = 483,000 acre-feet
  - Dry weather run-of-river water available for each operation for both rice crops is:
    - Gulf Coast = 48,000 acre-feet
    - Lakeside = 28,000 acre-feet
    - Garwood = 98,000 acre-feet
    - Pierce = 8,000 acre-feet
    - Total = 182,000 acre-feet
- **CALCULATIONS**
  - Dry weather interruptible stored water diversion demands for each operation for both rice crops are:
    - Gulf Coast = 134,000 acre-feet
    - Lakeside = 98,000 acre-feet
    - Garwood = 37,000 acre-feet
    - Pierce = 32,000 acre-feet
    - Total = 301,000 acre-feet
  - The portion of interruptible stored water available, as a percentage of the maximum stored water demand is about 66%.
  - Dry weather interruptible stored water supply available for each operation for both rice crops is 66% of each operation's

total stored water demand:

- Gulf Coast = 89,000 acre-feet
- Lakeside = 65,100 acre-feet
- Garwood = 24,600 acre-feet
- Pierce = 21,300 acre-feet
- Total = 200,000 acre-feet

- Calculated dry weather water shortages for each operation for both rice crops are:

  - Gulf Coast = 45,000 acre-feet
  - Lakeside = 32,900 acre-feet
  - Garwood = 12,400 acre-feet
  - Pierce = 10,700 acre-feet
  - Total = 101,000 acre-feet

The water shortages are clearly not equal volumes for all operations. However, the shortages in stored water are an equal percentage (34%) of each operation's interruptible stored water demand.

To further illustrate the allocation procedure, consider the Gulf Coast Division water allocation in the above example.

- Dry weather demand for the Division for both rice crops is 182,000 acre-feet.

- Dry weather run-of-river water available is 48,000 acre-feet.

- Dry weather interruptible stored water demand is 134,000 acre-feet.

- Dry weather interruptible stored water supply available is 89,000 acre-feet, or 66% of the interruptible stored demand for the Division.

- Calculated dry weather water shortage is 45,000 acre-feet or 34% of the total stored water demand for the Division.

2. Recommended Interruptible Water Demand Curtailment Policy

LCRA staff examined a number of alternative management policies for the Highland Lakes to meet interruptible water demands. Overall, the recommended alternative best balances the economic benefit to the rice producers, while protecting all firm demands. The principal benefit of this plan is that it protects the full demand for first crop rice in all years of the critical drought. This assurance of supply for full first crop is obtained at the price of reducing supplies of stored water earlier in the critical drought period than other management alternatives.

Policy Recommendation for Interruptible Curtailment and Cutoff

1) Open Supply - If the total January 1 storage in Lakes Travis and Buchanan combined is greater than 1,400,000 acre-feet (67% of the total maximum storage capacity) then LCRA will supply all interruptible water demands.

2) Gradual Curtailment will begin if the total January 1 storage is less than 1,400,000 acre-feet and greater than 325,000 acre-feet. The reduction in interruptible supply will be essentially proportional to the storage content. The interruptible stored water supply available will decrease gradually at a rate of approximately 4% for each 100,000 acre-foot decrease in combined storage on January 1. Examples of the reductions at two specific storage levels are:

- A reduction of approximately 13% in the interruptible water supply will be required when the storage level on January 1 is 1,100,000 acre-feet (52% of the total capacity).

- A reduction of approximately 38% in the interruptible water supply will be required when the storage level on January 1 is 500,000 acre-feet (24% of the total capacity).

3) Cutoff of the interruptible water supply for the coming year will occur when the combined storage level on January 1 is less than or equal to 325,000 acre-feet.

4) Reserve Storage Pool - If at any time during the year the total storage in Lakes Travis and Buchanan, combined, is less than or equal to 200,000 acre-feet then all use of interruptible stored water will be stopped.

5) During periods of curtailment or cutoff instituted on January 1, LCRA will cancel the curtailment of interruptible stored water for the irrigation districts at any time during the year prior to July 31, if the combined storage in Lakes Buchanan and Travis is projected to be equal to or greater than 1.4 million acre-feet anytime in July. Further, the remaining available interruptible supplies for the year may be reallocated, at this time, between irrigation operations if such allocations do not adversely affect any irrigation operation.

6) During periods of curtailments, LCRA will allow each irrigation operation the option of either: (1) using up to a maximum authorized volume of interruptible stored water allocated to that operation, or (2) using sufficient water to cultivate a level of acreage agreed upon by the operation and LCRA.

Figure 3 diagrams the conceptual Lake Management Policy by showing Curtailment Cutoff and Reserve Storage Pool levels relative to the combined storage of Lakes Travis and Buchanan.

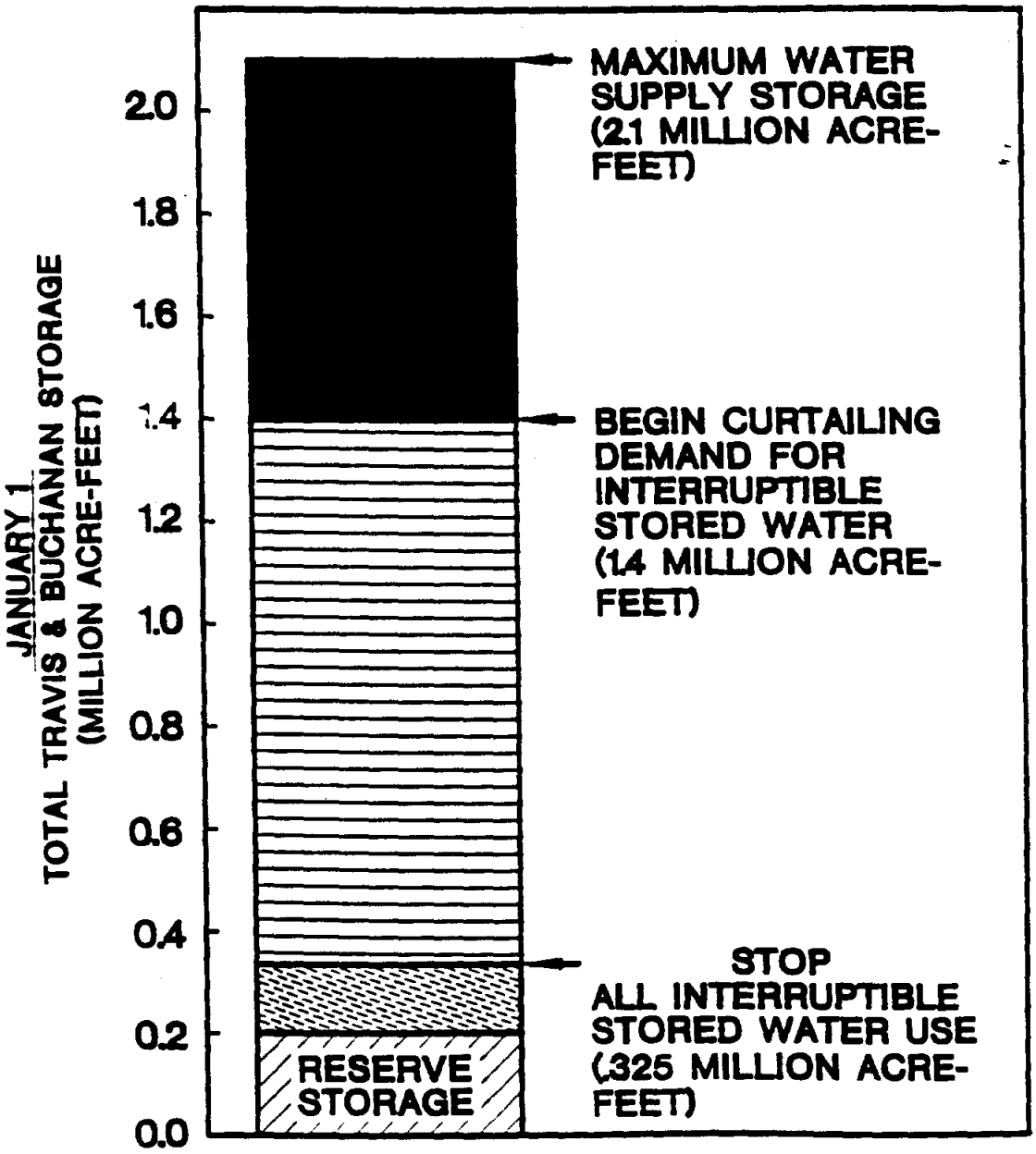
Since the curtailment begins at relatively high water storage levels, curtailment of irrigation water supplies may occur during some relatively mild droughts, however such curtailment would be limited in scope and duration. Further, it is likely that the rice producers will only be tentatively required to curtail second crop rice which is cultivated after first crop rice is harvested in July and August. Thus, the curtailment plan has the added advantage that spring rains and runoff may increase water supplies and reduce demand and thereby allow an increase in the estimate of interruptible stored water available for second crop rice. Rice producers could relatively easily increase their second crop acres if they were aware of any increased water supply by June 15.

To achieve the estimated benefits of the management policy, it is necessary for the irrigation operations to reduce their water demands to correspond to reductions in the estimated stored water supplies, in accordance with the procedures in this Plan or the terms and conditions of contracts between LCRA and stored water users. Close coordination between LCRA and the operations will be needed. Should an operation choose not to reduce the acreage cultivated in response to the projected shortage of interruptible water supply, LCRA will only supply that operation with its estimated portion of the reduced interruptible supply. No additional stored water will be released in that year for that irrigation operation once the diversion limit has been reached.

In addition to the above features, LCRA will require interruptible water customers to prepare and adopt a legally enforceable local drought management plan which specifies the actions to be taken to comply with the LCRA Drought Management Plan regarding the curtailment of interruptible supplies. LCRA staff will provide direct technical assistance with the preparation of required local plans. No local drought management plans have been developed to date by any LCRA customers. However, such plans are required for participation in the State of Texas water infrastructure loan programs administered by the Texas Water Development Board. A drought management plan has been prepared for the Barton Springs-Edwards Aquifer Conservation District located partially within the LCRA ten county statutory district.

FIGURE 3

CONCEPTUAL LAKES MANAGEMENT POLICY



3. Curtailment of Firm Water Demands

LCRA is required by TWC and the Texas Water Code to follow water supply allocation procedures to insure that there is no shortage or deficiency of stored water for firm demands during a repeat of the Drought of Record. Given the relatively small demand on firm water supplies at present, the possibility of a firm water shortage occurring is remote for the foreseeable future.

LCRA cannot determine with absolute certainty whether a particular drought event will be more or less severe than the Drought of Record. Therefore LCRA will request voluntary reduction of firm demands in the early stages of a drought.

LCRA cannot invoke mandatory curtailments of firm water demand unless it can be demonstrated that a particular drought event is more severe than the Drought of Record or some other water emergency that drastically reduces the available firm water supply. LCRA Water Resources staff has developed a simplified "drought monitoring procedure" for identifying a drought worse than the Drought of Record for the Highland Lakes watershed. Historical inflow data for the contributing watershed of the Highland Lakes were used in the development of this procedure.

4. Recommended Firm Water Demand Curtailment Policy

(a) Recommendation 1:

Voluntary water conservation measures will be implemented whenever either:

(1) there is a curtailment in interruptible stored water supplies or

(2) the total storage in Lakes Buchanan and Travis is less than 1.6 million acre-feet.

At such times, LCRA will implement an aggressive public information campaign to provide up-to-date information on water supply conditions and promote voluntary action to conserve water.

(b) Recommendation 2:

LCRA will further encourage the firm water customers to reduce water use by end users whenever the total storage in Lakes Travis and Buchanan is at or below 900,000 acre-feet. To implement end-user water demand reductions may require that mandatory water use restrictions be imposed on end users by the firm water wholesale customers themselves. To encourage such water demand reductions, LCRA will investigate alternative incentive policies, including the use of special water pricing incentives to participating wholesale water customers.

(c) Recommendation 3:

Implementation of the mandatory curtailments of firm water demands will occur whenever the river system is experiencing a drought more severe than the Drought of Record. During a drought more severe than the Drought of Record, LCRA will curtail and distribute the available supply of firm water among all of its firm water supply customers on a pro rata basis according to their demand for stored water. All uses of interruptible stored water will be totally cutoff prior to and during any mandatory curtailment of firm stored water supplies.

In addition to the above features, this curtailment policy for firm water demands includes the following elements:

(1) Required local plans. Each LCRA firm water customer will be required to prepare and adopt a legally enforceable local drought management plan which specifies the actions to be taken to comply with the LCRA Drought Management Plan regarding the curtailment of firm supplies. Such plans should be developed pursuant to LCRA guidelines and submitted for LCRA review and approval within a reasonable time. LCRA staff will provide direct technical assistance with the preparation of required local plans.

(2) Essential and non-essential water uses. To allow a distinction between essential and non-essential water uses during severe droughts, LCRA will petition the Texas Water Commission to determine and adopt definitions for these uses, as appropriate for drought management.

5. Impacts of the Recommended Management Policy

(a) Firm Water Demands and Supplies

All projected year 2000 demands for firm water are fully satisfied under these simulated critical drought conditions. The largest firm water demand is for the City of Austin. The majority of Austin's projected annual demand of 171,000 acre-feet is met from run-of-river flows diverted under its senior water rights. Approximately 63% of the demand during the 1947-1956 critical drought years is estimated to be supplied by these flows with the remainder supplied by firm stored water.

(b) Interruptible Water Demands and Supplies

Under the recommended management policy, all stored interruptible water available during a repetition of the Drought of Record is used by the four downstream irrigation operations, except for a total of 76,500 acre-feet of stored interruptible water released in simulated years 1947 thru 1949 for maintaining the flow

at Bay City. When these releases were made there was no curtailment of interruptible water supplies for the four major irrigation operations. As discussed above, it is assumed that the actual stored water allocation process distributes water by determining an equivalent allocation of acreage for first and second rice crops, by individual irrigation operation. It is assumed that each operation responds to reductions in water demands by following first and second rice cropping practices that maximize the net economic return to the rice producers in each operation . Such practices take into account the net income per acre and water demand for first and second rice crops, and the need for and cost of stored interruptible water. Using a cropping policy which maximizes net producer income, the rice operations would generally use available interruptible supplies to keep first crop acreage at maximum levels and adjust second crop acreage to any remaining interruptible supply available. As discussed previously, the allocation process for Garwood, Pierce Ranch and other users of interruptible water are, or will be, defined by contract or LCRA Board resolution.

Following the recommended curtailment policy during a simulated repetition of the 1941-1965 period, including the Drought of Record, the supplies of interruptible water are estimated to be insufficient to meet all rice irrigation demands. Some curtailment of stored water for rice production would be necessary because of insufficient stored water available at the beginning of 11 of the 25 years simulated to cultivate the full projected acreage. However, in three of these 11 years, the curtailment would be canceled at midyear since the simulated water in storage exceeded 1.4 million acre-feet on July 1. The average cultivated areas each year for total first and second crops over the 25-year simulated period are estimated at 93,600 and 69,900 acres, respectively. All acreage cultivated was supplied all the water needed to complete a successful harvest. This is only possible if the irrigation operations reduce the acres planted in response to reduced water supply estimates. The simulated acreage cultivated in first and second crops are given for all four operations combined and individually in Figures 4 - 8. As noted previously, however, the actual stored water curtailments may differ from the values reflected by the cultivated acreage as shown in this simulation, depending on the facts as they then exist and the terms and conditions of the contracts between LCRA and users.

(c) Lake Storage Levels

For the simulated repetition of the Drought of Record, the combined lake storage was reduced to very low levels in the worst drought years (Figure 9), even with the partial curtailment of interruptible supplies. Approximately 250,000 acre-feet of stored water remains in Lakes Travis and Buchanan combined at the lowest storage content. The simulated lake water surface elevations and storage levels are given in Figures 10 and 11, for Lakes Buchanan

and Travis, respectively. The minimum lake water surface levels during the simulation period are about 963 feet msl on Lake Buchanan and 569 feet msl on Lake Travis. Sufficient water is retained at the minimum storage content in Lake Travis to keep water diversions for all major water systems on Lake Travis, except for Jonestown, Cedar Park, and Lago Vista, which would require major intake extensions. The average for the beginning of August lake water surface elevations (for the repetition of the 1941-1965 period hydrology) are projected to be 1007 feet msl, on Lake Buchanan, and 655 feet msl, on Lake Travis.

The simulated minimum water levels in Lakes Travis and Buchanan are lower than the historical low levels of 614 feet and 983 feet, respectively. The greater drawdown on the lakes in the simulated operation is largely because of greater water demands and lower reservoir inflows than occurred historically. The projected year 2000 water demands are significantly greater than those that occurred in the 1941-1965 historical period. Firm water demands during the actual drought of record were only a small fraction of those projected by year 2000. Additionally, the rice producers only cultivated one crop of rice prior to about 1963. The current practice of producing two crops each year has increased the water demands of irrigation over those of the 1947-1956 critical drought period.

The second factor causing the simulated storage levels to be lower than historical levels is a difference in the reservoir inflows. The simulated operation uses historical inflows adjusted for any flow reductions caused by water diverted for upstream water rights, particularly major reservoirs including Stacy Reservoir. Most of the large reservoirs upstream of the Highland Lakes were not in operation during the critical drought period. During any repetition of the Drought of Record, these upstream reservoirs would likely significantly reduce inflows available for storage.

d. Flows in the Colorado River

For a repetition of the hydrologic conditions in the 1947-1956 critical drought years, the estimated average flow of the Colorado River at Bay City is about 460,000 acre-feet annually. For a repetition of the 1941-1965 period, the simulated annual flow at Bay City averages 1.2 million acre-feet. Of this total, a portion of the flow consists of dedicated stored water releases required by the TWC Order approving the Water Management Plan to satisfy the interim minimum flow requirements at the USGS Bay City stream flow gaging station.

In many of the years in the 1947-1956 critical drought period, the simulated flows do not fully meet the interim minimum flow requirements at Bay City. During this period, the simulated average annual deficiency in meeting the minimum flow levels is about 35,000 acre-feet. The dedicated firm and interruptible

stored water releases for the 1947-1956 critical period amount to an average of 28,000 acre-feet per year.

F. IMPLEMENTATION OF DROUGHT MANAGEMENT PLAN

1. Annual Review and Revisions

As part of the Water Management Plan, the DMP is subject to review each year. The TWC order approving the Water Management Plan stated that the priorities in the Water Management Plan are subject to change after the completion of the instream flow studies. The DMP may be revised at any time subject to approval by the LCRA Board and the TWC. Changing water supply and demand conditions on the Lower Colorado River will be reflected as necessary in future plans.

2. Administration

The curtailment of interruptible water supply will occur through the annual contracting process in November through January of each year. The curtailment of firm water will depend on storage levels and will be monitored continuously. Curtailment of interruptible water supply for Garwood and other entities supplied pursuant to long-term contracts will be accomplished pursuant to the terms of those contracts.

LCRA will monitor customer compliance with the required demand reduction goals and take enforcement action as necessary against noncompliant customers. Monitoring and enforcement of water use restrictions at the end-user level generally will be the customer's responsibility. At present, LCRA's ability to enforce curtailments of firm water demands is uncertain and may be limited to taking civil action to enjoin a non-compliant customer for breach-of-contract.

FIGURE 4

SIMULATED IRRIGATED ACREAGE (4 IRRIGATION DISTRICTS COMBINED)

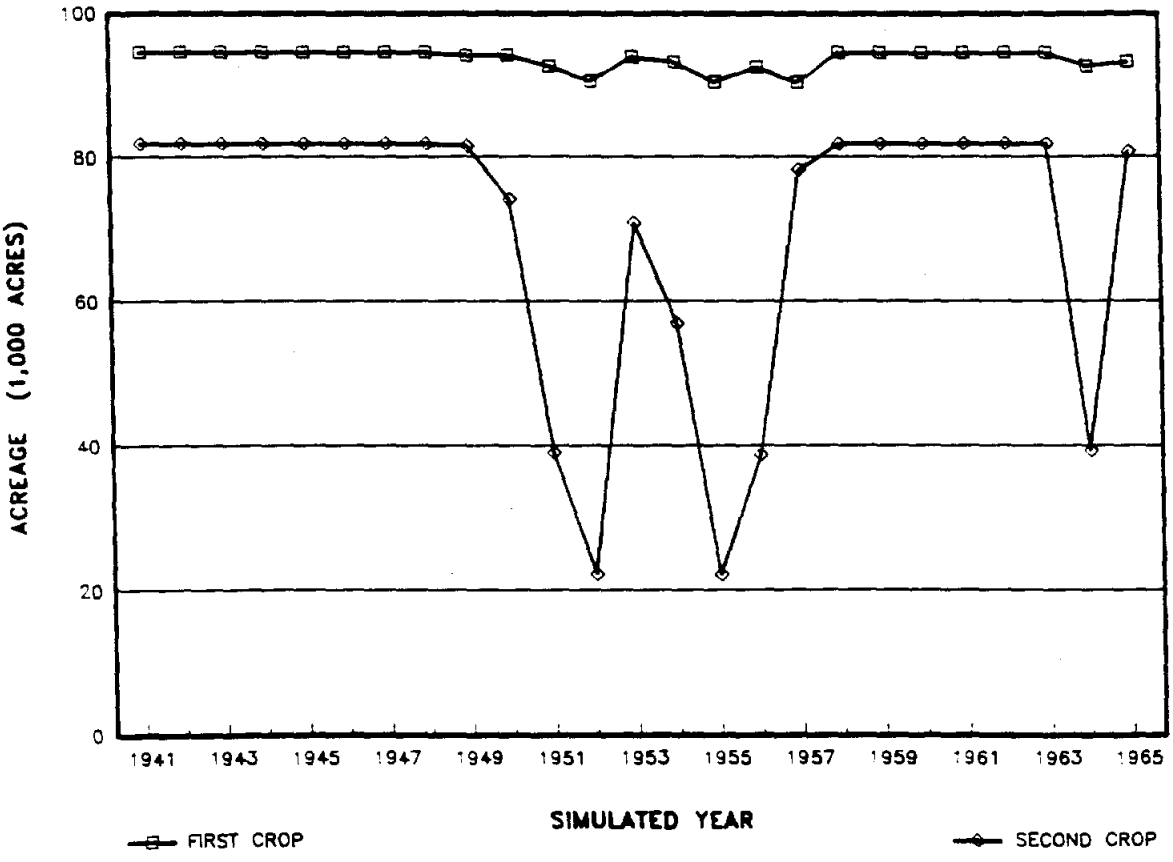


FIGURE 5

SIMULATED GULF COAST PLANTED ACREAGE

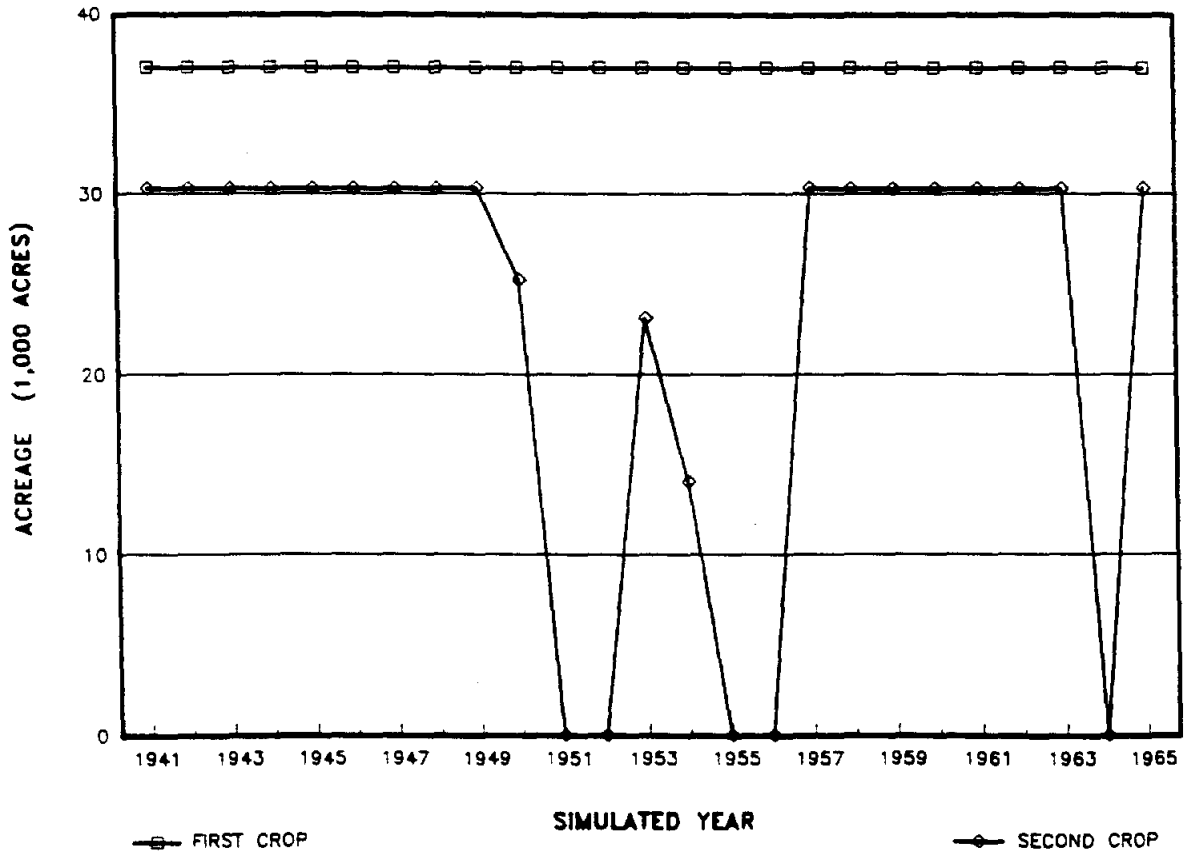


FIGURE 6

SIMULATED LAKESIDE PLANTED ACREAGE

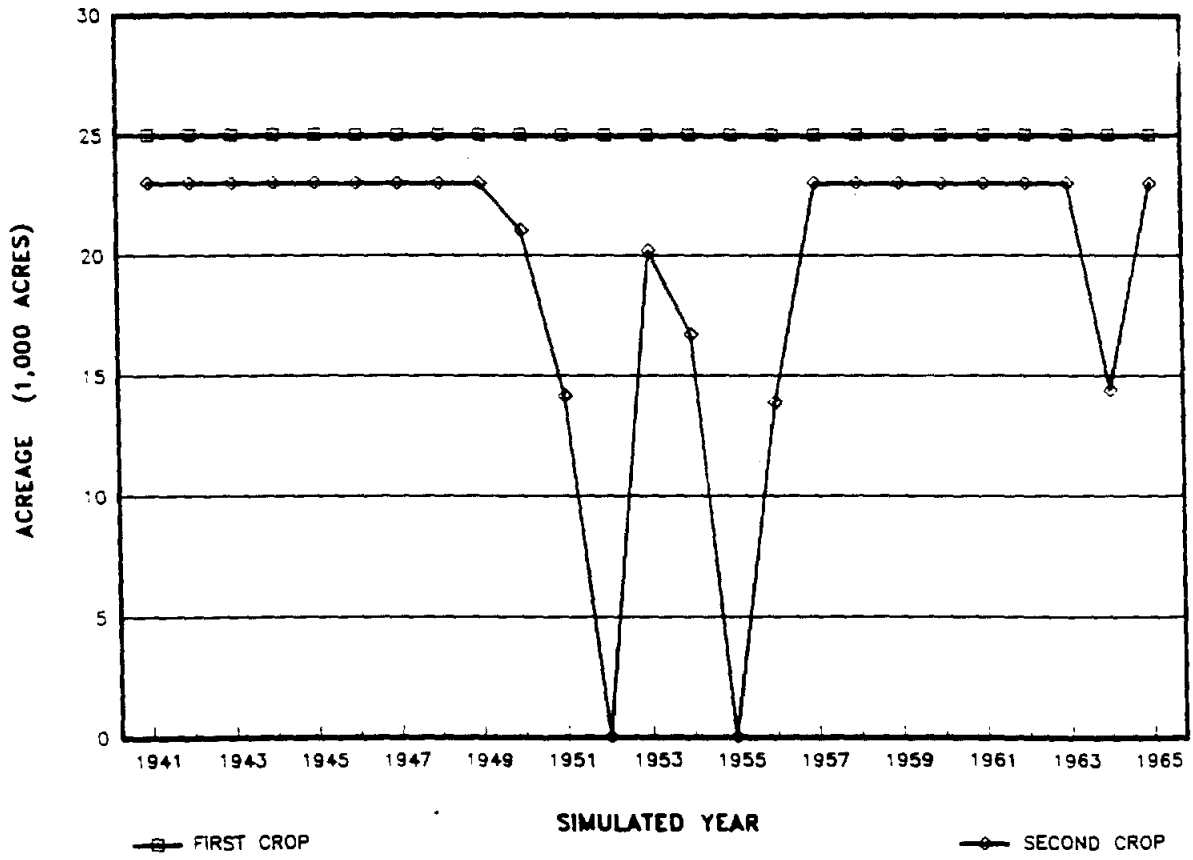


FIGURE 7

SIMULATED GARWOOD PLANTED ACREAGE

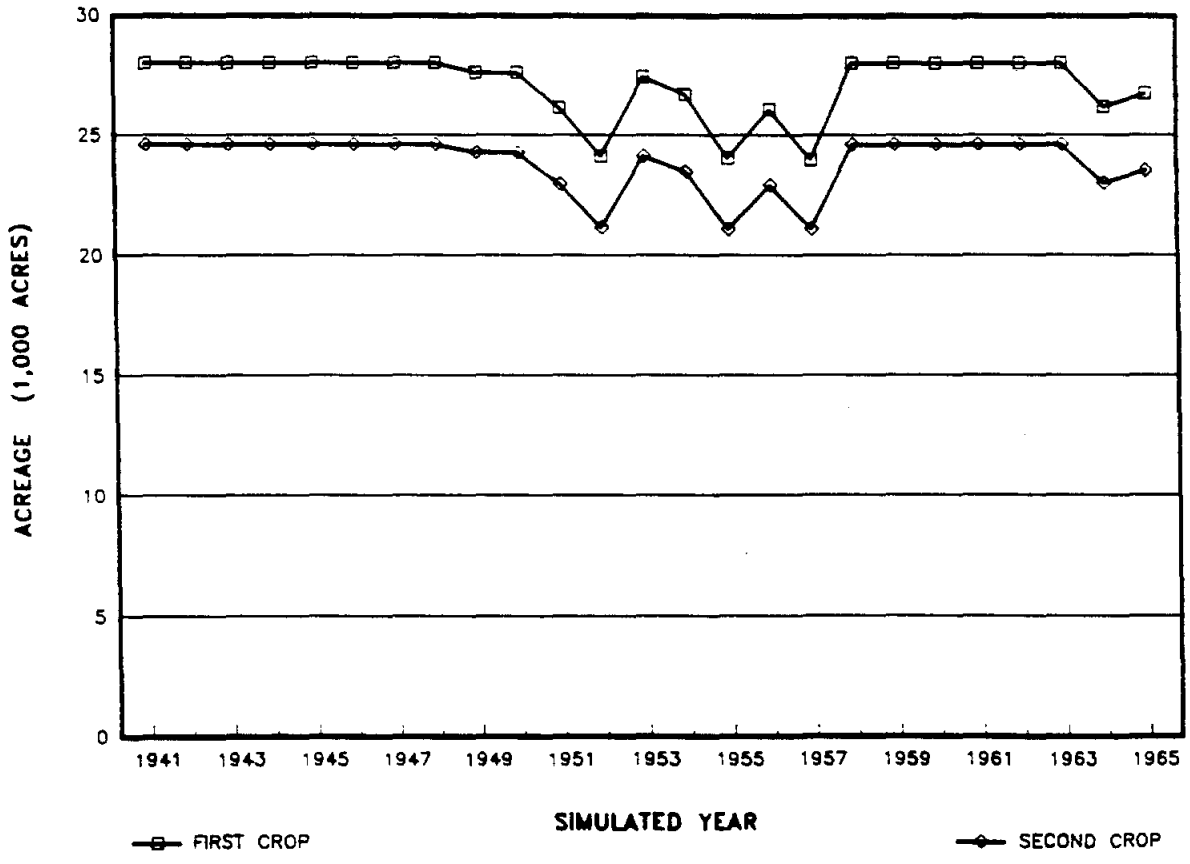


FIGURE 8

SIMULATED PIERCE RANCH PLANTED ACREAGE

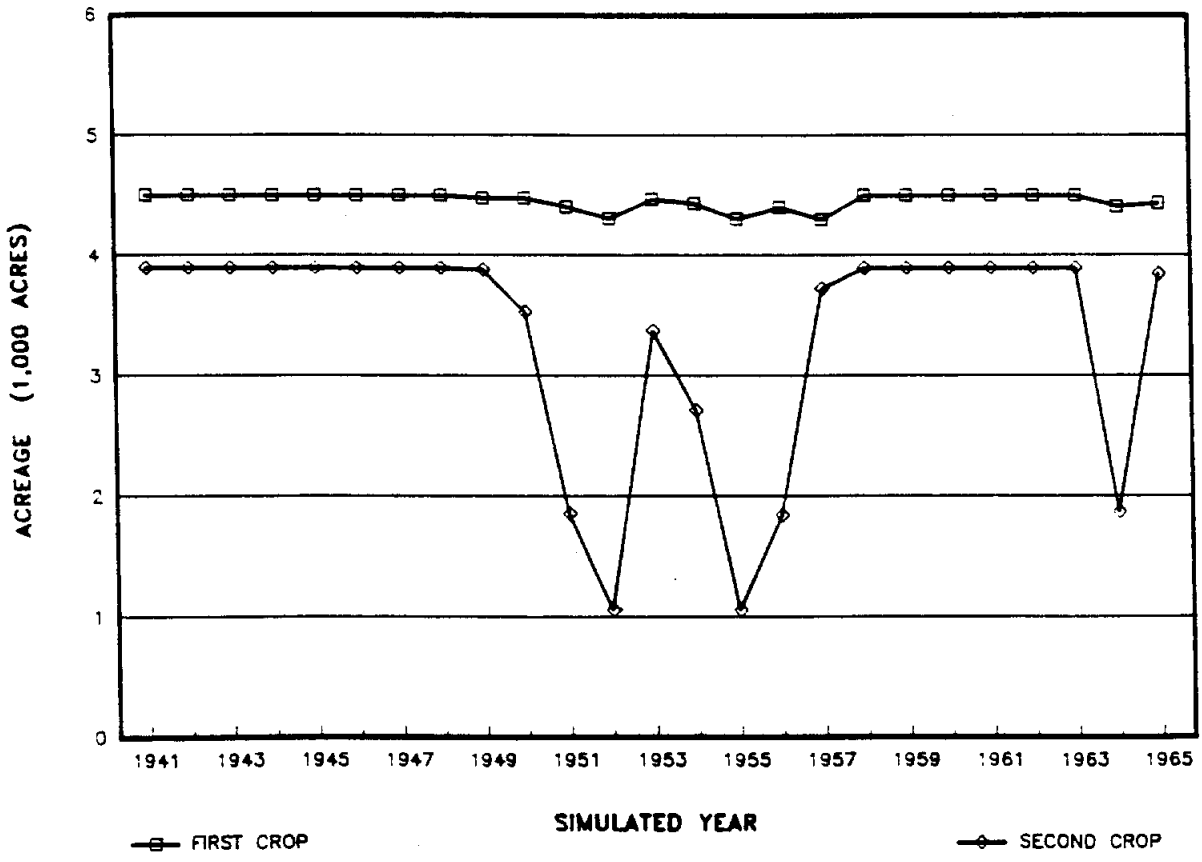


FIGURE 9

SIMULATED TRAVIS AND BUCHANAN STORAGE CONDITIONS

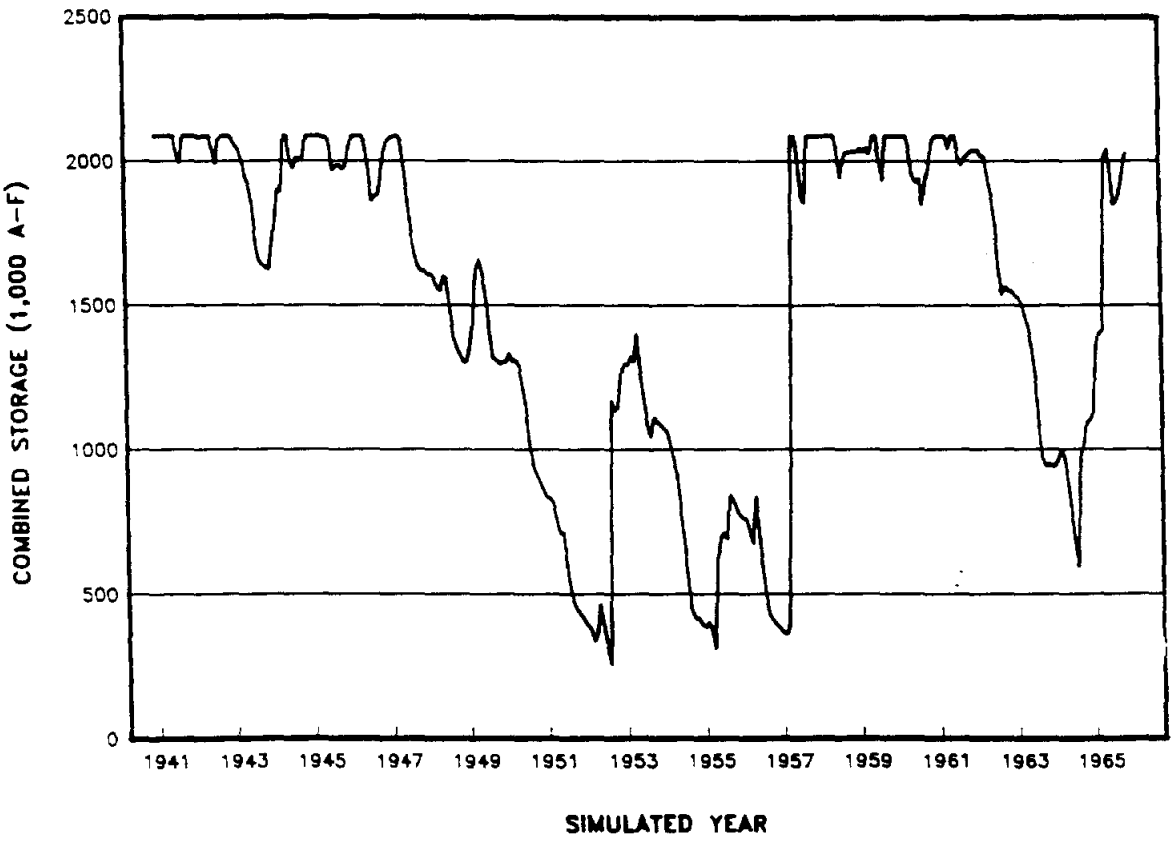


FIGURE 10

LAKE BUCHANAN SIMULATED ELEVATION AND STORAGE

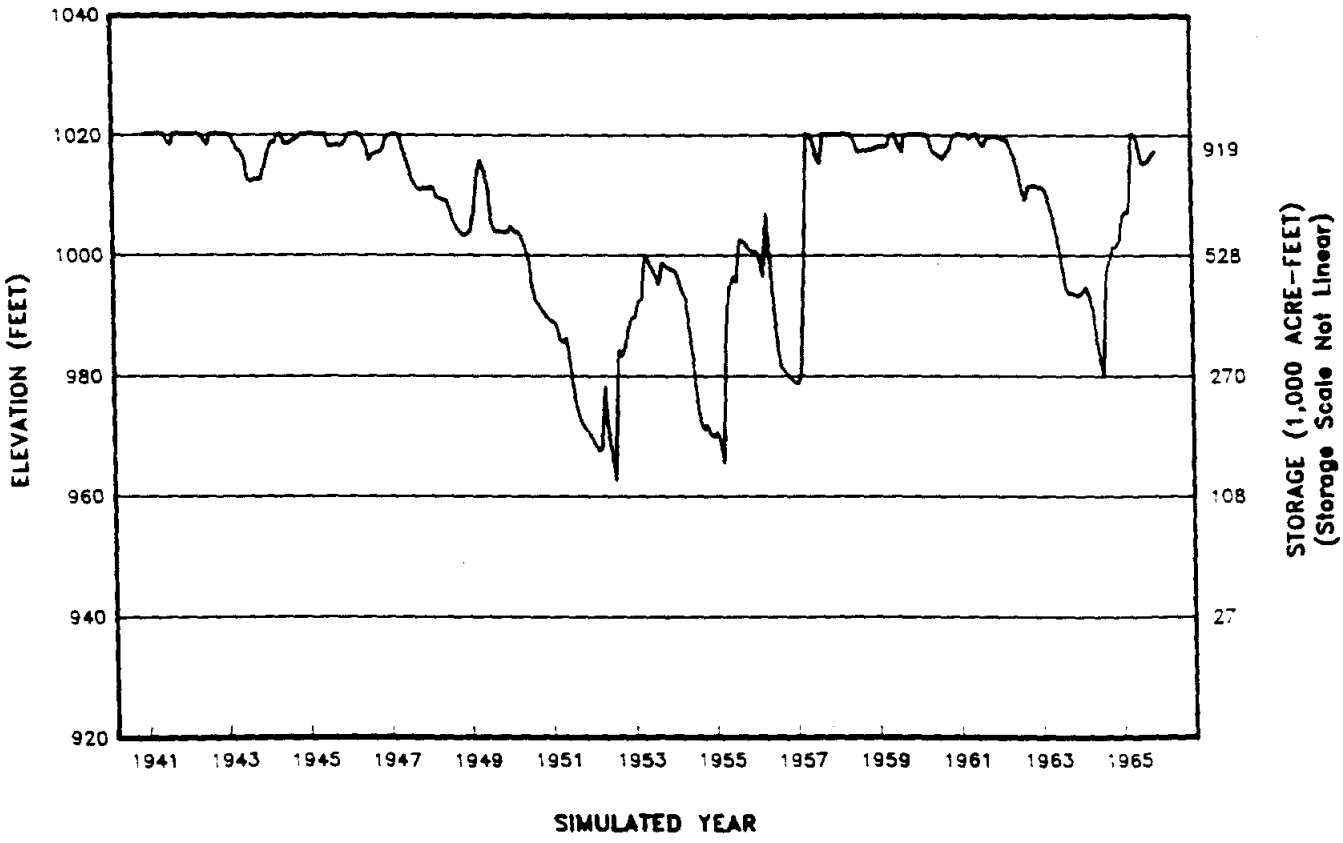
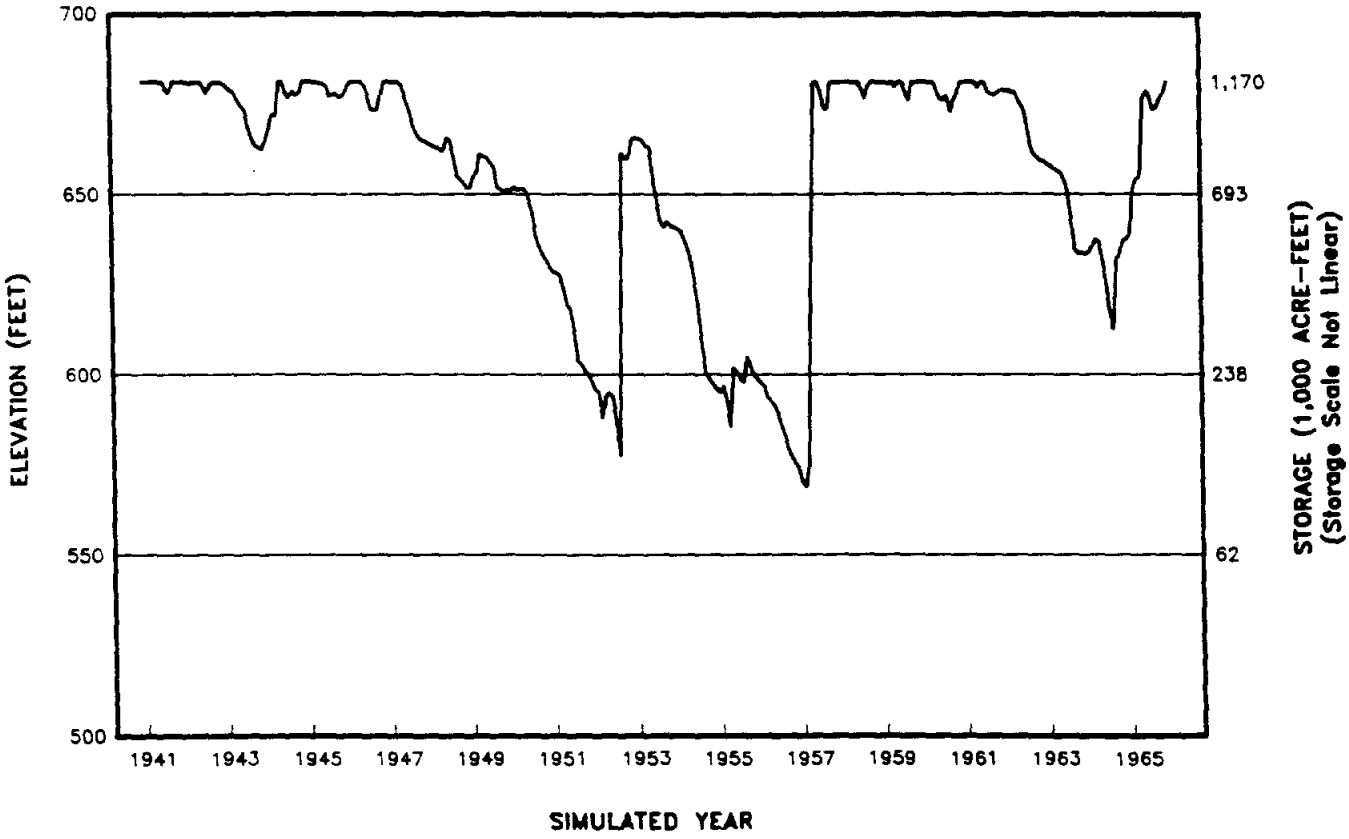


FIGURE 11

LAKE TRAVIS SIMULATED ELEVATION AND STORAGE



SECTION 3

CHAPTER 5

DETERMINATION OF THE COMBINED FIRM YIELD

A. LCRA Highland Lakes Water Rights

LCRA's water rights associated with the Highland Lakes are summarized in Table 6 as found in the Final Judgement and Decree. In order to reduce the many findings into a single table, some of the context may have been lost in the summarization. The reader should reference the Final Judgement and Decree for a more complete understanding of these rights and their complex history.

TABLE 6
SUMMARY OF LCRA's HIGHLAND LAKES WATER RIGHTS

PERMIT (NO.)	RIGHT	DATE	AMOUNT AC-FT/YR	USE
Buchanan (1259)	Impound	3/29/26	992,475	Recreation
	Consume	3/7/38	1,500,000[b]	Municipal Irrigation Mining
	Divert	n/a	3630 cfs	Hydro generation
Inks (1259A)	Impound	3/29/26	17,545	Recreation
	Divert	n/a	2600 cfs	Hydro generation
LBJ (953A)	Impound	3/29/26	138,500	Recreation
	Divert	n/a	9000 cfs	Hydro generation
Marble Falls (998)	Impound	3/29/26	8,760	Recreation
	Divert	n/a	8160 cfs	Hydro generation
Travis (1260)	Impound	3/29/26	1,170,000	Recreation
	Consume	3/7/38[a]	1,500,000[b]	Municipal Industrial Irrigation Mining
	Divert	n/a	5530 cfs	Hydro generation

Note: cfs is cubic feet per second.

a. Priority may not be imposed against any junior permanent water right with a priority date senior to 11/1/87, unless LCRA's right to divert and use water from Lakes Buchanan and Travis is limited to the Combined Firm Yield.

b. This amount includes both Lake Buchanan and Travis. The bed and banks of the Colorado River may be used for conveyance.

B. Downstream Water Rights Senior to the Highland Lakes

The Final Determination and Final Judgement and Decree found that water rights existed downstream of the Highland Lakes which are senior to the rights listed in Table 6. These are listed in Table 7.

TABLE 7
DOWNSTREAM WATER RIGHTS SENIOR TO THE HIGHLAND LAKES

OWNER	USE	AC-FT/YR	DATE	DIVERSION
AUSTIN	Municipal & Industrial	296,403	11-15-1900	644 CFS
LAKESIDE*	Irrigation	52,500	01-04-1901	700 CFS
GARWOOD	Irrigation	168,000	11-01-1900	600 CFS (950
PIERCE	Irrigation	55,000	09-01-1907	400 CFS
LCRA***	(To be Determined)	55,000	09-01-1907	400 CFS
GULF COAST*	Irrigation	228,570	12-01-1900	1267 CFS
TOTAL		855,473		3611 CFS

*** Lakeside and Gulf Coast water rights are owned by LCRA.**

**** City of Austin Diversion Rate is not limited. Rate shown is maximum assumed necessary for full utilization of water right.**

***LCRA purchased 55,000 acre-feet of Pierce Ranch's water right.

There are other smaller senior rights not listed individually, which total 1934.5 acre-feet per year with a total diversion rate of 17.7 cfs. LCRA is required to pass the water that flows into Lakes Buchanan and Travis on through the system of lakes to honor each of these rights up to the maximum authorized amount, if the water is needed and would have been available to those diverters had the dams not been built. The Final Judgement further ruled that LCRA could not include inflows passed through to honor these rights when calculating the Combined Firm Yield of Lakes Buchanan and Travis.

C. Water Rights Junior to LCRA

The Final Judgement and Decree concluded that LCRA could not impose its priority of Lake Buchanan and Travis' right against any junior permanent water right with a priority date senior to November 1, 1987, unless LCRA's right to divert and use water from the lakes was limited to their Combined Firm Yield, or the holder of the Junior right had agreed otherwise.

D. COMBINED FIRM YIELD OF LAKES BUCHANAN AND TRAVIS

Two new reservoir yield terms and definitions were introduced in the Final Judgement and Decree. These terms, Combined Theoretical Yield, and Combined Firm Yield, each allowed Lakes Buchanan and Travis to be operated as a system. The Combined Theoretical Yield was defined as the yield of the lakes if no other impoundment occurred upstream, and no water had to be passed through for senior rights. The Combined Theoretical Yield has not been calculated within this study.

The Combined Firm Yield of Lakes Buchanan and Travis is that portion of the yield remaining after honoring the full extent of upstream and downstream senior water rights. An interim value of 500,000 acre-feet per year was specified, which was in effect until the Commission adopted the Water Management Plan and determined the Combined Firm Yield. The Owen Ivie Reservoir firm yield was calculated separately from the Highland Lakes, then added back in, to give the total Combined Firm Yield for Permits 1259 and 1260.

1. Reservoir Operation Models:

The reservoir operation model is an important tool. It provides the ability to analyze a reservoir, or reservoir system, for its ability to supply water under numerous scenarios. Depending on the system in question, the model used can range from a simple, single reservoir operation to a complex, multiple reservoir operation model. To establish the firm yields of Owen Ivie Reservoir and the Highland Lakes, the two extremes of models were required.

(a) Owen Ivie Reservoir Model:

The firm yield of Owen Ivie Reservoir was determined using a standard single reservoir operations model. The model is based on a simple mass balance. The required inputs include inflow, net evaporation, a monthly water demand distribution, and an area/capacity curve for the reservoir. Both the inflow and the evaporation will be discussed in later sections. The demand distribution was extracted from a Texas Department of Water Resources memo of March 21, 1978 concerning the Stacy Dam permit application. The area/capacity curve was taken

from the Freese and Nichols, Inc. report titled Engineering Report on Stacy Dam, 1977.

(b) Highland Lakes Model:

The Highland Lakes' Combined Firm Yield was analyzed using a multiple reservoir operations model developed by the staff of LCRA. This model computes a firm yield assuming user defined local water demands at each of the system reservoirs. The required inputs include inflows, net evaporations, local water demands, monthly water demand distributions, minimum and maximum allowable contents, and area/capacity curves for each reservoir in the system. In addition, an operations policy defining individual reservoir operation and a Lake Travis demand distribution are required. The inflows, net evaporations, and area/capacity curves will be discussed in later sections. The defined minimum and maximum allowable contents are found in Table 8.

TABLE 8
Highland Lakes Allowable Operations Contents

RESERVOIR NAME	CONTENTS (AC-FT) MINIMUM	MAXIMUM
BUCHANAN	0	918,000
INKS	17,540	17,540
LBJ	138,500	138,500
MARBLE FALLS	8,760	8,760
TRAVIS	0	1,170,069

The only monthly demand distribution utilized is reflected as a release from Lake Travis. This distribution was generated using records of diversions by the City of Austin and by the four major irrigators downstream. The resulting distribution is found in Table 9.

TABLE 9
Lake Travis Annual Demand Distribution (%)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
4.8	4.6	5.9	7.9	10.6	12.7	12.6	14.1	10.2	6.5	5.1	5.0

2. Highland Lakes Operations:

This section defines how storage from each of the system's reservoirs is utilized in meeting the downstream demands. LCRA specifies the proportion of the demands to be satisfied from each reservoir based on current system storages. The ultimate goal is the maximization of usable water from the system.

The two principal storage reservoirs of the Highland Lakes are Buchanan and Travis. Buchanan has a large surface area when it is at or near conservation storage capacity. This results in large losses due to evaporation. Lake Travis generally receives much more inflow than Lake Buchanan. As a result, it is more susceptible to spilling during normal operations. The operations process was developed to minimize the impacts of the losses due to evaporation and to spills.

The process allows full utilization of Travis until its storage drops below 850,000 acre-feet. At that point, the downstream demands are met at a rate of 65% from Travis and 35% from Buchanan. When the storage in Travis drops below 700,000 acre-feet, Buchanan is called on to meet 90% of the downstream demand. When operations draw Buchanan down to between 50,000 and 150,000 acre-feet, Buchanan is then called on to meet only 35% of the demand. Finally, when the storage in Buchanan drops below 50,000 acre-feet, Travis is called on to meet all downstream demands. The process is shown in Table 10. This operation was derived through repetitive simulations and may not represent the optimal solution.

TABLE 10
Highland Lakes Operations Process

LAKE TRAVIS END OF MONTH CONTENT (AF)	LAKE BUCHANAN RELEASE RATE (%)
GREATER THAN 850,000 (El.= 662 ft)	0
LESS THAN 850,000 AND GREATER THAN 700,000	35
LESS THAN 700,000 (El. = 651 ft)	90

LAKE BUCHANAN END OF MONTH CONTENT (AF)	LAKE BUCHANAN RELEASE RATE (%)
LESS THAN 150,000 AND (El. = 966 ft) GREATER THAN 50,000	35
LESS THAN 50,000 (El. = 948 ft)	0 [1]

[1] Releases made only for diverters from Lakes Inks, LBJ, and Marble Falls.

It should be noted that, during the entire period of operation, Buchanan storage is used to meet any and all

demands not met within the system, which may include local area demands and evaporation losses. The ultimate purpose depends on the demands and the specified minimum allowable contents of the intermediate reservoirs (Inks, LBJ, and Marble Falls).

3. Data Sources for Determining Reservoir System Combined Firm Yield

A variety of data sources are required to furnish all of the information needed to calculate the Combined Firm Yield of the Highland Lakes. This section describes the sources and development of the required hydrologic, water demand, and reservoir system physical description data. The major part of this section concerns the evaluation of the water available, on a daily basis, from inflows from the drainage area of the Colorado River downstream of the Highland Lakes. Also analyzed in detail is the required pass through of daily inflows into the Highland Lakes to meet the daily water demands of senior water rights that could not be met first from the treated wastewater return flows and natural inflows entering the Colorado River downstream of Mansfield Dam. The analysis of daily flow conditions in the lower river considers the 25 year period from 1941 through 1965. This period includes the worst drought of record in the lower Colorado River Basin.

(a) Reservoir Inflow:

Because firm yield calculations for reservoirs are most always predicated upon the hydrologic recurrence of the most severe drought period for which data are available, the hydrologic setting for the time of recurrence has to be agreed upon. The most critical hydrologic factor in the calculations is the inflow to the reservoir(s). Ordinarily, it is agreed that the inflow that actually occurred during the drought period will be adjusted to simulate that for a future time period. For example: "Watershed conditions of 2030". Man's water-use activities in the watershed since the actual drought period occurred usually result in adjusted inflow values being considerably less than those that occurred.

(1) Water Availability Model:

To aid in adjusting runoff to that expected if the drought period of record were to recur, the Texas Water Commission developed a computer model. The model basically takes monthly runoff data, adjusts it back to "virgin" runoff, then imposes demands on the runoff equal to the maximum water-use right authorized, or to the extent water is available. The resulting adjusted runoff becomes that available for appropriation under the Texas

Water Code, and usable in firm yield calculations. Adjusted monthly values of inflow to Lakes Buchanan and Travis for the period January 1940 to December 1972, were provided LCRA by the TWC for calculations of the Combined Firm Yield of the LCRA system. These values are shown in Appendix 2C, Volume II.

(2) Junior Rights Current Considerations

Of the rights currently being analyzed, the permit authorizing Stacy Reservoir has the most junior priority. LCRA has an operating agreement with the Colorado River Municipal Water District (CRMWD) which calls for a gradual filling of Stacy. This will allow an incremental increase in Stacy's firm yield as CRMWD's contractual commitments increase. As water is passed in the interim period, LCRA will make those pass throughs available to downstream senior water rights. However, in this report Stacy Reservoir was not operated to pass flow to fulfill downstream senior run of the river water rights.

(3) Future Considerations

Adjustments to the monthly inflow values supplied by the Texas Water Commission are being considered. Where water rights junior to a reservoir, or reservoir system, were encountered, the supplied inflows reflected that the junior right was allowed to divert any available flow unless there was insufficient storage in the downstream reservoir to meet its demand. Then, and only then, was the junior right forced to pass water to the reservoir. In actuality, the junior right should pass flows if the storage volume in the reservoir downstream is below maximum conservation storage. The reason for this is that the junior right, by taking water, could be impairing the reservoir's ability to supply its authorization if the critical drought is repeated. For this reason, where the model allowed diversions when the Highland Lakes were below their conservation storage, the modeled diversions by junior rights upstream might be added back to the supplied inflows. The amount added back will reflect some estimate of potential flow losses between the junior right and the receiving reservoir. This procedure has not yet been modelled. It is planned to be calculated, and an amended value for the Combined Firm Yield submitted at some future date.

(b) Description of Reservoir System

The Highland Lakes system is comprised of two water storage reservoirs, Lakes Buchanan and Travis, and three intermediate pass-through reservoirs, Lakes Inks, LBJ,

and Marble Falls. Lake Austin, the last of the lakes, is owned by the City of Austin, but operated by LCRA by agreement, and may be referred to as part of the system from time to time. Figure 12 shows the respective location of each lake.

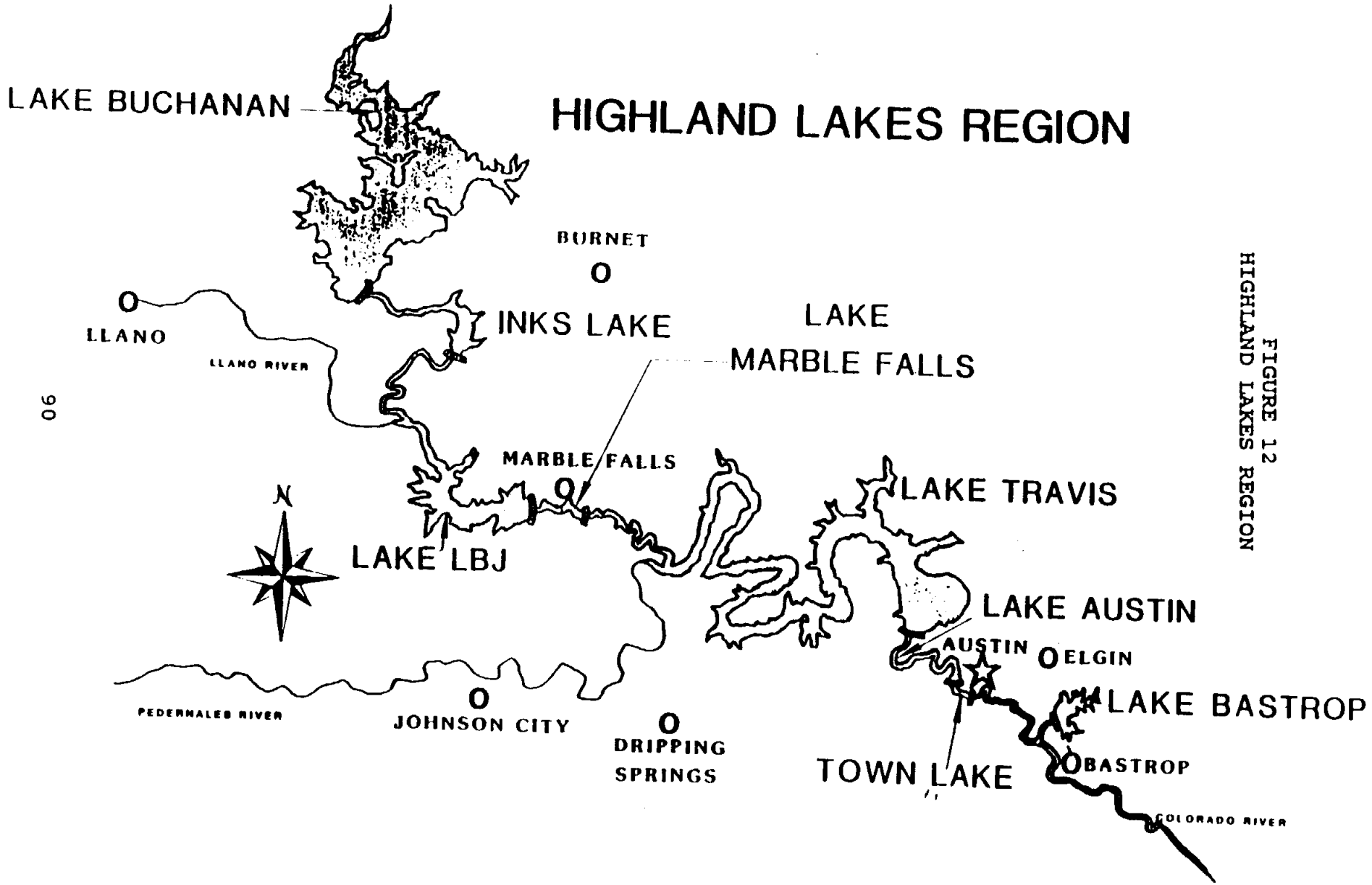


FIGURE 12
HIGHLAND LAKES REGION

(c) Reservoir Evaporation

Evaporation data was taken from the Texas Department of Water Resources LP-60 Report entitled Present and Future Surface-Water Availability in the Colorado River Basin, Texas, dated June 1978. The following excerpt is taken from page V-26, "Reservoir Evaporation Rates":

"The monthly net evaporation rates, for the period 1941 through 1965, were determined for each reservoir project considered in the study area. TWDB Report 64, Monthly Evaporation Rates for Texas, 1940 through 1965, provided net reservoir evaporation data by each one degree quadrangle within the State of Texas. These data are based on available evaporation pan data and appropriate evaporation pan coefficients. In order to convert these data to project areas, the data by quadrangle were weighted inversely proportional to the distance from the project area to the center of the four adjacent quadrangles. An established computer program was used to transfer the data to project areas. The latitude and longitude for each project was selected (generally about 1/3 the distance from the dam to the headwaters of the reservoir) and the center of each quadrangle was assumed to be the focal point of the data for that quadrangle, thereby a computer routine was used to compute the appropriate distances for the horizontal and vertical variations."

The tables in Appendix 2B, Volume II. show the monthly net reservoir evaporation rates, in feet, for each reservoir.

(d) Downstream Water Availability

The Final Judgement and Decree requires that all water demands downstream of the Highland Lakes be satisfied to the maximum extent possible by inflows to the Colorado River downstream of those lakes. In order to determine the water available from these unregulated inflows, the flow conditions in the river must be determined on a daily basis.

This section first identifies the major senior water rights in the lower river and estimates the daily water demands to fully satisfy the maximum authorized annual water diversion of each of these water right holders. Next, the daily flow conditions in the river from Mansfield Dam to Bay City are simulated using the daily unregulated inflows entering the river downstream of the Highland Lakes. Daily water demands at a specific location are satisfied to the extent that flow is

available in the river at that point on that specific day. Those daily water demands that are not satisfied by the unregulated runoff become demands upon the daily inflows into the Highland Lakes. An optimization procedure is used to calculate the minimum required pass through of daily inflows to meet the remaining downstream water demands, to the extent possible. The daily reservoir inflows remaining, after the calculated pass through flows are subtracted, are considered available for storage in the Highland Lakes and are used in the estimation of the Combined Firm Yield of the Lakes.

(1) Senior Rights Demands

This section details how each of the listed senior rights was modeled in the daily pass through analysis. The main concern involved the development of a daily demand distribution which would be representative of those senior rights diversions. It was decided to define the required distributions using historical daily diversions. Two distributions were derived, one municipal and the other irrigation.

The municipal distribution (Figure 13) was derived using the historical City of Austin diversions recorded during the years 1976 through 1985 . The same date diversions were totaled for all years (ie. all January 1st diversions for all years) and then an average daily percentage was derived.

The irrigation distribution (Figure 14) was derived similarly. The same period of record was used (1976-1985) as was the same date methodology for defining the daily percentages. The only difference was that the historical diversions for LCRA's Lakeside and Gulf Coast Irrigation Divisions, Garwood Irrigation Company and Pierce Ranch were totaled and used in lieu of the single City of Austin diversion. As a result, the distribution used for irrigation truly reflects the various irrigation practices of the largest downstream diverters. This distribution was used to simulate all irrigation diversions. The primary need for this assumption is that there were no daily diversion records available for the other simulated rights.

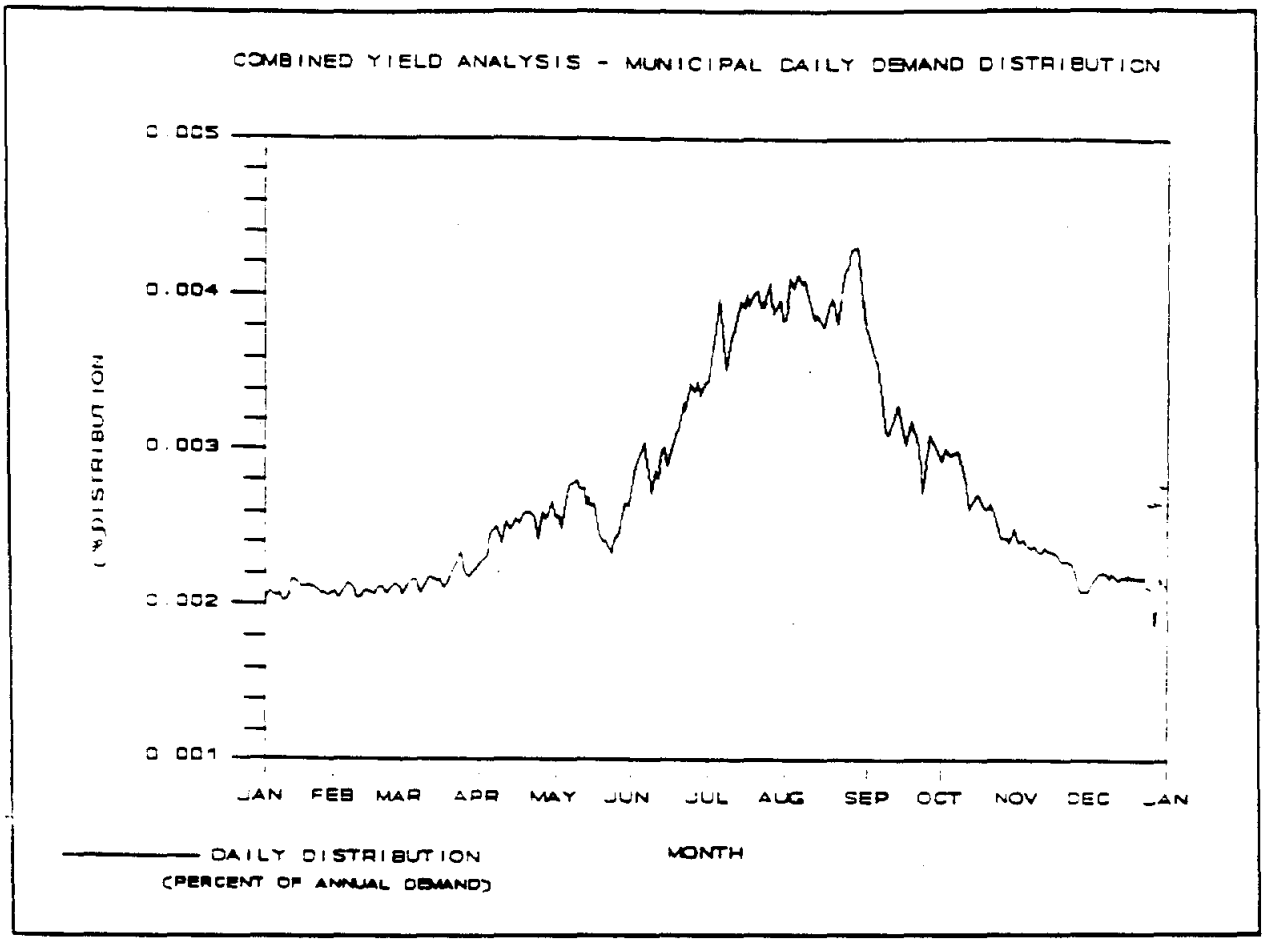


FIGURE 13
MUNICIPAL DAILY DEMAND DISTRIBUTION

(2) Intervening Inflows And Channel Losses From Mansfield Dam To Bay City

During years of average and high levels of rainfall, the Colorado River typically discharges large volumes of streamflow into the Gulf of Mexico and the Lavaca-Tres Palacios estuary. On an annual average, this total flow is 1.7 million acre-feet, as measured at the Bay City gaging station. This average is for the period 1941-1984 and includes many years of drought, particularly the historic critical drought period of 1950-1957. While the Highland Lakes control most of the streamflow upstream of Mansfield Dam, the runoff in the lower Colorado River Basin below Mansfield Dam is virtually uncontrolled.

The Colorado River downstream of Lake Travis has a drainage area of approximately 3,500 square miles.

Runoff from this area averages approximately 600 thousand acre-feet annually. This water represents a significant water resource to the lower Colorado River Basin and the adjacent coastal basins.

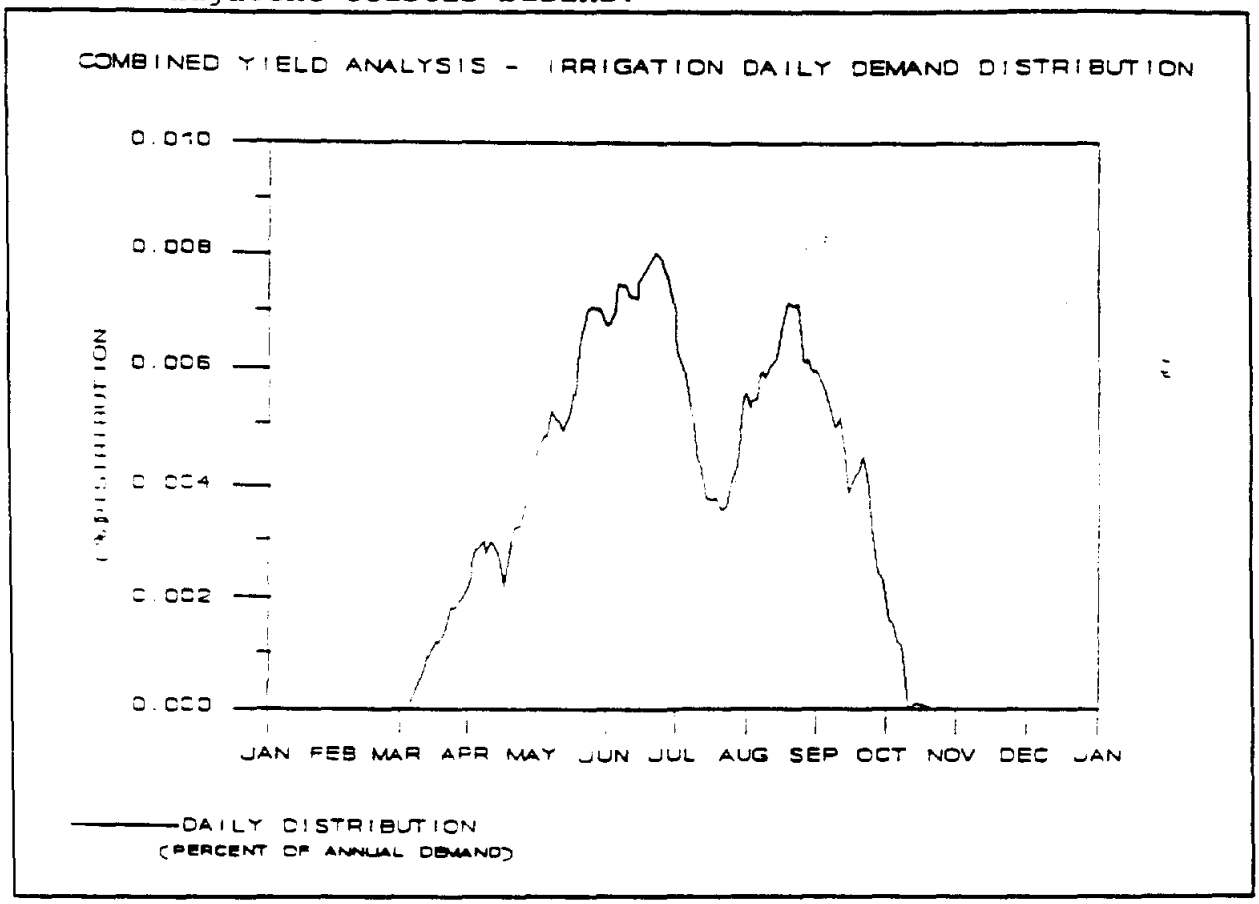


FIGURE 14
IRRIGATION DAILY DEMAND DISTRIBUTION

Since there is limited capacity to store runoff in the Colorado River Basin below Austin, the dependability of this runoff is subject to the ability of users to divert and store the runoff when it does occur. Since the timing of this runoff is highly variable, it is important to consider its daily distribution.

(i) Natural Runoff and Springflow

The most extensive analysis of the daily runoff in the drainage basins of the Colorado River below Lake Travis was undertaken by the Texas Department of Water Resources (TDWR) as part of "Colorado Coastal Plains Study" of the U.S. Bureau of Reclamation, Department of the Interior. The

results of the TDWR study were published in 1978 in TDWR Report LP-60, entitled "Present and Future Surface-Water Availability in the Colorado River Basin, Texas."

The daily inflows to the Colorado River were analyzed in LP-60 for each of five stream segments: (1) Mansfield Dam to the Austin stream gage, (2) Austin to Smithville, (3) Smithville to Columbus, (4) Columbus to Wharton, and (5) Wharton to Bay City. Daily flow and diversion records, where available, were used to determine the incremental net daily inflow for the drainage areas for each of the five river segments for the period 1941-1965, inclusive. The net daily inflows represented the sum of the runoff from the drainage area contributing directly to the stream segment, spring flows, and any return flows, minus channel losses (seepage and evapotranspiration) and diversions by man.

Daily diversions for the major surface water irrigation users during the 1941-1965 period were not available. Thus, they were not used in the calculations of incremental net inflows in LP-60. Additionally, the City of Austin daily wastewater discharges for the same period were not available, and similarly were not used to adjust the gaged flow records. However, information is available on the annual Austin effluent discharges from 1949 to present. For the critical drought period of 1949-1957, the average annual return flow from the City of Austin was 12,500 acre-feet. This volume of return flow is thus included in the net daily inflows calculated in LP-60 for the Austin to Smithville river segment. Chapter 5 of LP-60 gives a complete description of the development of the incremental net daily inflows.

Not all the net daily inflows developed in LP-60 were used in this study. The net inflows from LP-60 for the three river segments from Mansfield Dam to Columbus were used without change. However, the net inflows for the Columbus to Bay City portion of the river were not used since they included the historical diversions for rice irrigation. Thus they are not representative of the actual inflows and channel losses in the river. For the Management Plan analysis of the Combined Firm Yield of the Highland Lakes, the net daily inflows from the drainage area between Columbus and Bay City are set to zero, which is a very conservative approach.

(ii). City of Austin Treated Wastewater Effluent Discharges

Inflows to the Colorado River below the Highland Lakes includes discharges of treated wastewater. By far, the largest of these discharges is from the City of Austin wastewater treatment plants to the east and south of Austin. For the Management Plan Combined Firm Yield analysis, the City of Austin effluent discharges are projected to be 149,800 acre-feet per year. This projection is based upon Austin fully using its maximum authorized annual municipal use senior water right of 272,403 acre-feet and then returning all effluent derived from that water. The resulting wastewater flow is assumed to be equal to the historical percentage (55%) of municipal water diversions returning as wastewater. This estimate of return flow is 149,800 acre-feet per year. The water used under Austin's water rights for steam electric power cooling water is not included in the return flow estimates.

It is recognized that currently the City of Austin is not returning this amount of water to the river; however, the criteria established for determining the Combined Firm Yield dictates that all water right holders must be assumed to be using all the water which they are entitled. For the City of Austin this amounts to 272,403 acre-feet per year for municipal use under its senior water right. The assumption has also been made that wastewater from this use will return to the river at a rate equal to the historical percentage; however, Austin may find other uses or other methods of disposal of such wastewater, thereby reducing the percentage. Additionally, the percentage may be decreased by decreases in inflow and infiltration to the City's wastewater collection system.

The annual return flow is distributed on a monthly basis according to historical monthly discharge patterns for the years 1978 through 1987, inclusive (Table 11). A uniform daily distribution is assumed for flow in any given month.

TABLE 11

MONTHLY DISTRIBUTION OF ANNUAL
CITY OF AUSTIN RETURN FLOW
CALENDAR YEARS 1978 - 1987

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
%	8.06	7.52	8.47	8.09	9.00	9.14	8.30	8.07	8.10	9.09	7.60	8.56	100%

The net runoff data for the river segment between the Austin stream gage and the Smithville stream gage includes approximately 12,500 acre-feet of historical discharges for the City of Austin during the historical critical drought period. To avoid double accounting of this historical return flow, the volume of the City of Austin return flow added to the system for the purposes of flow simulation is considered to be 137,300 acre-feet annually (149,800 less 12,500 acre-feet). The monthly distribution of that return flow is given in Table 12.

TABLE 12
MONTHLY RETURN FLOWS FOR THE CITY OF AUSTIN
ADJUSTED FOR HISTORICAL RETURN FLOWS
(1000 ACRE-FEET)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
11.1	10.3	11.6	11.1	12.4	12.5	11.4	11.1	11.1	12.5	10.4	11.8	137.3

Return flows from communities in the Colorado River Basin below Austin were not included as inflows to the river since the volume of projected inflows is very small compared to the natural inflows.

(iii). Return Flows From Irrigation

Studies made by TDWR in the 1970's indicated that as much as 35 percent of the water applied for irrigation of rice returned to surface water streams and eventually to coastal bays and estuaries. This represents an important source of fresh-water inflow to the estuaries. These inflows are estimated at about 150,000 acre-feet annually. Virtually none of this return flow reenters the Colorado River at or upstream of Bay City.

Because of the anticipated agricultural conservation measures, the estimated return flow percentage for the year 2030 will likely decrease from historical rates to a level of approximately 25 percent. These return flows must be considered in all estimates of total freshwater inflow to Texas bays and estuaries.

(3) Flow Routing Coefficients

To properly analyze the downstream system, it was determined that multiple day flow routing relationships would be required. The following equation represents the routing correlation of downstream to upstream discharges :

$$QD = [QU_t \times C_1] + [QU_{t-1} \times C_2] + [QU_{t-2} \times C_3] \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where QD and QU represent the downstream and the upstream discharges, respectively, t is the current day, and C is the routing coefficient.

The downstream system was divided into five reaches (Table 13). To enable staff to utilize the incremental inflows developed by the Texas Department of Water Resources in their report LP-60, these reaches were defined using the same end point locations. Each reach required a set of routing coefficients. These coefficients were derived using the curve fitting program QFIT, which was developed by the Texas Water Development Board (Report VM-49).

TABLE 13
Downstream Reach Definition

REACH NUMBER	LOCATION
1	MANSFIELD DAM TO USGS AUSTIN GAGE
2	USGS AUSTIN GAGE TO OLD USGS SMITHVILLE GAGE
3	OLD USGS SMITHVILLE GAGE TO USGS COLUMBUS GAGE
4	USGS COLUMBUS GAGE TO USGS WHARTON GAGE
5	USGS WHARTON GAGE TO USGS BAY CITY GAGE

Historical daily gage station records were obtained for each of the selected sites to be used as input to QFIT. Hydrograph pairs were selected for each reach which represented discharges in the range of 500 to 3000 cfs (the typical flow regime encountered during the irrigation season). In addition, the hydrograph pairs selected each had to exhibit the classic hydrograph wave shape. The values in each hydrograph had to have enough change to allow discernment of the wave from the upstream to the downstream gage.

After the hydrograph pairs were selected, QFIT was run under a variety of equation forms to test for the most reasonable curve fitting method. The specific coefficient calculation method resulting used only variable inflow coefficients, with outflow coefficients set to zero, and with the summation of all inflow coefficients equal to one. While runs were also

made which allowed variable outflow coefficients, these were used for cross-checking only, with runs actually being applied only when the resulting outflow coefficients equaled zero.

For each hydrograph pair, the number of prior days to be used in the flow equation was varied to test this factor's influence on the resulting coefficients. The predicted and observed outflow values were examined, and any large deviations were noted. The percentage difference between total predicted and observed outflows, or average daily deviation, was also checked, and only runs with an average daily deviation of less than one percent were further applied.

The resulting values were compared to known travel times for potential elimination. Those which appeared reasonable were maintained. The final coefficients were then generated by taking the average of the remaining sets of coefficients. The values used in the daily analyses are found in Table 14.

TABLE 14
Daily Flow Routing Coefficients

REACH NUMBER	DAY T	DAY T-1	DAY T-2
1	1.000	0.000	0.000
2	0.000	0.528	0.472
3	0.000	0.556	0.444
4	0.055	0.716	0.229
5	0.290	0.710	0.000

(4) Daily Flow Routing Procedure

The daily flow routing procedure is a simple mass balance. For each reach, a flow is computed which has two components. The primary component is the lateral inflow from within the reach and the second is the flow being passed from the upstream reach. The equations used for the flow routing are as follow:

$$QR_i = QR_{i-1} + (QL \times F_i) - D_i \quad \ldots\ldots\ldots \quad (2)$$

$$F_i = (DA_i - DA_{i-1}) / A \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where QR is the flow remaining after local diversion, i represents the diversion point within the reach (the values of i range from 2 to the number of diversion points simulated within the given reach), QL is the lateral inflow, F is the drainage area ratio of the diversion point, D is the diversion, DA is the drainage area at the current diversion point, and A is the drainage area of the reach. The initial value of QR for a given reach is QD as defined by equation

(1).

As can be seen by equations (2) and (3), it is assumed that only a proportionate amount of the lateral flow is available at any diversion point within the reach. Also, that this proportionate amount is based on the drainage area of the reach to the water-right holder's diversion point. The upstream flow is available to all diverters in the reach.

To simplify computations, it was assumed that the daily streamflow reflected at the upstream end of a reach would be routed to the downstream end before any extractions were made for local water rights. This action actually imposes an increased amount of conservatism into the routing. By routing the flows to the downstream end, additional attenuation is incurred which would not have physically occurred. This assumption will shift the time of diversion with respect to the pass through discharges in addition to causing additional discharges to potentially be required.

A review of the lateral inflows defined for LP-60 will show a considerable number of negative flows. Records of these negative flows were maintained in the routing model. These values were not routed from reach to reach, rather, they were stored for each reach as a demand from the system. The model kept summary records of the unsatisfied authorizations and the reach losses. These were then used in generating the required pass through flows to assure that the downstream demands were satisfied to the greatest extent possible.

The computation procedure of how much downstream demand remains after accounting for local area flows is as follows:

a. Compute the quantity of water available to the most upstream right. This requires that the daily lateral flows be adjusted by using a drainage area ratio and that the daily upstream flows be added to the result (note that the daily upstream flow has already been adjusted to reflect the attenuation which would result from passing it from the upstream to the downstream end of the reach);

b. Extract the amount required to meet the noted water right. If the daily flow is insufficient, maintain a record of the reach deficit, otherwise make the remaining daily flow available to the next downstream water right;

c. If all water rights in the reach have not been analyzed, return to step 1, else continue to step 4;

d. Record reach daily water deficits for further analysis. Two values are maintained for this study. One is the amount of the daily unsatisfied right and the other is the daily

stream flow loss which would need to be satisfied to allow flow to reach the additional reaches located downstream.

(5) Resulting Downstream Demand

The downstream area was divided into five reaches. The water demands associated with the full senior water rights in each reach are found in Table 15.

TABLE 15
Modeled Reach Demands

REACH NUMBER	DIVERSION DEMAND (ACRE-FEET/YEAR)
1	296,403
2	2,192
3	0
4	330,500
5	228,570

The total modeled demand is 857,665 acre-feet per year. The first step in developing the pass-through values of the Highland Lakes inflow was to determine to what extent the downstream inflows could not satisfy the lower basin demands. The results of this analysis are as follows:

a. Average annual unsatisfied demand was 520,657 acre-feet;

b. Maximum annual unsatisfied demand was 674,095 acre-feet; and

c. Minimum annual unsatisfied demand was 340,500 acre-feet.

These unsatisfied demands were then used as the input demands for determining the required pass through of inflows from the Highland Lakes.

(e) Required Releases of Daily Reservoir Inflows for Downstream Senior Water Rights

This section describes the procedure used to calculate the amount of daily inflow to the Highland Lakes that must be released to satisfy, to the extent possible, the water demands of the downstream holders of senior water rights. That portion of the daily inflows that remain is considered available for storage in the Highland Lakes.

(1) Inflow Pass Through Considerations

Under the terms of the Final Judgement and Decree and for the purposes of determining the Combined Firm Yield, daily inflows into the Highland Lakes must be released to the extent necessary to meet any downstream water rights senior to those of LCRA for the Highland Lakes. Not all inflows on a given day need to be passed through Mansfield Dam. Only that portion of the inflows needed to satisfy demands of the senior water right holders must be released.

All surface water diversions for senior downstream water rights must first be satisfied by inflows to the Colorado River from drainage areas downstream of Lake Travis. Only that portion of the senior water rights that cannot be meet from inflows to the Colorado River downstream of Mansfield Dam become the downstream demands for which inflows are passed through the Highland Lakes.

In this analysis, no distinction is made as to priority among the downstream water rights senior to LCRA's rights. The purpose of this section is to describe the method used to estimate the required releases of reservoir inflows to meet all senior rights regardless of their relative priority.

Determining the required reservoir releases of inflow depends upon the results of the routing of the unregulated, daily inflows below Mansfield Dam. Similarly, the results of the reservoir inflow release calculations are used in the reservoir firm yield calculations.

(2) Solution Procedure

The basic method proposed to determine the minimum reservoir inflows allowed to move downstream is to simulate, on a daily basis, the hydrologic conditions in all reaches of the river below Mansfield Dam.

(i) Steps in the Solution Process

The sequence of steps in the determination of the optimal reservoir inflow releases are indicated below.

Step 1. Read daily data for period of simulation: reservoir inflows, deficits in senior water right diversions, and channel losses not fully satisfied.

Step 2. Begin on initial day of simulation.

Step 3. Subtract the City of Austin water demand for the current day from the reservoir inflows for that day. If the resulting number is less than or equal to zero then set

the inflow available for reservoir storage to zero for that day and go to Step 7. If the resulting number is greater than zero then inflow is potentially available to meet any senior water right demand deficits downstream. Go to Step 4.

Step 4. Calculate total deficiencies in downstream senior water rights diversions for next eight days, including current day. If there are no deficiencies then go to Step 7. If there are deficiencies then go to Step 5.

Step 5. Determine the minimum amount of inflows to release to meet downstream senior water rights. This minimum release amount is calculated by solving the Linear Programming Flow Routing Problem (described below) for eight day period beginning on current day. Go to Step 6.

Step 6. Store optimal reservoir outflow for current day. Also, store any remaining unsatisfied channel losses and senior water right demands. Go to Step 7.

Step 7. Consider next day. If the end of the simulation period is reached then stop. Otherwise, go to Step 3.

(ii) Required Input Data

- Linear daily flow routing equations for each river segment between Mansfield Dam, Austin gage, Smithville gage, Columbus gage, Wharton gage, and Bay City gage.

- Diversion requirements (deficits) for senior water rights for each river segment that could not be met from routing inflows below Mansfield Dam.

- Net channel losses upstream of diversion deficits. These must be fully satisfied on each river segment before any senior right diversion deficit is computed on that river segment or any downstream segment.

- Combined daily inflows to Lakes Buchanan and Travis.

- All data are for the period January 1, 1941 through December 31, 1965, inclusive.

(3) Hydrologic Routing Relationships

Basic to determining the optimum reservoir releases is the hydrologic flow routing relationships. Figure 15 indicates the location of stream gages and water diversion demands used in the routing. The equations used to predict the daily flow at various points on the lower Colorado River have been developed by Water Resources Management staff. The flow

routing relationships and equations are discussed separately for each river segment. The flow routing equations used to simulate the passage of daily unregulated inflows below Lake Travis are identical to those used in the calculation of daily reservoir inflow releases.

LOCATION OF DIVERSION POINTS FOR ROUTING OF RESERVOIR RELEASES

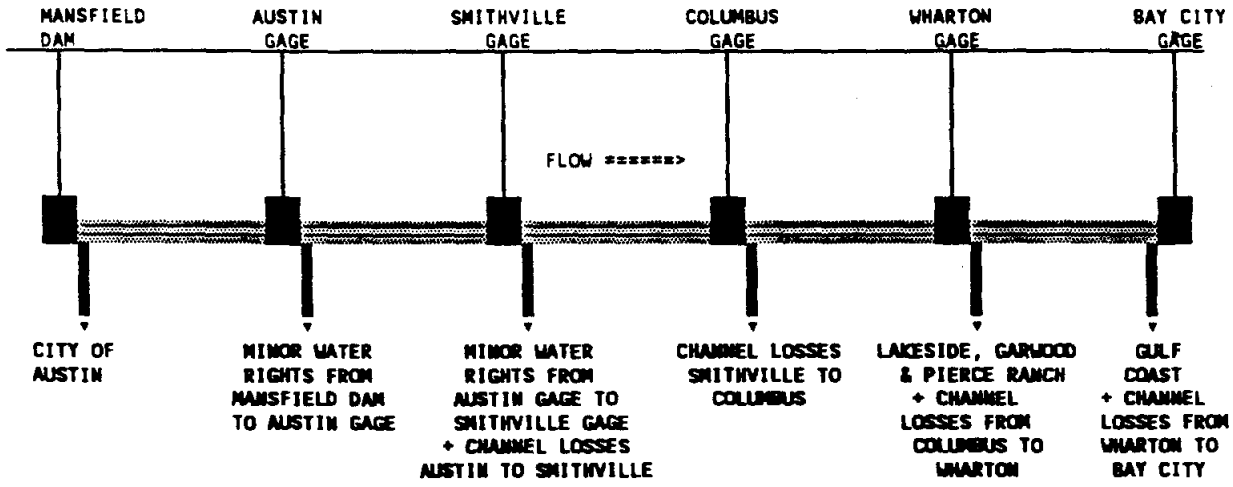


FIGURE (15)

(i) **Mansfield Dam to Austin Gage**

This stream segment receives inflow on day t from releases through Lake Travis ($I_{1,t}$). The City of Austin has part of its diversion ($COA_{1,t}$) at the upstream end of the section (Lake Austin). The remainder of its diversion ($COA_{2,t}$) is at Town Lake. For this analysis, this downstream diversion is treated as if it occurs at the upstream end of the river section. Therefore, the net daily flow into the reach is

$$\text{Reach Net Inflow on day } t = I_{1,t} - COA_{1,t} - COA_{2,t} \geq 0 \quad \ldots\ldots (1)$$

The flow travel time between Mansfield Dam and the Austin gage is only a few hours. Therefore, the daily outflow ($O_{1,t}$) at the Austin gage location is set equal to the inflow to the next downstream reach $I_{2,t}$.

The daily net incremental inflows for this reach are all nonnegative.

Thus no channel losses will accumulate at the Austin gage.

(ii) **Austin Gage to Smithville Gage**

This stream segment has minor daily water rights ($AS_{1,t}$) which are assumed to be withdrawn at the upstream end of the reach. Thus the net daily inflow to the reach is

Reach Net Inflow on day t = $I_{2,t} = O_{1,t} - AS_{1,t} \geq 0$.....(2)

This inflow is then routed to give the outflow on day t ($O_{2,t}$) at the Smithville gage location using the following daily flow routing equation for that stream segment.

$O_{2,t} = .528*I_{2,t-1} + .472*I_{2,t-2}$.....(3)

(iii) **Smithville Gage to Columbus Gage**

This stream segment has minor water rights on day t ($AC_{1,t}$) which are assumed to be withdrawn at the upstream end of the reach. The daily net incremental inflows for the Austin to Smithville river segment may be negative during certain periods. Any negative net incremental inflows on day t at the Smithville gage ($CL_{2,t} \leq 0$) calculated during the routing of uncontrolled inflows must be added to the deficit water rights diversions in determining the net reach inflow. Thus,

Reach Net Inflow on day t = $I_{3,t} = O_{2,t} - AC_{1,t} + CL_{2,t} \geq 0$.....(4)

This inflow is then routed to give the daily outflow (O_3,t) at the Columbus gage location using the following daily flow routing equation for that stream segment.

$O_{3,t} = .556*I_{3,t-1} + .444*I_{3,t-2}$.....(5)

(iv) **Columbus Gage to Wharton Gage**

This stream segment has major water rights demands on day t for the LCRA Lakeside Irrigation Division (LK_t) and Garwood Irrigation Company (GW_t) which are assumed to be withdrawn at the upstream end of the Wharton to Bay City reach. The daily net incremental inflows for the Smithville to Columbus river segment may be negative during certain periods. Any negative net flows at the Columbus gage on day t ($CL_{3,t} \leq 0$) calculated during the routing of uncontrolled inflows must be added to the deficit water rights diversions in determining the net reach inflow. Thus,

Reach Net Inflow on day t = $I_{4,t} = O_{3,t} + CL_{3,t} \geq 0$.....(6)

This inflow is then routed to give the daily outflow ($O_{4,t}$) at the Wharton gage location using the following daily flow routing equation for that stream segment.

$O_{4,t} = .055*I_{4,t} + .716*I_{4,t-1} + .229*I_{4,t-2}$.....(7)

(v) **Wharton Gage to Bay City Gage**

This stream segment has major water rights diversions for day t for Pierce Ranch (PR_t) and the LCRA Gulf Coast Irrigation Division (GC_t). Pierce Ranch diversions are assumed to be withdrawn at the upstream end of the reach. Diversions for Bay City are assumed to be withdrawn at the downstream end. In addition, the Garwood and Lakeside diversions are assumed to be withdrawn at the upstream end of this river segment.

The daily net incremental inflows for the Columbus to Wharton river segment are assumed to be zero. Thus,

Reach Net Inflow on day t = $I_{5,t} = O_{4,t} - PR_t - LK_t - GW_t \geq 0$....(8)

This inflow is then routed, using the following daily flow routing equation for this reach, to give the outflow in day t ($O_{5,t}$) of the reach prior to diversions for the Gulf Coast Division.

$O_{5,t} = .290*I_{5,t} + .710*I_{5,t-1}$.....(9)

The diversions for the Gulf Coast Irrigation Division are subtracted from the flow into the Bay City gage to obtain the resulting daily outflow. Thus,

Reach Net Outflow on day t = $O_{6,t} = O_{5,t} - GC_t \geq 0$.....(10)

(vi) **Time of Travel for Flows**

A flow release from Lake Travis takes a number of days to pass Bay City. Based upon the flow routing equations noted above, all flows released on a given day would have reached Bay City in eight days, beginning on the day of release. Therefore, eight days is considered sufficiently long to allow the influence of any reservoir release on a given day to pass completely through all river segments.

The simulated change in flow rates as water moves downstream is illustrated in Figure 16. A 1,000 cfs flow is assumed at Austin on day 1, with no flow at Austin for the remaining seven days. The flows in the river downstream of Austin are assumed to be zero on day 1.

(4) Channel Losses

Water flowing in the Colorado River is lost from plant evapotranspiration, surface evaporation and ground-water recharge. When these losses exceed the inflows from tributaries, ground-water seepage, and direct rainfall, then net channel losses occur.

The daily net incremental inflow data for the reaches below Lake Travis include many periods when channel losses (negative net incremental inflows) occur. In the flow routing of any reservoir releases, these negative inflows on a river segment act as "water demands" which must be fully satisfied before water can flow past that reach to a downstream senior water right holder. Therefore, to meet a downstream water right diversion demand requires the passage of reservoir inflows to the extent needed to fully satisfy the demand, up to the maximum amount of daily inflow to the reservoir. However, when there are no deficits in senior water rights diversions, then there is no need to release reservoir inflows just to satisfy channel losses below Lake Travis.

(5) Flow Routing Optimization Problem

(i) Problem Statement

Step 5 in the solution process determines the volume of reservoir inflows, on a given day, to pass downstream to meet the demands of senior water rights holders. This required release of daily reservoir inflows is determined by finding the minimum reservoir releases that satisfy, to the maximum extent possible, the water demands of senior water rights holders, while satisfying the following constraints:

The movement of water downstream in the lower Colorado River is governed by the set of linear flow routing equations (3), (5), (7) and (9).

The daily reservoir release cannot exceed the corresponding daily reservoir inflow.

Flow is conserved at all stream junctions as specified by equations (1), (2), (4), (6), (8), and (10).

Upstream channel flow losses must be satisfied fully before any downstream water rights diversion deficits can be satisfied.

All inflows to the Colorado River below Lake Travis have been used to the maximum extent possible to meet the maximum authorized diversion demands of downstream senior water rights holders.

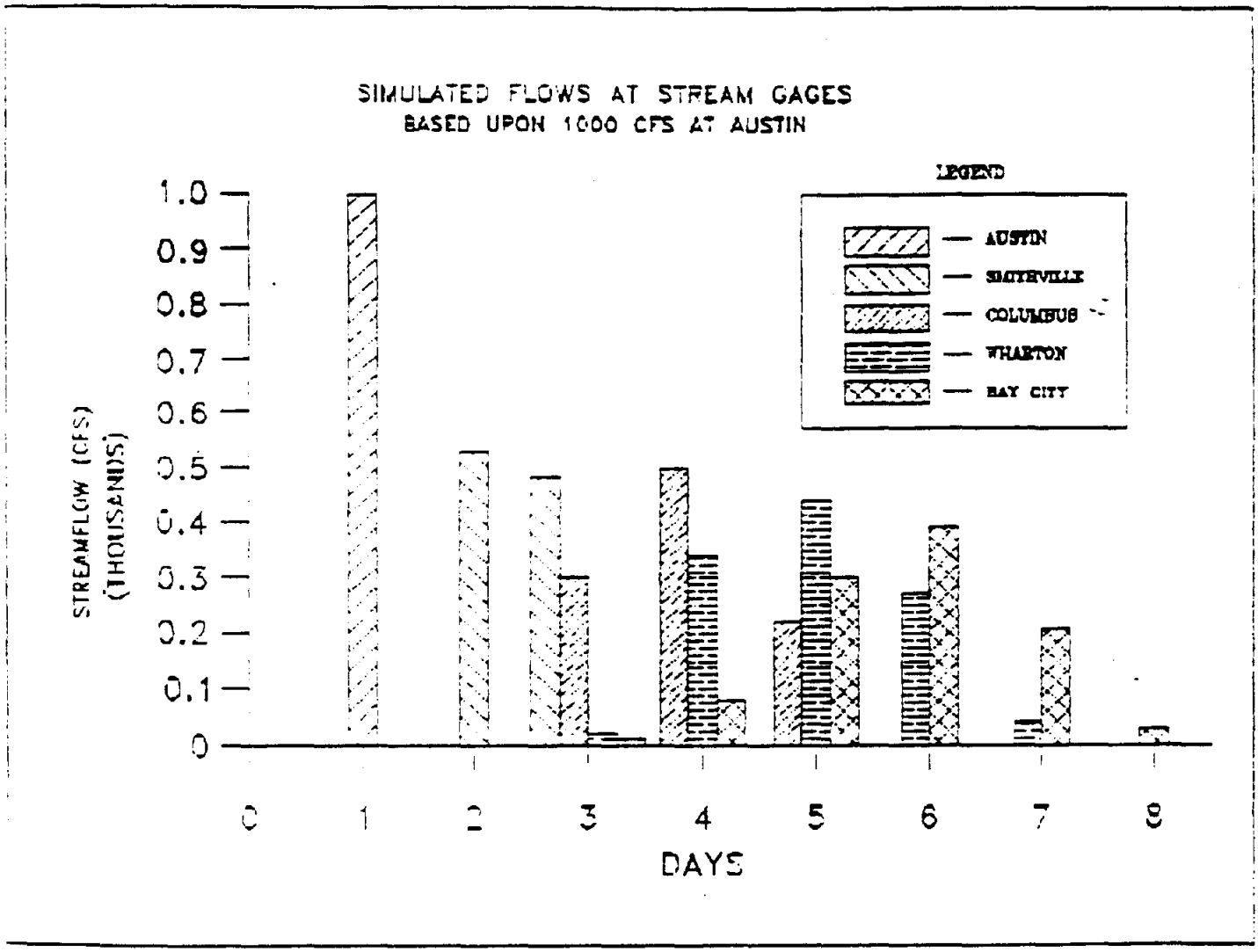


Figure 16
SIMULATION OF DOWNSTREAM FLOW RATE DECREASES

All river flows and diversions are nonnegative.

(ii) Linear Programming Optimization Technique

The minimum daily releases may be found by solving a sequence of Linear Programming (LP) optimization problems, one for each day in the simulation period when inflows may satisfy diversion demands. Linear Programming is a mathematical solution technique which maximizes a linear function while satisfying a set of linear equality or inequality constraints. The Linear Programming formulation for the reservoir release problem is given as finding the value of $I_{1,t}$ which maximizes, over days t through t+7, the total water demands met plus the total channel losses minus a penalty cost for water passing the Bay City gage. The solution must satisfy equations 1 through 10 for all eight days and must release no more than the inflow on day t.

The penalty cost is given by α times the total flows past Bay City in the eight days, where α is a constant coefficient. The penalty factor is needed to keep from releasing more water than is absolutely necessary to meet the downstream demands. Without a penalty for flows past Bay City, the Linear Programming solution can give a release in excess of the minimum needed. Such a release would give the same benefits of meeting all the diversions as the minimum release.

For example, suppose that 5,000 acre-feet of inflow occurs on a given day and that only 1,000 acre-feet is needed as a release to satisfy all demands downstream. Thus, any release value from 1,000 to 5,000 acre-feet is an alternative solution to satisfying all downstream demands. Without a penalty term, the Linear Programming solution may be larger than 1,000 acre-feet of release.

The 25 year simulation period is evaluated with a given constant value of α. The value of α is varied between these simulation to determine the penalty factor which gives the least releases of inflows while meeting the maximum downstream demands.

(6) Simulation Results

The solution process described above was used to determine the inflows needed to be passed to downstream water rights holders on a daily basis for the period 1941 through 1965, inclusive. Table 16 gives a summary of the inflows, demands, channel losses, and spills for the period using a variety of spill penalty values. The use of different penalty values allows an assessment of the tradeoffs between inflows available for storage and for downstream water diversions.

As would be expected, as the penalty value increases, there is a decrease in the water spilled past Bay City. However, as the spill penalty increases, the downstream water diversions remain essentially constant. The maximum water diversions possible are given when the penalty factor is zero.
An important result of the simulations is that storing inflow in the upstream reservoirs, instead of releasing it downstream, does not necessarily cause appreciable decreases in water diversions for water rights downstream. Figure 17 illustrates this condition. The amount of downstream water diversions remains within 1% of the maximum possible diversion until the penalty coefficient value is between 1.0 and 2.0. However, the inflows available for storage increases by 4.6 million acre-feet over the 25-year period: from 15.2 million acre-feet (for α=0.) to 19.8 million acre-feet (for α =2.0). Further, the 25-year total volume of released reservoir inflows passing Bay City decreases by 4.4 million acre-feet: from 4.52 million acre-feet (for α =0.) to 127 thousand acre-feet (for α =2.0). Thus, the additional water available for storage is actually water that would otherwise spill from the Colorado River Basin.

An α value of 2.0 appears to provide a reasonable penalty for spilling water past Bay City without unduly reducing the inflows released and actually diverted for downstream senior water right holders. Using this penalty value, the simulated water diversions are reduced about four percent from the maximum possible diversion volume of 4.63 million acre-feet (for α = 0.) to 4.47 million acre-feet. This is a reduction of 160 thousand acre-feet over the entire 25-years of simulation.

TABLE 16
SUMMARY OF DOWNSTREAM FLOW RATE SIMULATION

CATEGORY	SIMULATED TOTAL VOLUMES FOR PERIOD 1941-1965 (1,000,000 ACRE-FEET)					
	SPILL PENALTY COEFFICIENT (α)					
	.00	.10	.40	1.0	2.0	3.0
Reservoir Inflow	24.445	24.445	24.445	24.445	24.445	24.445
Water Diversion Demands	13.012	13.012	13.012	13.012	13.012	13.012
Channel Losses Met	.121	.121	.119	.119	.119	.105
Diversion Demands Met from Pass Through Reservoir Inflows	4.631	4.615	4.591	4.553	4.466	4.440
Flow Past Bay City Resulting from Pass Throughs of Inflows	4.524	1.723	.670	.458	.127	.075
Total Pass Throughs of Reservoir Inflows	9.276	6.459	5.380	5.131	4.712	4.621
Inflow Available for Storage in the Highland Lakes	15.169	17.986	19.065	19.314	19.733	19.824

TOTAL DIVERSION DEMANDS FOR SENIOR WATER RIGHTS BELOW MANSFIELD DAM TO BE MET FROM PASS THROUGHS OF RESERVOIR INFLOWS

(ACRE-FEET)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1941	19136	16123	19308	20437	26966	28675	34930	93097	79584	25678	10499	5839	380272
1942	12203	7411	9216	17726	58917	129662	71108	118740	59903	23634	18107	17595	550631
1943	17028	15479	18059	48610	87445	123107	75828	121213	64930	17726	12226	13821	507337
1944	12671	6862	6388	27108	47579	93998	87352	109096	48771	23868	12968	8175	485791
1945	4920	6900	6249	2546	60811	79737	77785	93627	50375	20316	14580	10122	428923
1946	6894	4401	5081	19104	27426	48813	60609	117286	42117	13623	1253	4397	351004
1947	1543	10138	14495	20090	73121	121685	83304	97286	45027	19344	14737	13829	514599
1948	16998	17883	13851	46260	75126	127996	84074	108065	68127	18698	14196	14382	605656
1949	14797	13617	16133	26016	79475	109915	79046	114042	69862	21294	12518	11550	568265
1950	12387	9954	17131	26809	69392	90708	77347	120122	58375	21113	15080	17264	535682
1951	15770	13607	17317	53394	99812	94273	97135	124186	58629	20849	16510	16225	627707
1952	15608	14461	21944	44267	80395	120731	88605	126336	65124	20528	10848	13164	622011
1953	10910	12980	18146	42700	55623	129987	76589	119034	51908	19848	13101	9823	560649
1954	12853	11286	23554	51633	92017	136315	100538	117915	74303	20550	15695	17202	673861
1955	15870	13190	25066	50968	75132	104300	84950	115303	74433	21260	12371	16742	609585
1956	14928	12252	21805	52934	90904	127484	94716	122141	76736	20859	14951	16355	666065
1957	15749	13412	14513	22682	19489	17301	46306	112513	71377	5579	91	1349	340361
1958	1384	488	6929	15340	21331	76663	62610	109494	40788	8821	7619	11592	363059
1959	11390	8393	12534	15292	53033	97310	81716	108521	61249	4081	5041	7259	465819
1960	5807	3758	5916	15542	63609	108973	52900	94805	64404	13934	9741	3962	443351
1961	3770	4682	4464	18087	73739	56095	21766	92491	41013	14412	7320	8393	346232
1962	10763	13565	15128	32158	88929	100217	80167	119408	61303	16110	13589	12022	564314
1963	11608	11723	17514	43654	91983	127934	90779	127702	79320	20605	16365	15144	654331
1964	14418	13406	16189	58439	103577	117673	91947	125078	60585	18253	13692	13988	647245
1965	10703	3072	10200	26686	26420	48118	60676	114922	68319	15269	10162	4682	399229

TABLE 17

SIMULATED MONTHLY SENIOR WATER RIGHTS DIVERSIONS FROM RESERVOIR INFLOWS

(ACRE-FEET)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1941	19136	16123	19312	20248	27069	26901	33691	29562	57388	24456	10499	5839	290224
1942	12203	7411	9107	16094	56359	99307	15132	37088	50499	23008	18107	17595	361908
1943	17000	12213	17139	21097	30181	46863	16768	1402	16975	13373	10404	12439	215853
1944	12671	6862	6388	15982	31780	62900	14041	14503	36586	17637	12968	8175	240493
1945	4920	6900	6249	2546	45088	45676	33822	12228	18799	18178	14440	10122	218968
1946	6894	4401	5081	12719	25985	19024	5824	2197	26086	12855	1253	4397	126715
1947	1543	10138	14495	16923	38123	19830	4140	2330	268	728	6439	8774	123731
1948	8103	10977	7436	18070	32328	31068	50841	26202	10808	3348	1890	6418	207489
1949	11122	12855	15685	17943	57066	49779	14941	6646	12535	8252	9093	11485	227401
1950	12139	9954	1253	9547	32767	12481	7258	4549	7641	1620	1424	1946	102579
1951	2388	8343	9533	964	28701	41215	1997	728	5226	3510	3169	2911	108685
1952	3052	1481	2703	19565	35615	26935	8946	12579	26012	2836	6856	13107	159687
1953	10910	10527	15732	14495	27291	2729	6291	21551	7226	14991	5295	2049	139087
1954	5408	4865	607	2421	49759	4035	1485	2009	1692	2352	6414	1015	82063
1955	6574	11114	940	2521	29359	68541	40926	33761	18375	13003	2336	2921	230370
1956	5367	8365	748	8309	52910	2963	839	6617	12930	3711	4315	4942	112015
1957	1741	6804	11691	10379	15474	14757	21648	2853	16819	5253	91	1349	108859
1958	1384	488	6929	15207	21244	44929	37399	19352	21347	8821	7619	11592	196312
1959	11390	8393	11672	12072	31939	48072	56407	17802	5737	4081	5041	7259	219866
1960	5807	3758	5916	14786	28280	5571	22443	39613	11216	12827	9741	3962	163920
1961	3770	4682	4464	16183	29319	28589	21463	35438	12976	14412	7320	8393	187009
1962	10763	13565	9097	19690	14620	26689	232	1854	5180	14914	10935	11544	139084
1963	10989	11118	10622	6531	35915	63006	4053	1126	4224	8486	13375	11891	181336
1964	12679	13406	16046	19985	20030	4933	16	6186	21081	18255	13692	13988	160296
1965	10703	3072	10200	19565	14873	35117	20634	2392	15156	15269	10162	4682	161824

TABLE 18

SIMULATED MONTHLY CHANNEL LOSSES SATISFIED BY RESERVOIR PASS THROUGHS

(ACRE-FEET)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1941	0	0	0	454	9184	4805	101	232	817	192	0	0	15786
1942	0	0	54	0	2	3461	420	1890	5020	1677	0	0	12523
1943	0	0	1039	2183	129	1982	71	0	167	0	0	0	5570
1944	0	0	0	73	1949	1130	0	62	1083	30	0	0	4328
1945	0	0	0	0	204	196	3709	0	375	0	0	0	4485
1946	0	0	0	125	0	0	0	0	119	0	0	0	244
1947	0	0	0	0	155	0	0	0	0	0	0	0	155
1948	0	0	0	145	83	133	2378	16	0	182	0	0	2936
1949	0	0	157	0	0	206	0	0	156	0	0	0	519
1950	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	1015	1085	0	0	0	0	0	0	2100
1952	0	0	0	0	133	2519	0	0	4395	0	0	0	7046
1953	0	0	0	505	1359	0	0	0	0	0	0	0	1864
1954	0	0	0	0	2997	0	0	0	0	0	0	0	2997
1955	0	0	0	0	6905	8860	3498	3046	8135	2259	0	0	32704
1956	0	0	0	0	5093	0	0	0	0	0	0	0	5093
1957	0	0	0	0	7295	6118	0	0	245	0	0	0	13657
1958	0	0	0	0	0	266	0	0	0	0	0	0	266
1959	0	0	0	0	0	0	2118	111	0	315	0	0	2544
1960	0	0	0	0	0	178	0	0	0	0	0	0	178
1961	0	0	0	0	112	658	0	0	0	0	0	0	771
1962	0	0	0	0	2	1126	0	0	0	0	0	0	1128
1963	0	0	0	0	40	0	0	0	0	0	0	0	40
1964	0	0	0	1018	557	59	0	0	288	0	0	0	1920
1965	0	0	0	89	0	0	0	0	0	0	0	0	89

TABLE 19

SIMULATED MONTHLY FLOWS PAST BAY CITY FROM RESERVOIR PASS THROUGHS

(ACRE-FEET)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1941	0	0	0	775	2955	2862	1485	0	1187	251	0	0	9515
1942	0	0	203	491	3987	3406	142	2290	4202	585	0	0	15307
1943	0	0	4	561	79	2054	537	0	1000	0	0	0	4235
1944	0	0	0	303	2333	3429	0	0	1286	118	0	0	7469
1945	0	0	0	1	2406	913	1737	0	70	1	0	0	5128
1946	0	0	0	244	2612	739	34	0	474	0	0	0	4104
1947	0	0	0	610	2007	0	63	0	0	0	0	0	2679
1948	0	0	3	617	1372	689	2016	536	156	47	0	0	5436
1949	0	0	211	168	2171	1168	47	0	0	0	0	0	3765
1950	0	0	0	0	726	482	18	0	16	0	0	0	1243
1951	0	0	0	0	2224	1645	0	0	2	0	0	0	3871
1952	0	0	0	910	1318	1033	0	0	1364	0	0	0	4625
1953	0	0	4	117	913	0	0	266	382	0	0	0	1681
1954	0	0	0	0	1139	51	0	0	0	0	0	0	1190
1955	0	0	0	0	3817	7750	2022	0	3219	733	0	0	17540
1956	0	0	0	130	3298	0	0	0	0	0	0	0	3428
1957	0	0	0	27	4754	3267	267	0	0	0	0	0	8316
1958	0	0	0	0	1939	3461	1009	0	520	0	0	0	6929
1959	0	0	25	318	746	2777	2483	0	0	210	0	0	6558
1960	0	0	0	389	82	0	227	1662	0	0	0	0	2360
1961	0	0	0	738	202	1117	1101	449	464	0	0	0	4073
1962	0	0	0	453	70	140	0	0	0	0	0	0	663
1963	0	0	0	0	794	977	0	0	0	0	0	0	1770
1964	0	0	163	883	0	0	0	0	180	1	0	0	1227
1965	0	0	46	614	871	1954	95	0	0	0	0	0	3580

TABLE 20

SIMULATED MONTHLY RESERVOIR INFLOWS AVAILABLE FOR STORAGE

(ACRE-FEET)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1941	78213	213250	264511	422194	747597	380518	117806	3917	12309	162238	41931	32705	2477189
1942	25242	19467	18382	248336	233338	37215	4264	40728	87478	290136	83511	30986	1119082
1943	6336	3272	6501	7308	0	69894	7593	0	10085	16100	1926	3407	132421
1944	77131	84752	113052	14811	393515	51694	0	87106	67216	20966	14822	89298	1014363
1945	150148	154941	184864	250246	24865	28559	37994	0	59314	22014	6467	21776	941188
1946	57182	81404	44527	76811	133121	11294	0	341	31451	21857	93950	70330	622268
1947	203837	52150	67619	26686	10707	0	0	0	0	0	607	9749	371356
1948	24	6552	6866	7820	25509	151761	39361	791	6544	879	0	54	246160
1949	2788	46669	78337	185329	44489	3732	0	0	0	12300	184	8659	382486
1950	3375	24280	0	17787	5966	3750	1426	0	1426	0	0	0	58011
1951	0	0	2493	0	19352	54342	0	0	1717	0	0	0	77904
1952	0	0	0	54242	120077	2058	0	0	919291	0	18007	106962	1220638
1953	44003	3274	36106	11440	128739	0	0	2350	2082	71960	149	75	300179
1954	274	0	0	0	2659	0	0	0	0	589	12681	0	16203
1955	1854	18156	0	51	349086	103974	63065	0	172229	7226	0	0	715642
1956	0	3675	0	11201	214530	0	0	0	0	3560	2057	1327	236349
1957	0	363	32041	616597	1129879	481621	0	0	38214	697493	196589	84010	3276807
1958	100382	356619	221545	71611	224697	202295	3534	0	67457	56519	50197	23796	1378652
1959	16704	32693	14624	48158	5643	233663	64422	0	1222	668260	46788	109411	1241589
1960	206798	153416	69775	45812	10420	0	13006	72451	2120	80121	42202	147195	843317
1961	159820	279671	97389	16756	0	346163	68337	0	4460	44941	15033	22033	1054603
1962	10065	14471	0	7114	0	9355	0	0	0	45229	1172	1696	89101
1963	875	3018	292	335	6553	11059	0	0	0	4	19394	48	41577
1964	4962	24951	34839	14985	0	28	0	0	406673	43958	79034	10223	619653
1965	30706	225311	43628	13929	596289	53847	263	0	102408	51222	51607	87439	1256649

TABLE 21

(i) Water Diversions

Table 17 gives the monthly demands for all senior water rights holders downstream of Mansfield Dam after using all available inflows to the Colorado River downstream of Lake Travis. The monthly inflows used directly to satisfy these diversion demands of senior water rights, using α =2.0, are shown in Table 18.

(ii) Channel Losses

The monthly inflows required to meet channel losses, using α=2.0 are, shown in Table 19.

(iii) Flows Past Bay City

The monthly inflows passing the Bay City stream gage, using α=2.0, are shown in Table 20.

(iv) Inflows Available for Storage

The monthly inflows available for storage in the Highland Lakes, using α=2.0, are shown in Table 21.

E. Combined Firm Yield Summary

The Combined Firm Yield of Lakes Travis and Buchanan was determined in accordance with the directives of the Final Judgement and is as shown in Table 22. The essential criteria specified in the decree for the determination of the Combined Firm Yield was that all senior downstream water rights must be honored by LCRA by passing through inflows necessary to meet those senior water rights to their fullest extent. Those senior water rights include not only the City of Austin, Garwood, and Pierce Ranch Irrigation Companies but also the irrigation units owned by LCRA - Lakeside and Gulf Coast Irrigation Divisions. Honoring these senior water rights at their fully authorized diversion rate and annual demand has a major impact on the firm yield determination of Lakes Travis and Buchanan. In considering the Combined Firm Yield as calculated herein, we should keep in mind that current demands under the senior downstream water rights are about 65 percent of the authorized total. It is problematical whether or not future demands will approach the authorized quantities. Future contractual relationships with the senior downstream water rights holders may also have significant impact on the Combined Firm Yield of Lakes Travis and Buchanan.

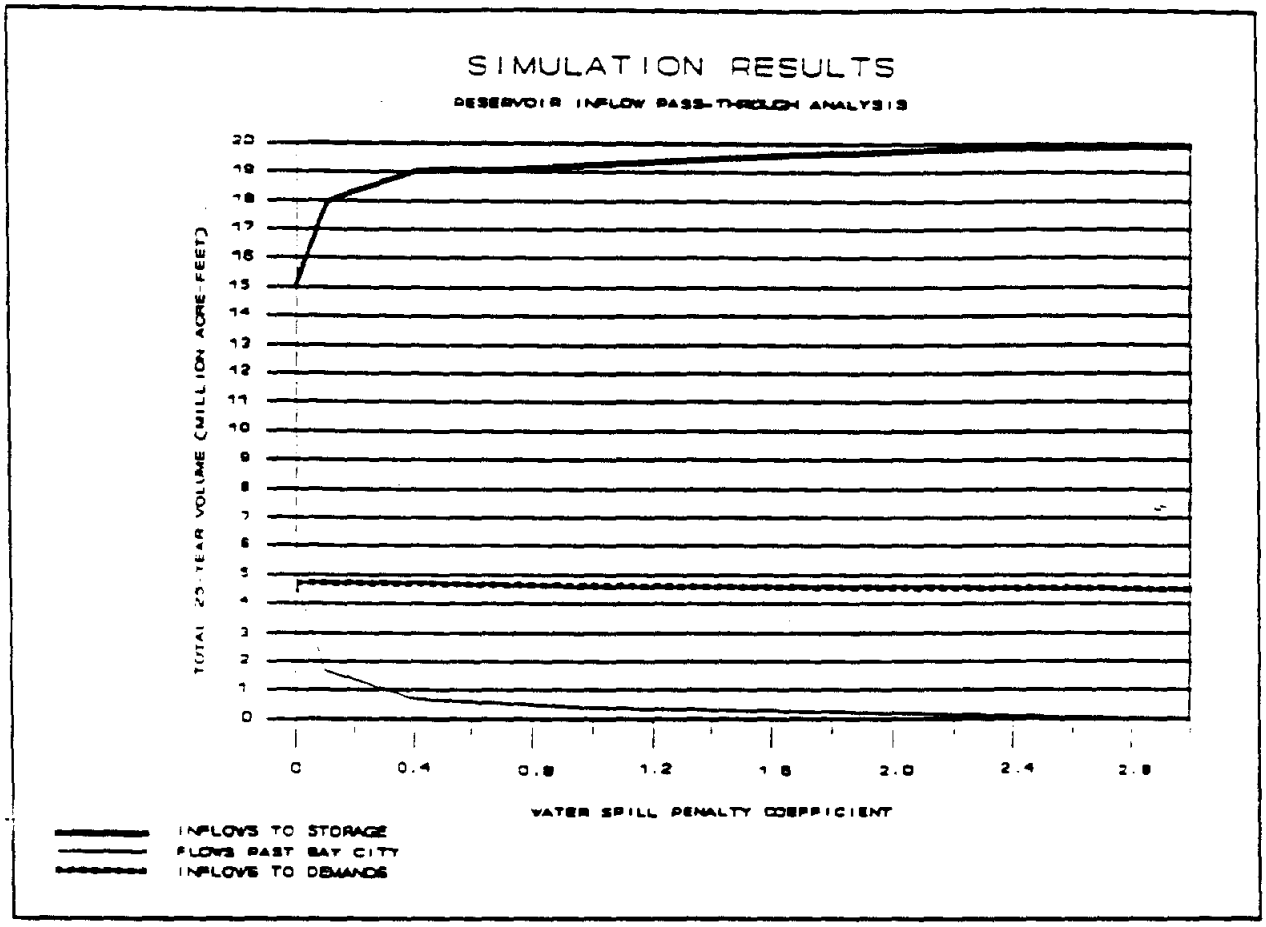


FIGURE 17
SIMULATION RESULTS RESERVOIR PASS THROUGH ANALYSIS

TABLE 22
Combined Firm Yield
Permits 1259 and 1260
Acre-Feet/Year

Highland Lakes	445,266
Owen Ivie	90,546
Total	535,812

(1) Hydrologic Significance of Firm Yield

The Combined Firm Yield as determined and used herein is based on a drought period (1947-57) identified as the most severe occurring during the 90-year period since data collection started in February 1898. Although firm yield of reservoirs is usually expressed as the minimum supply available in any single year, the cumulative effect of the drought period is the most influencing factor. For example, the minimum annual streamflow since 1898, at the Austin gaging station has been 358,880 acre-feet in 1917; whereas, the minimum annual

streamflow at the station during the 1947-57 drought period was 558,080 acre-feet.

Statistical inference in hydrology is based on being able to array annual events in normal distributions. Therefore, computing the recurrence interval for variable-duration drought periods is not practical with only a 90-year period of record. Moreover, the hydrologic considerations necessary in computing the Combined Firm Yield as defined herein, removes much of the natural hydrologic recurrence associated with drought periods.

(2) Demand Alternatives

The Combined Firm Yield computed for the Highland Lakes is based on passing through streamflow as required to satisfy downstream senior rights up to their maximum authorized annual amount. Actual operations under the Plan will see streamflow passed through to satisfy senior rights holder's actual demands. In many years the actual demands can be expected to be less than the maximum authorized rights. Of course, this is a major factor in being able to fulfill water supply demands in many years greater than the Combined Firm Yield.

CHAPTER 6

WATER OPERATIONS SYSTEM

A. INTRODUCTION

The Water Operations System is a network including remote data acquisition, central computers, and hydrologic models (Figure 18). It is being used on a daily basis to monitor the Colorado River and operate the Highland Lakes.

B. HYDROMETEOROLOGICAL DATA ACQUISITION NETWORK

LCRA has in operation a Hydrometeorological Data Acquisition System (Hydromet) which allows remote interrogation of a networked system of twenty-one self-reporting rainfall gages, twenty-two remotely monitored streamflow gages and six reservoir elevation gages. Twenty of the streamflow gages also gathers rainfall information, giving a total of forty-one rainfall sites. The network is polled each hour, and all data is verified and stored in a real-time data base on the Central Computer System. Communications are a combination of microwave and UHF radio. The relational data provided by the Hydromet monitors flows above and below the lakes. Figure 19 shows the location of these gages. In 1988, LCRA will complete this network by installing additional equipment downstream of the lakes to allow better definition of tributary inflows in the lower basin. Figure 20 shows the location of these lower basin gages.

C. Central Computer System

A Central Computer System comprised of two Digital Equipment Corporation MicroVAX II mini computers, one of which is designated as an operations system located at the LCRA System Operations Control Center, and the other designated as a development system located at the Water Resources office. Real time data is logged and maintained on an on-line historical data base for one year. This is available for access by operations models, historical analyses, or other needs.

D. Hydrologic Models

LCRA currently maintains hydrologic models which are utilized for routine operations of the system. Each model was developed to meet specific operational needs. The Daily Operations Model was developed to assist and improve release operations for downstream water supply commitments. The Flood Operations Model was developed to aid in definition and

operation of flood management. Each model is further discussed in the following sections.

(1) Daily Operations Model

Each day LCRA analyzes downstream inflow and demands by accessing streamflow data, totalling demands, and making multiple computer runs of the Daily Operations Model. This determines the optimum amount of water to be released, by maximizing use of downstream inflows and minimizing the amount of water which must be released from storage. Realizing the seven-day flow time from storage to the farthest downstream diverter, the operator can determine the optimal release from storage by simulating the effect releases have downstream when added to the natural inflows. Graphical output can be viewed on color CRT or printed using TEKTRONIX graphics routines. Figure 21 shows a diagram of the model with a sample output run shown in Appendix 4A, Volume II.

(2) Flood Management Model

The Flood Management Model is a user oriented operation tool which accesses real-time data and routes flood flows through the Highland Lakes. Its primary purpose is to allow optimum flood control operations of Mansfield Dam by forecasting inflow 12-36 hours in advance. These forecasts are necessary to protect the 100-year flood plain elevation on Lake Travis and downstream through the City of Austin. Additionally, due to flood plain encroachment both upstream and downstream of Mansfield Dam, it is necessary to have these forecasts for all lakes. To reduce flood damage potential, flood operations are governed by lake elevation and inflow forecasts, rather than line-of-sight operations. The Flood Management Model allows the user to simulate releases at all dams to determine the optimum utilization of flood flows. Releases from Mansfield Dam are routed through Lake Austin and Town Lake downstream to the Gulf of Mexico. Rainfall data from the raingage network is used to calculate runoff and for estimates of additional inflow into the Highland Lakes and the river downstream of Austin. The results of the model in the form of graphical output can be viewed on color CRT or printed using TEKTRONIX graphics routines. A more complete explanation of the model is included in Appendix 4B, Volume II.

E. STANDARD OPERATING PROCEDURES FOR THE HIGHLAND LAKES

There are currently two modes of Standard Operating Procedures for the Highland Lakes. The first is the daily operations mode, in which daily demands for water are met by releases from Lakes Buchanan and Travis and the intermediate reservoirs are maintained within normal operating levels. The second is flood control, which primarily concerns Lake Travis since it

is the only reservoir with a dedicated flood pool. Incorporation of the Water Management Plan will add a third mode for drought contingency It will also modify Daily Operations procedures to incorporate instream flow requirements, allocation of releases, allocation of inflow, and improvements in customer communications.

(1) Daily Operations

Daily Operations are a joint effort between the System Operations Control Center (SOCC), Hydro Operations personnel located at the dams, and Water Operations personnel located at the Central Office complex (Figure 22). Water Operations personnel determine the required release by contacting downstream customers, operating the Daily Operations Model, and posting the daily release schedule. The SOCC then determines the optimum time during the day to release the water based on the daily power peak demand, and orders the hydro generation units to begin and end at the necessary times. Hydro Operations personnel at each dam determine which unit to run at each dam, and operate the unit at the optimum efficiency at the required load.

(a) Standard Operating Levels

Standard operating levels are as noted in Table 23.

Table 23
Standard Operating Levels for the Highland Lakes

LAKE	TARGET ELEVATION RANGE (NGVD)	
Lake Buchanan	**1020.35**	
Inks Lake	**887.30**	**+/- 0.4**
Lake LBJ	**824.70**	**+/- 0.3**
Lake Marble Falls	**736.60**	**+/- 0.4**
Lake Travis	**681.00**	
Lake Austin	**492.30**	**+/- 0.5**

(b) Dedicated Release Demands on Storage

The procedure outlined in (Table 10) concerning the Highland Lakes Operating Policy describes in detail the standard operating procedure for determining the percent demand on Lake Buchanan's storage versus Lake Travis' storage.

(c) Variances on Daily Operations Procedure

From time to time the LCRA must deviate from normal operating procedures to perform necessary maintenance, or to honor the

request of a public entity. Examples of this may be drawing down a lake preceding maintenance on a dam, in the interest of safety, or interrupting daily release operations for public events, such as the Austin Aqua Festival. The LCRA retains the right to use its discretion in operating its reservoirs during such events, to protect its investments and the public safety, as a responsive public servant.

(2) Flood Operations

Flood operations are governed by the Corps of Engineers/Bureau of Reclamation/LCRA Water Control Manual for Mansfield Dam. The principal operating criteria in this manual are summarized in Appendix B, Volume I.. Operating procedures for the remaining structures are simply to refill Lake Buchanan's conservation pool, to pass excess flows as they occur, and to keep outflow rates less than or equal to inflow rates. These procedures are summarized in Figure 23.

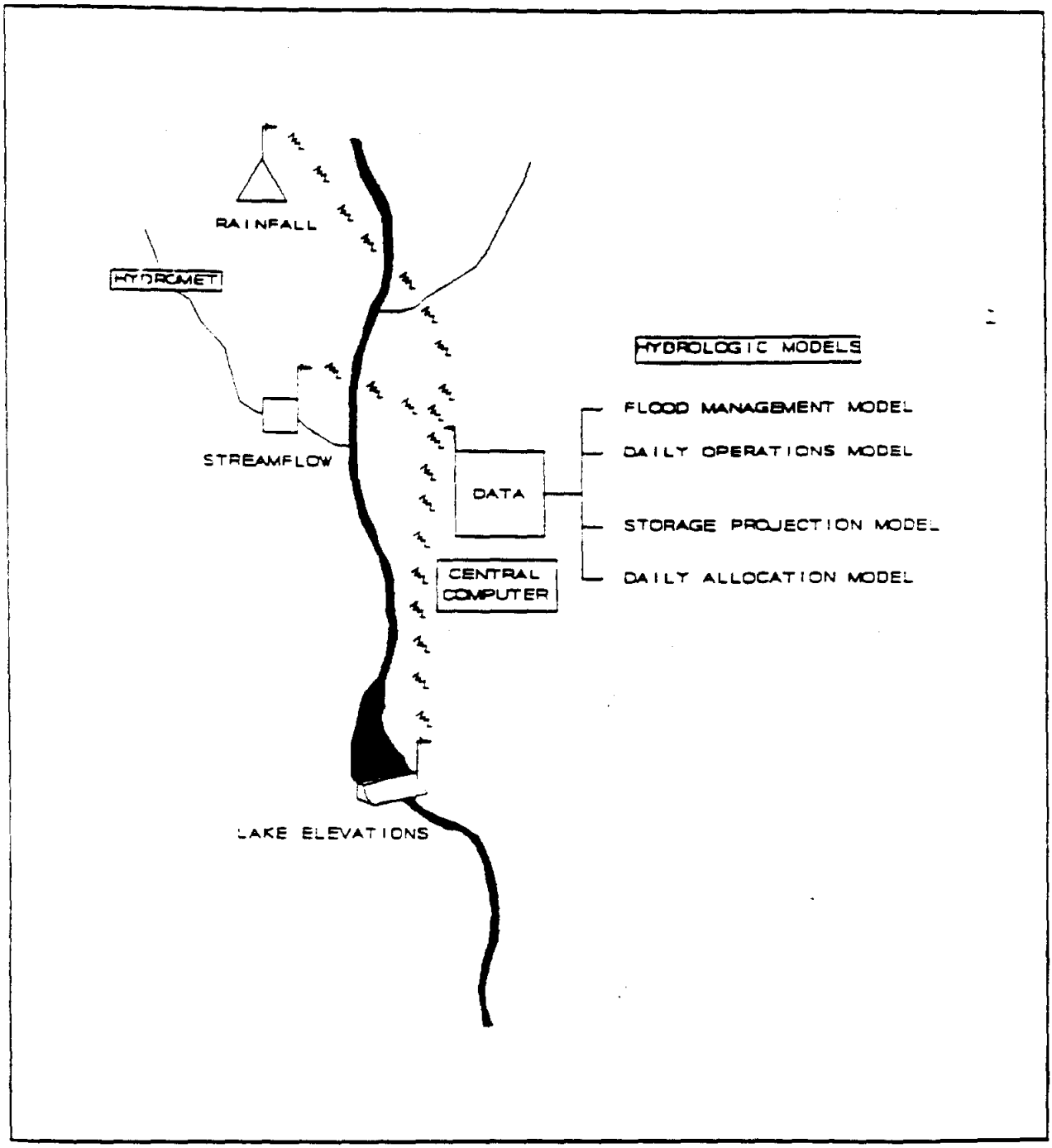


FIGURE 18
LCRA WATER OPERATIONS SYSTEM

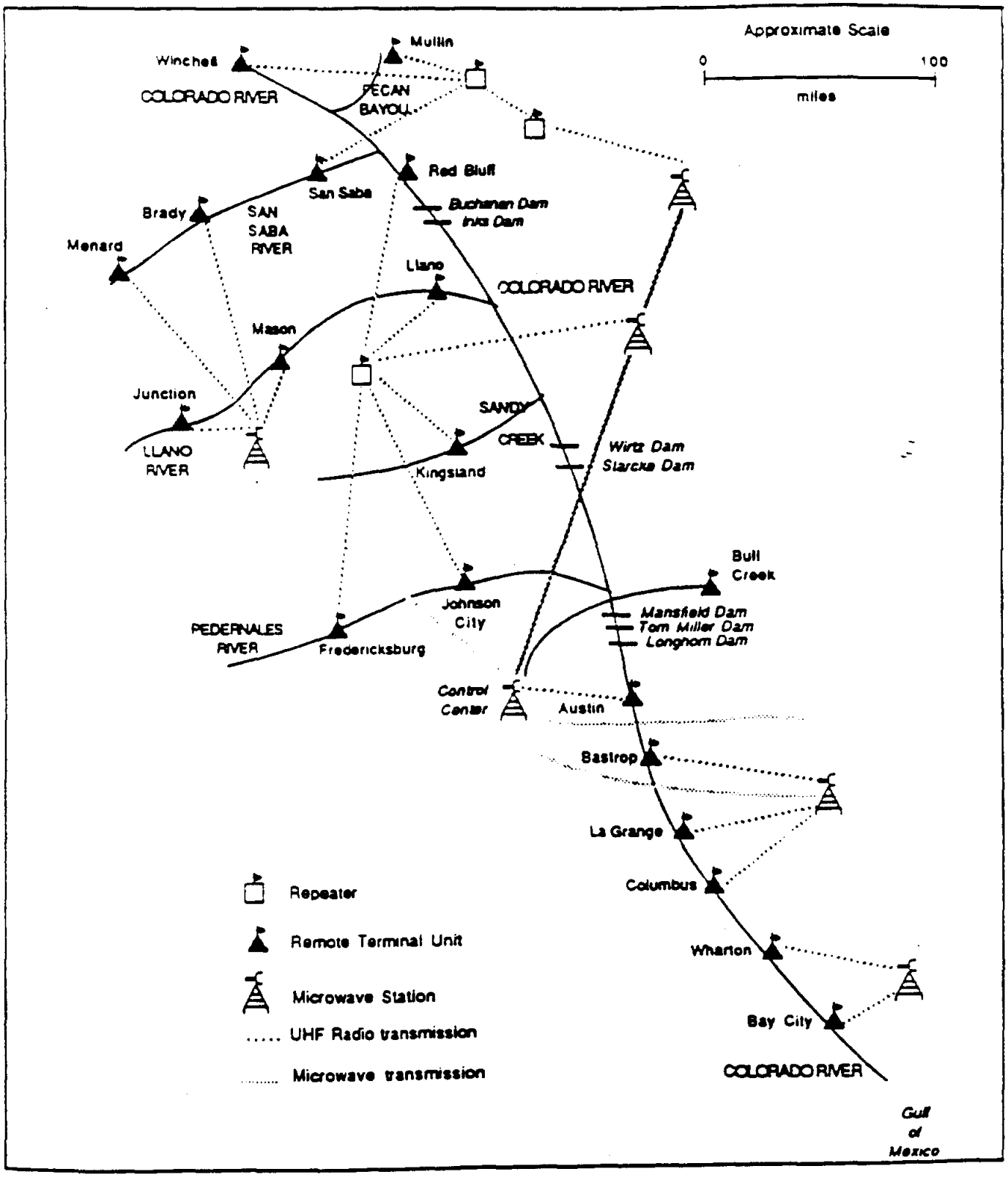


FIGURE 19
LOWER COLORADO RIVER AUTHORITY HYDROMETEOROLOGICAL
DATA COLLECTION (HYDROMET) NETWORK

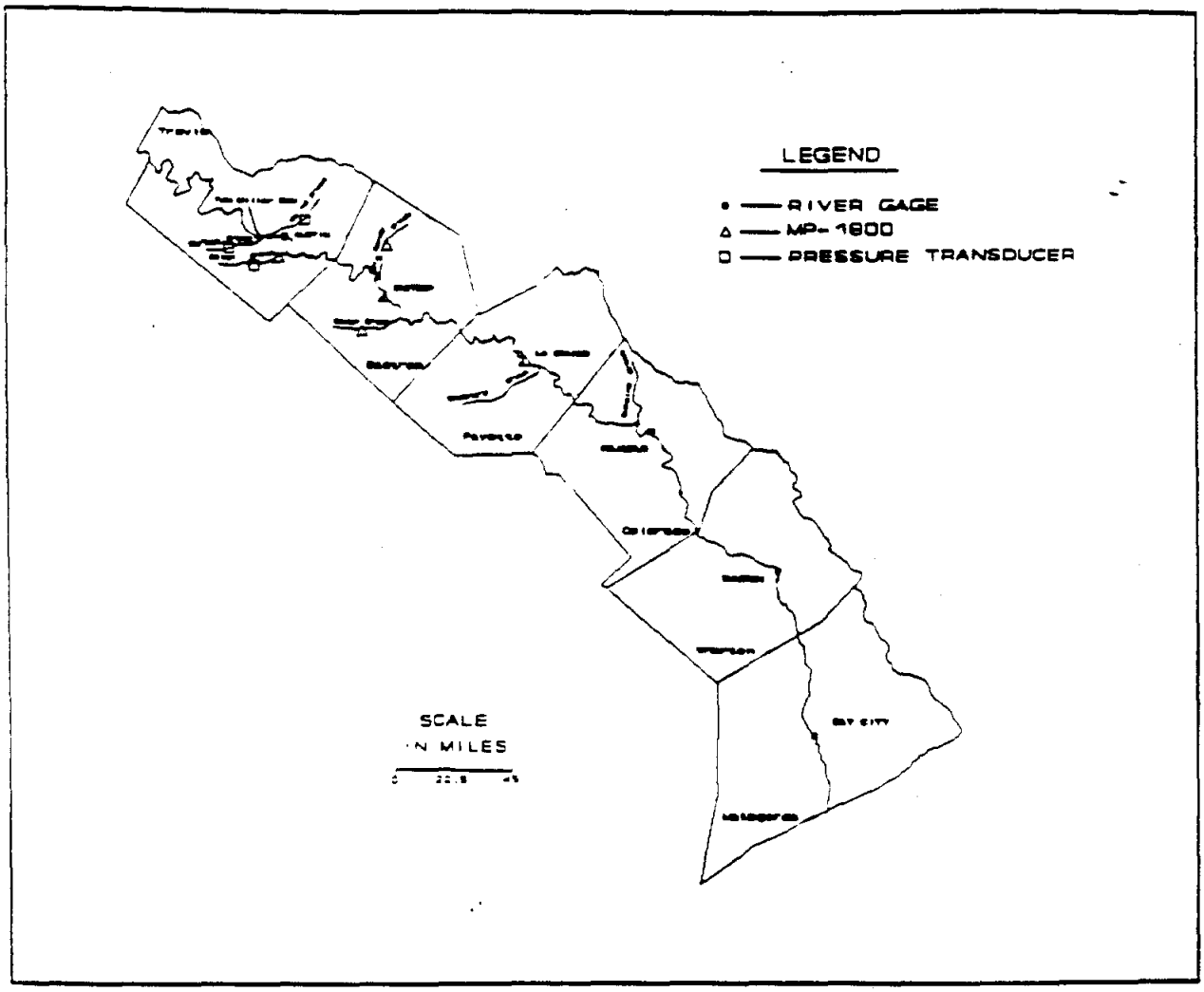


FIGURE 20
LCRA LOWER BASIN RIVER GAGE NETWORK

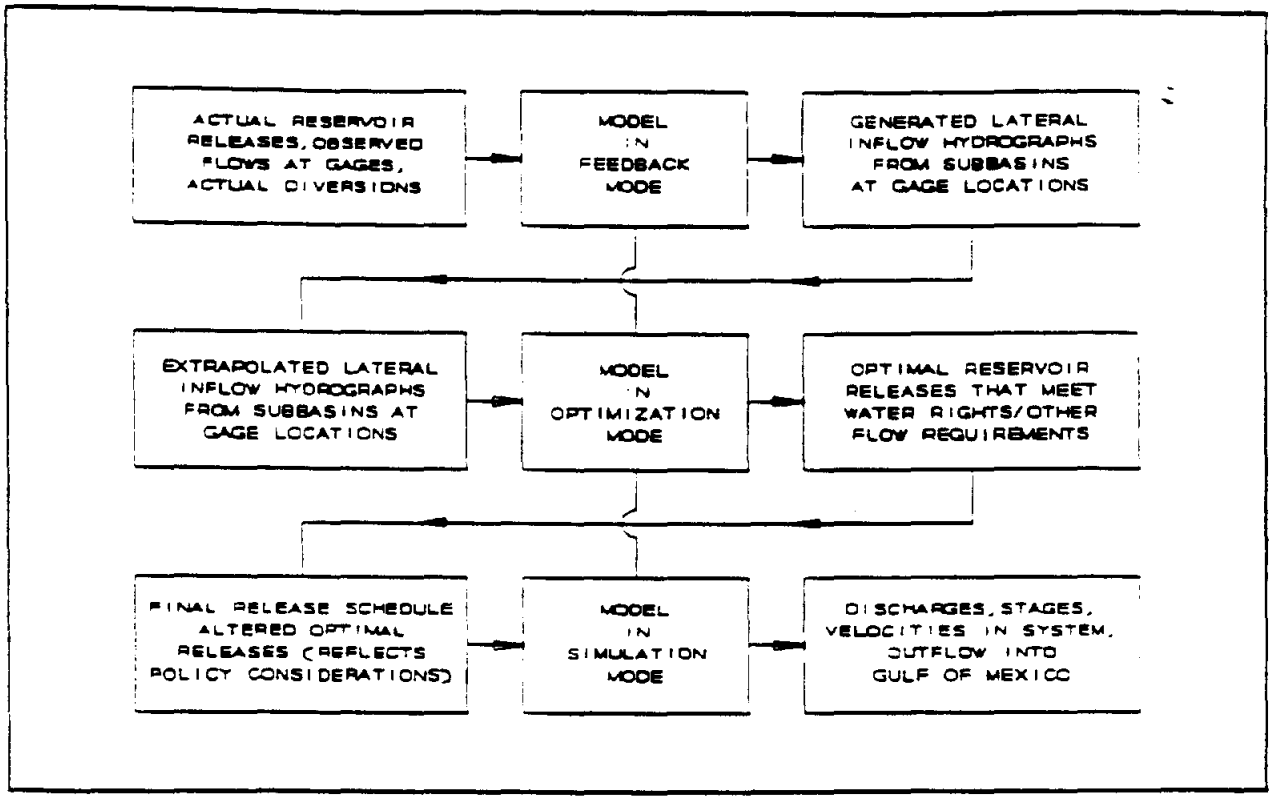


FIGURE 21
DAILY OPERATIONS MODEL ONE-LINE

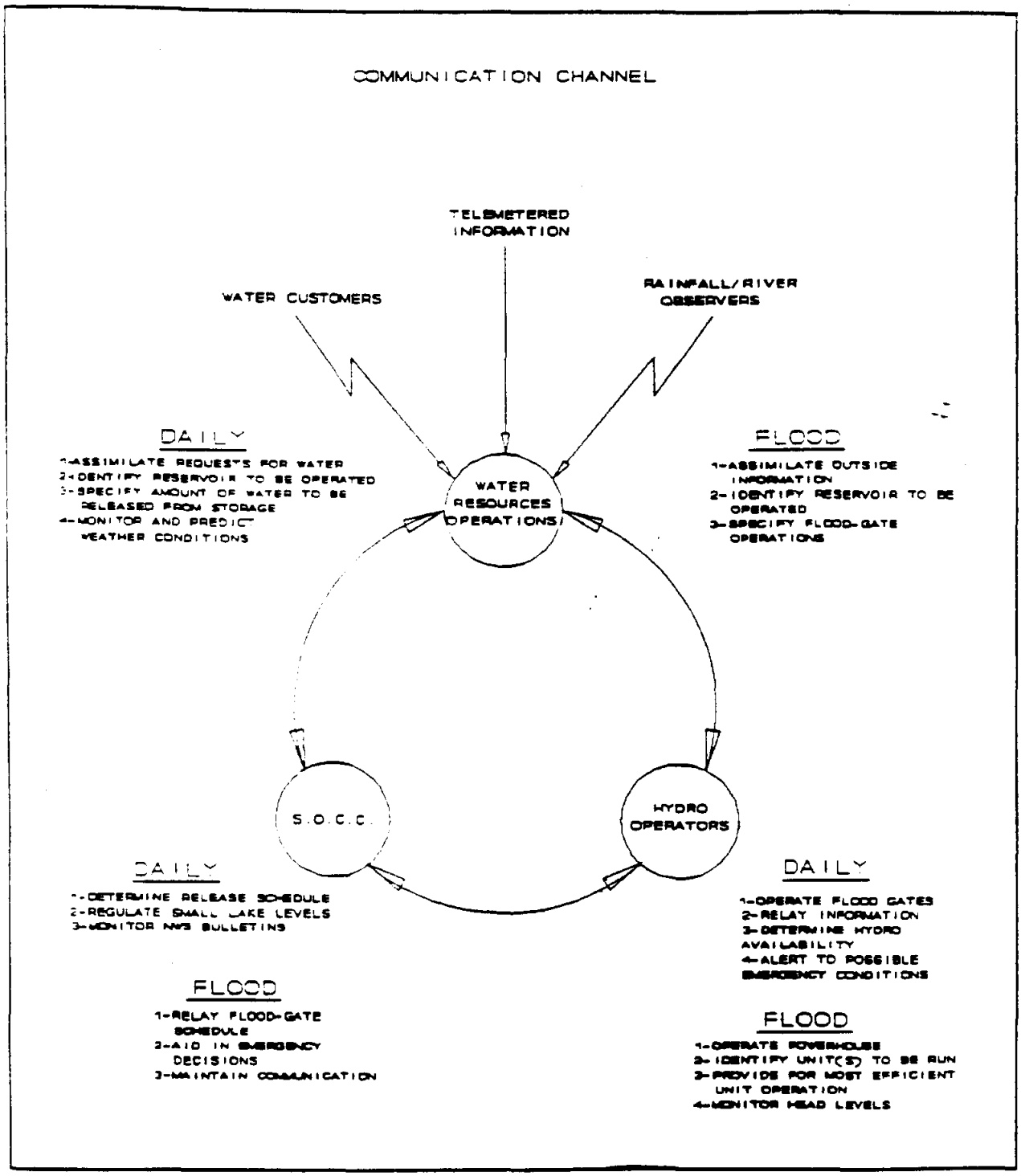
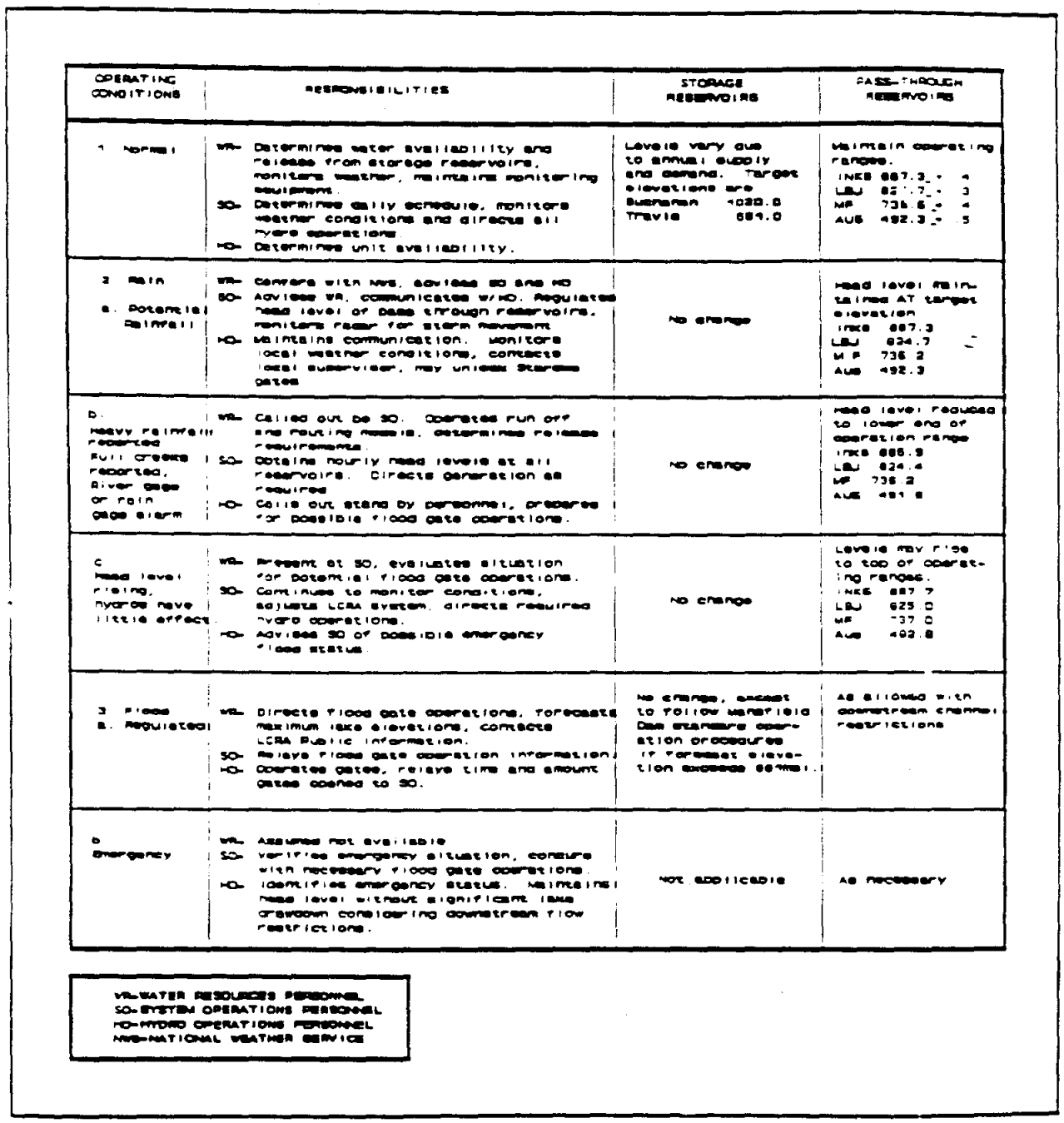


FIGURE 22
LCRA WATER OPERATIONS COMMUNICATION CHANNEL



OPERATING CONDITIONS	RESPONSIBILITIES	STORAGE RESERVOIRS	PASS-THROUGH RESERVOIRS
1 Normal	WR- Determines water availability and releases from storage reservoirs, monitors weather, maintains monitoring equipment. SO- Determines daily schedule, monitors weather conditions and directs all hydro operations. HO- Determines unit availability.	Levels vary due to annual supply and demand. Target elevations are Buchanan 1020.6 Travis 681.0	Maintain operating ranges. INKS 887.3 ± .4 LBJ 824.7 ± .3 MF 736.6 ± .4 AUS 492.3 ± .5
2 Rain a. Potential Rainfall	WR- Confers with NWS, advises SO and HO SO- Advises WR, communicates w/HO. Regulates head level of pass through reservoirs, monitors radar for storm movement HO- Maintains communication, monitors local weather conditions, contacts local supervisor, may unless Starnes gates	No change	Head level maintained AT target elevation INKS 887.3 LBJ 824.7 MF 736.2 AUS 492.3
b. Heavy rainfall reported Full creeks reported, River gage or rain gage alarm	WR- Called out by SO. Operates run off and routing models, determines release requirements. SO- Obtains hourly head levels at all reservoirs. Directs generation as required HO- Calls out stand by personnel, prepares for possible flood gate operations.	No change	Head level reduced to lower end of operation range INKS 886.9 LBJ 824.4 MF 736.2 AUS 491.8
c Head level rising, hydros have little effect	WR- Present at SO, evaluates situation for potential flood gate operations. SO- Continues to monitor conditions, adjusts LCRA system, directs required hydro operations. HO- Advises SO of possible emergency flood status	No change	Levels may rise to top of operating ranges. INKS 887.7 LBJ 825.0 MF 737.0 AUS 492.8
3 Floods a. Regulated	WR- Directs flood gate operations, forecasts maximum lake elevations, contacts LCRA Public Information. SO- Relays flood gate operation information HO- Operates gates, relays time and amount gates opened to SO.	No change, except to follow Mansfield Dam starnes operation procedures if forecast elevation exceeds 887msl.	As allowed with downstream channel restrictions
b Emergency	WR- Assumed not available SO- Verifies emergency situation, ensure with necessary flood gate operations. HO- Identifies emergency status. Maintains head level without significant lake drawdown considering downstream flow restrictions.	Not applicable	As necessary

WR=WATER RESOURCES PERSONNEL
SO=SYSTEM OPERATIONS PERSONNEL
HO=HYDRO OPERATIONS PERSONNEL
NWS=NATIONAL WEATHER SERVICE

FIGURE 23
STANDARD FLOOD CONTROL OPERATING PROCEDURES
FOR INTERMEDIATE RESERVOIRS

APPENDIX A

LCRA BOARD POLICY

502 - INTERBASIN TRANSFERS

April 23, 1992

502.10 PURPOSE

The purpose of this policy is to avoid, if possible and consistent with the law, any future transfer of water from the lower Colorado River basin to other river basins which are detrimental to the interest of LCRA's ten-county statutory district.

LCRA recognizes that in the past, through its actions, investments have been made in the reliance that water will be available from the lower Colorado River for use either in the district or within the basin. LCRA will honor those past written commitments.

502.20 POLICY

LCRA, while recognizing the jurisdiction of the Texas Water Commission, will oppose future interbasin transfers of water outside the lower Colorado River basin unless the transfer is within LCRA's ten-county statutory district or it is demonstrated to the satisfaction of the Board that (1) the transfer will have no detrimental effect on the public welfare or commercial interests of LCRA's ten-county statutory district and (2) the receiving basin is prudently using and conserving existing water resources and aggressively planning and developing needed additional local water supplies.

The determination of detrimental effect will be based on the estimated direct and indirect impacts, both present and future, of the proposed interbasin transfer on all of the following considerations:

1. Existing water rights and obligations;

2. Contractual commitments by LCRA;

3. Water supplies for environmental purposes and economic activities, including instream flows, inflows to the bays and estuaries, municipal, industrial, irrigation, and lake and river recreation and tourism; and

RESPONSE TO REQUEST FOR LOWERING OF LCRA OPERATED LAKES

WFC 503.00 **Approved: Martin McLean**
Chairman LCRA Board

503.10 PURPOSE

The purpose of this policy statement is to establish guidelines for responses to requests for the systematic lowering of LCRA operated lakes when requested to do so in the public interest.

503.20 CONSTRAINTS

This policy consolidates all previous practices of lake lowering, and particularly shall apply to Inks Lake, Lake LBJ, Lake Marble Falls, and Lake Austin. With the exception of Lake Austin, LCRA owns these lakes and respective dams, as well as the associated water rights permits from the Texas Water Commission. Lake Austin is owned by the City of Austin. By contract with the City dated February 5, 1938, which was amended and extended to the year 2007, by agreement dated December 15, 1966, the City and LCRA have agreed to the following:

City maintains "full control, use, and enjoyment of the reservoir created by the Austin (Tom Miller) Dam" for "recreational purposes".

LCRA owns Austin Dam and by contract operates Austin Dam so that the lake level will "not be lowered more than three feet except in emergency when the water level may be lowered five feet".

503.22 POLICY

1. LCRA will not approve those requests which interfere with essential operations of LCRA such as flood control and water supply.

2. LCRA will not approve requests which, in the opinion of the management of LCRA, create substantial loss of hydropower or are otherwise too costly.

4. Water quality and aquatic ecosystems in the Highland Lakes and lower Colorado River basin and associated bays and estuaries.

Anyone requesting LCRA's acquiescence in a proposed interbasin transfer must provide LCRA with comprehensive evaluations of the environmental, economic and institutional impacts from the proposed transfer.

In the event of coordinated statewide interbasin water transfers, LCRA may participate to address regional water resources problems if such transfers: (1) comply with the criterion of no detrimental effect indicated in this policy and (2) provide positive economic or environmental benefits to LCRA's ten-county statutory district.

As the steward of the lower Colorado River, LCRA will, in the event of interbasin transfers, seek to be the negotiating and contracting party. In any interbasin transfer, water supplies from the lower Colorado River will be provided only through temporary water sale contracts. LCRA opposes any sale of water rights for use outside of the LCRA's ten-county statutory district.

502.30 AUTHORITY

LCRA Act, §§ 2(a) and (q).

EFFECTIVE: July 7, 1986. Amended March 19, 1987 (republished), and April 23, 1992.

3. LCRA will charge for any losses which occur resulting from requests which are deemed reasonable by LCRA and do not interfere with the essential operation of the river control system. If lowering the lake is consistent with LCRA's operations and involves no losses, there will be no charge.

4. Only written requests will be considered except in cases where the General Manager determines the existence of a public emergency. These requests must be addressed to LCRA General Manager and signed by an authorized agent of the requesting entity.

5. Requests must be received by LCRA at least eight weeks prior to the proposed date for starting drawdown of any lake. All requests will be accompanied by a non-refundable application fee. The amount of the fee will be set by the Office of Water and Natural Resources.

6. All requests will be explicit in regard to number of feet the lake is to be lowered and the period of time the lake is desired to be down. LCRA lakes are not to be lowered more than once in a twelve-month period without specific Board action.

7. Requests for lake lowering will not be acted upon until both LCRA and the requesting party have agreed upon the terms, costs and conditions of the action and have approved and sign the standard form of LCRA Lake Lowering Agreement. Public notice of lake lowering will only occur after execution of such agreement.

503.23 Exceptions

1. Requests for lowering of Lakes Buchanan and Travis will not be considered under this general policy due to the fact that they are storage lakes for the system.

2. Requests for lowering of any lake during the months of March through October, which are the peak "system demand" months for water supply, will not generally be considered.

503.24 Reimbursement for LCRA Losses

1. For Inks Lake, Lake LBJ, and Lake Marble Falls, LCRA shall be reimbursed by the requesting party according to the fuel replacement cost plus normal overhead of the generation capability lost due to the reduction in head level at the respective dam during lake drawdown. Any generation necessary to maintain the requested lowered level during the requested time period shall also be reimbursed.

2. Water released from Lake Austin is not recoverable for storage since it is downstream of LCRA's storage reservoirs. Therefore, the amount of water released from storage in Lake Travis to refill Lake Austin will be paid for by the requestor at the current water rate, unless the level of Lake Travis is above 681 (feet above mean sea level), or Lake Austin refills due to rainfall on its watershed.

3. Subsequent to refilling, the Water Operations staff will calculate the cost of the operation as outlined above, and after approval by the General Manager, will submit this cost to the Finance Department for invoicing.

503.30 RESPONSIBILITIES

503.31 LCRA

1. Under the direction of the General Manager, the Office of Water and Natural Resources or Water Operations will determine the responses to requests for lowering of any lake as well as operations during the lowering and refilling of the lake. All responses to requests are to be mailed within three weeks of receipt.

2. All responses shall contain sufficient qualifications, approved by the General Counsel, that will indemnify the LCRA in all actions attributable to the lowering and refilling of the lakes.

3. LCRA will provide notice to the public through print and electronic media on the date, time and degree of lake levels at least two weeks in advance of any action.

Management Directives and Internal Operating Procedures shall be developed and implemented if and as appropriate pursuant to this policy.

503.32 Requestor

By original signature upon and return of a copy of LCRA response, requestor must agree to indemnification acceptable to the LCRA.

503.40 AUTHORIZATION

LCRA Act - 1975 Amendment and Sec. 9.

This policy supersedes all prior policy statements to the extent inconsistent with this policy statement.

Approved as to legality:

General Counsel

Recommended for Republication:

General Manager

REPUBLICATION DATE: 3/19/87

WATER RESOURCES MANAGEMENT

WFC 504.00 Approved: Raymond F. Barker
Chairman, LCRA Board

504.10 PURPOSE

The purpose of this policy statement is to establish guidelines for LCRA's role as a regional planning authority for Water Resources Management of the watershed of the lower Colorado River included within its ten (10) county district. This policy statement is written in conformity with the Charter of the Lower Colorado River Authority Act and related Bylaws provisions.

504.20 DEFINITIONS

504.21 Water Resources Management

For purposes of this policy statement, Water Resources Management includes all water charters provided in the Lower Colorado River Authority Act including the control, storage, preservation, use and sale of water in LCRA's ten (1) county district and watershed of the Lower Colorado River. This definition includes all projects and programs necessary to ensure an adequate supply of water, including construction of reservoirs, development of water treatment and wastewater treatment facilities and associated water quality services, optimal use of the water supply, and appropriate sales of water.

504.22 Regional Planning

For purposes of this policy statement, regional planning is defined as the coordination with other jurisdictions (federal, state and local) as to needed policies, programs, and projects within both the watershed and the district. This includes performance of necessary data and information collection, assimilation and analysis tasks to develop appropriate water resources management programs, initiation of plan development and implementation schedules in response to needs assessments and development of financing strategies to implement water resources management plans.

504.30 POLICY

It shall be the policy of LCRA to fulfill its Water Resources Management responsibility role as chartered in the Lower Colorado River Authority Act by initiating appropriate regional programs and projects to control, store, preserve, use and sell the surface and underground waters within the Authority's lower Colorado River watershed.

In fulfilling this role, LCRA shall take the initiative in regional planning to assure (1) an adequate supply of water, (2) construction of reservoirs to control and store water, (3) development of water treatment facilities, (4) construction of wastewater treatment facilities, (5) development of water quality programs and related activities, (6) optimal use of the water supply, and (7) appropriate sales of water to the various publics of the Authority.

LCRA shall demonstrate singular initiative in regional planning within the Lower Colorado River Authority's watershed, and shall encourage and may participate in financing, building and operation of inter-jurisdictional water and wastewater supply and treatment facilities within the Lower Colorado River Authority's ten (10) county district, and in addition shall take a leadership role in anticipating and responding to public service needs as they relate to water resources.

504.40 RESPONSIBILITIES

The General Manager will evaluate all proposed Water Resources Management programs and projects utilizing the criteria stated in 504.10 PURPOSE and 504.30 POLICY of this policy statement. If the proposed programs or projects meet such criteria, the General Manager may approve such programs and projects within budgeted funds previously approved by the Board of Directors.

504.50 AUTHORITY

LCRA Act, Secs. 2(a), (c), (e), (i), (p), (q) and (t).

LCRA Bylaws, Sec. 2.10.

This policy supersedes all prior policy statements to the extent inconsistent with this policy statement.

Approved as to legality: Glen E. Taylor
General Counsel

Recommended for Republication:
General Manager

ORIGINAL ADOPTION DATE: June 1984

AMENDMENT DATES: March 1987 (republished only)
February 1991

WATER QUALITY LEADERSHIP POLICY

WFC 507.00

Approved: Raymond F. Barker
Chairman, LCRA Board

507.10 PURPOSE

The purpose of this policy is to provide direction and guidance for LCRA's leadership role in protecting and improving the water quality in the ground and surface waters in LCRA's 10-county statutory district. This policy states LCRA's goals and direction regarding point and nonpoint sources of pollution, regional wastewater facilities, and ground water protection.

507.20 POLICY

LCRA shall provide leadership in protecting and, where possible, enhancing the water quality in the Highland Lakes and in achieving the greatest possible protection and improvement in the water quality of the surface and ground water resources within LCRA's 10-county statutory district.

It is the policy of the LCRA Board that LCRA management and staff take the initiative for proposing innovative and effective actions to achieve LCRA water quality goals. This policy places a duty on the staff to determine what is necessary to achieve LCRA's goals and to present the LCRA Board with options for actions to achieve those goals. All interventions as a party in hearings before the Texas Water Commission and other administrative agencies shall require Board approval.

Emergency situations may require action by LCRA without prior approval by the Board. The General Manager is hereby authorized to take emergency actions subject to Board approval at the next Board meeting.

LCRA shall establish memoranda of understanding with the Texas Water Commission, the Texas Water Development Board, and other governmental entities, as appropriate, to ensure a high level of coordination and cooperation in achieving LCRA's goals for water quality. LCRA shall seek to cooperate with and avoid unnecessary duplication of the efforts of other agencies or units of government in its water quality actions and programs.

In exercising its leadership role in water quality, LCRA will strive to be a model in the planning, construction, and management of all its facilities and operations.

507.21 Leadership Goals on Point Source Pollution Prevention

LCRA shall take the lead in advocating before the Texas Water Commission the strictest feasible standards for achieving the water quality goals set forth in Section 507.20 of this policy. To accomplish these goals, LCRA will: 1) monitor water quality; 2) conduct technical studies on the impact of point source pollution on the Colorado River and its tributaries; 3) research and determine the best available means of achieving such standards; and 4) undertake any educational efforts, court actions or legislation which the Board may authorize to advance the water quality goals of LCRA.

Until such time that an economical technology is demonstrated to be available to clean wastewater to the state of purity that will enable it to be returned to the lakes without impairing water quality, LCRA shall support a ban on the issuance of new wastewater treatment plant permits for discharges to any and all of the reservoirs in the Highland Lakes chain including Lake Buchanan, Lake Inks, Lake LBJ, Lake Marble Falls, Lake Travis, Lake Austin and Town Lake. LCRA opposes any expansion of existing wastewater treatment plants unless the increased flow volume results in improvement of water quality as compared to the status quo by significantly reducing the total pollutant loading discharged into the receiving waters. The ban will include all stretches of the tributaries within ten (10) stream miles of the spillway elevations of the several reservoirs except Lake Travis which shall be measured from 681 feet above mean sea level. In accordance with this ban, LCRA shall oppose applications for wastewater discharge permits, renewals, and/or amendments which do not comply with this policy.

With respect to all other wastewater treatment plants and other point sources of pollution that discharge into the lower Colorado River or its tributaries within the 10-county district subject to LCRA jurisdiction, LCRA shall oppose any new discharge permits that do not utilize the most feasibly effective technology to minimize pollution. With respect to proposed expansion of existing point sources, LCRA shall oppose such expansion if they do not result in a reduction of the total pollutant loading discharged into the lower Colorado River or its tributaries unless the applicant can show that it is already using all feasible methods to keep pollution to a minimum.

LCRA staff shall monitor point source discharges within its 10-county statutory district as appropriate. LCRA staff shall review applications for proposed permits for such discharges and, with Board approval, take actions necessary to further LCRA goals for water quality.

507.22 Leadership Goals on Non-Potable Reuse and Land Application of Wastewater Plant Discharges

LCRA shall encourage and support the reclamation and reuse of wastewater treatment plant effluent as a source of water supply for existing or anticipated non-potable water demands. LCRA shall encourage and support land application of effluent as an alternative to discharges when such application is determined to be technically, economically and environmentally feasible.

LCRA shall support research, regulatory initiatives, and legislation to advance non-potable reuse as an alternative to direct discharge of effluent.

507.23 Leadership Goals on Nonpoint Source Pollution Prevention and Control

LCRA will take the lead in a comprehensive effort to prevent and control nonpoint source pollution of the ground and surface waters within LCRA's 10-county statutory district. The first priority, in cooperation with other concerned public and private entities, will be to take actions appropriate to assure nonpoint sources of water pollution are controlled to the fullest extent feasible around the Highland Lakes.

LCRA shall adopt a program of nonpoint source pollution prevention, control and abatement for all LCRA owned and controlled lands within the 10-county statutory district and in the LCRA electric utility service area.

LCRA shall support research and consider actions that result in alternative and innovative technologies and improved management of private on-site wastewater facilities.

LCRA shall require appropriate and effective nonpoint source pollution control programs in all water sale contracts, in lease agreements for the use of LCRA properties, and in water and wastewater service agreements.

507.24 LCRA Regional Wastewater Facilities

In order to fulfill its role and responsibility for water quality protection as stated in the LCRA Act and the water quality goals of this policy, LCRA will take the lead in developing and managing regional wastewater treatment facilities. Regional management may include planning, constructing, operating or managing centralized or decentralized wastewater treatment facilities.

Criteria for LCRA participation in the development and management of wastewater treatment facilities shall include local public support and willingness to pay fees sufficient to finance the construction, operation, and maintenance of facilities. Such fees shall in all cases be cost-of-service based. LCRA will seek to finance utility projects in the most economical manner possible through assisting other entities, through its own financing authority, and through assistance from the Texas Water Development Board.

In developing wastewater utility projects that satisfy the above stated criteria, LCRA shall investigate alternatives for providing service at a scale and with treatment technologies that are appropriate to the area to be served. In addition, LCRA shall investigate and implement appropriate water conservation and reuse measures as they relate to the type of utility service to be provided.

507.30 AUTHORITY

Tex. Rev. Civ. Stat. Ann. Art. 717q (Vernon 1988).

Tex. Rev. Civ. Stat. Ann. Art. 4413 (32c) (Vernon 1988).

Texas Water Code, Chapters 26 and 30.

LCRA Act, Sections 1, 2, 9, 10 and 11.

Management Directives and Internal Operating Procedures shall be developed and implemented, if and as appropriate, pursuant to this policy.

This policy statement supersedes all prior policy statements to the extent inconsistent with this policy statement.

Approved as to legality: Glen E. Taylor

Glen E. Taylor, General Counsel

Recommended for Board approval:

Mark Rose, General Manager

Original Adoption Date: August 18, 1988

Amendment Date: June 27, 1991

WATER PRICING POLICY

WFC 508.00

Approved: Jack M. Johnson
Chairman, LCRA Board

508.10 PURPOSE

The purpose of this policy is to establish the water pricing policy of LCRA for the waters managed by LCRA. It is intended that this policy will serve to assist in LCRA's leadership role in management of water supply and water quality.

508.20 POLICY

LCRA shall establish rates for the sale of water which are not prejudicial or unduly discriminatory, but are equitable and recover LCRA's cost of supplying such water.

508.21 Rate Setting Criteria

In setting rates, LCRA shall consider, but not be limited to, the following criteria:

Cost of Service

In pricing water, LCRA will consider the average cost and marginal cost of supplying water. LCRA's costs may include: the costs of operating existing reservoirs; the costs of developing future water supply including additional reservoirs and ground water recharge projects; the costs for protection, enhancement and conservation of the ground and surface water quality and supply in the 10-county statutory district; and such other future costs of service. Within this framework, cost variations will be considered by season, time and duration of use, degree of delivery reliability and quality of water delivered.

Value of Water Resources

In pricing water, LCRA will consider the market value of water as well as the relative value of varying degrees of delivery reliability to all classes of water customers, both current and potential. This value of service determination may consider variations by season, time and duration of use and quality of water.

Environmental Protection

The base pricing of water shall take into account the quality of the water provided, as well as the cost of protecting the ecological balance in the Colorado River Basin and the coastal bay/estuarine system. Such pricing may include the costs for maintenance of necessary instream flows and attainment or compliance with all applicable water quality standards. Any enhancement in water quality by the actions of LCRA will be considered an additional cost of water resource management.

Conservation

The pricing of water will encourage water conservation practices which improve water use efficiency, increase re-use and recycling, or minimize water waste such that the available water supply is maximized for present and future uses.

508.22 Water Sales Contracts

All future water sale contracts shall contain conditions requiring such conservation and water quality measures that may be feasible and economical. Pursuant to LCRA's Certificate of Adjudication from the Texas Water Commission, LCRA shall not supply or commit to supply any water to any other party except pursuant to a written contract. In addition, LCRA will not supply water to itself except pursuant to resolution adopted by LCRA's Board of Directors that defines such commitment. All contracts and resolutions along with associated rates will be considered to be for firm uninterruptible water unless the contract specifically provides that such commitment is subject to interruption or curtailment.

508.23 Implementation

Implementation of this pricing policy shall be carried out within a time frame which attempts to minimize adverse impacts upon the customers of LCRA.

508.30 RESPONSIBILITIES

It shall be the responsibility of the General Manager to assure that all rates and rate changes are presented to the LCRA Board of Directors for approval, and that all water customers are afforded an opportunity to comment on such actions prior to the Board's approval.

508.40 AUTHORITY

Texas Water Code, Chapters 11 and 12.

LCRA Act, Sections 1, 9, 10 and 11.

LCRA Board Policies FI 301.00, FI 304.00 and WFC 507.00.

This policy statement supersedes all prior policy statements to the extent inconsistent with this policy statement, specifically WFC 501.00 Management of Stored Water, WFC 504.00 Water Resource Management (Section 504.30 POLICY - last paragraph), and WFC 505.00 Water Programs (Section 505.27 Financing of Water Programs).

Approved as to legality: _____
General Counsel

Recommended for Board Approval: _____
General Manager

EFFECTIVE DATE: December 16, 1988

LCRA WATER CONSERVATION POLICY

WFC 509.00

Approved: Jack M. Johnson
LCRA Board Chairman

509.10 PURPOSE

This policy provides direction for LCRA's leadership role in assuring an adequate supply of clean water within the LCRA 10-county statutory district sufficient to meet the needs of municipal, agricultural, industrial and recreational uses for the future through promoting the conservation of the ground and surface waters.

509.20 POLICY

LCRA shall exercise leadership in promoting, and where appropriate, requiring the conservation of ground and surface waters within LCRA's 10-county statutory district. LCRA's goals shall be to promote the development and application of practices and technologies that improve water use efficiency, increase the beneficial reuse and recycling of water, and minimize the waste of water such that water supplies are extended. LCRA shall support and assist local, state, federal and private-sector initiatives to develop, demonstrate and apply water conservation measures where appropriate. LCRA shall implement technical assistance, demonstration projects, public information and education programs on water conservation.

In the operation and management of LCRA facilities and properties, LCRA shall use water efficiency measures and demonstrate advanced water conserving technology. All future water sales contracts shall contain appropriate conditions requiring conservation measures that are economically feasible.

509.21 Technical Assistance

Given LCRA's limited resources, LCRA's efforts in technical assistance shall focus on the development and implementation of local water conservation and drought contingency programs that encourage local initiative and achievement. Upon request, LCRA shall provide the Texas Water Development Board and the Texas Water Commission with assistance in the development and review of water conservation plans affecting the LCRA 10-county statutory district.

509.22 LCRA Support of Research and Legislation

LCRA shall support research, regulatory initiatives and legislation that advance the conservation and beneficial reuse of water in the LCRA 10-county statutory district. LCRA also shall assist in the research and transfer of technology and information regarding cost-effective conservation measures for the benefit of water users within the 10-county statutory district.

509.23 Municipal and Industrial Water Efficiency

LCRA shall integrate, as appropriate, water efficiency measures into the development and implementation of LCRA programs and projects. Such programs and projects shall include but not be limited to: water resources planning and demand forecasting; water and wastewater utility service studies, projects and service agreements; water rate design; environmental programs; and energy efficiency programs.

509.24 Agricultural Water Efficiency

LCRA shall support and assist public and private-sector initiatives to develop, demonstrate, and apply cultivation and irrigation practices to improve on-farm water use efficiency.

LCRA shall assist with the transfer of information and technology for improving on-farm water use efficiency from research to the producer.

LCRA shall undertake maintenance, rehabilitation and management practices to minimize water losses from LCRA irrigation water delivery systems.

509.30 AUTHORITY

LCRA Act, Section 2.

Management Directives and Operating Procedures shall be developed and implemented, if and as appropriate, pursuant to this policy.

This policy supersedes all prior policy statements to the extent inconsistent with this policy statement.

Approved as to legality: Thomas D. Mason

Recommended for Board Approval: A. Dal Freeman

EFFECTIVE DATE: October 20, 1988

IRRIGATION WATER SALES

WFC 510.00

Approved: Burton B. LeTulle
Chairman, LCRA Board

510.10 PURPOSE

This policy sets criteria for LCRA sales of water for irrigation purposes within LCRA's 10 county statutory district other than those in the Conservation Base Acreage described in LCRA's Water Management Plan.

510.20 POLICY

In considering applications for irrigation water sales contracts, it shall be LCRA's policy to encourage the purchase of stored interruptible water. LCRA will contract for sales of firm stored water from the Highland Lakes Combined Firm Yield for irrigation, if requested, under the conditions stated herein.

510.21 Terms and Conditions for Irrigation Water Sales Contracts

LCRA will supply firm water for irrigation purposes from the available Highland Lakes Combined Firm Yield water supply not reserved or otherwise committed by the LCRA Board for future uses. The terms for contracts issued to serve irrigation water needs shall not extend beyond the year 2000. The contracts shall include a take or pay clause for the full amount of the water provided under the contract. Customers shall be required to consider the use of alternative supplies, as they may become available, to replace the firm water supplied under the contract.

In developing contracts for irrigation water under the guidelines of this policy, LCRA will make no assurances to existing or potential customers of future water supplies from the Combined Firm Yield past the year 2000.

510.22 Impact Evaluation

In the year 2000, or sooner if the Board deems it necessary, LCRA will re-assess the remaining amount of uncommitted Combined Firm Yield and LCRA interruptible water supplies to determine if this policy should be continued or altered.

510.30 RESPONSIBILITIES

Management Directives and Internal Operating Procedures shall be developed and implemented if and as appropriate pursuant to this policy.

510.40 AUTHORITY

LCRA Act, § 2(a).

LCRA's Certificates of Adjudication (14-5478, as amended; and 14-5482, as amended).

LCRA Water Management Plan for the Lower Colorado River.

Approved as to legality: Glen E. Taylor
General Counsel

Recommended for approval:
General Manager

ADOPTION DATE: 08/23/90

LCRA GROUNDWATER POLICY

WFC 511.00 Approved: Raymond F. Barker
Chairman LCRA Board

511.10 PURPOSE

The purpose of this policy is to state LCRA's goals and establish guidelines for the protection and conservation of groundwater supplies in its 10-county statutory district. The policy provides direction for LCRA to work with emerging and existing underground water districts and for ongoing assessments of groundwater supply in order to protect quality and assure the provision of adequate water supplies for beneficial purposes within LCRA's 10-county statutory district.

511.20 POLICY

511.21 Groundwater Quality Protection

LCRA will exercise a leadership role in the protection of groundwater within the LCRA 10-county statutory district. LCRA will, within the limits of its resources and in close cooperation with other public and private entities, monitor the quality of groundwater, develop and disseminate public information, and provide technical assistance on the enhancement and protection of groundwater.

LCRA recognizes that groundwater protection and enhancement is a responsibility shared with the Texas Water Commission and numerous other local agencies and that LCRA can be most effective with its limited resources acting in concert with others. LCRA will give priority to testing groundwater supplies that are not regularly tested by other agencies and to cooperative efforts with other public agencies.

Within these guidelines, LCRA may take action to prevent both point and nonpoint source pollution of groundwater resources within the 10-county statutory district, including, but not limited to, the passage of LCRA ordinances and regulations and the development of specific programs and projects to prevent and control groundwater pollution. Such projects and programs may be developed alone or in conjunction with other public and private agencies.

LCRA may monitor and analyze, as needed and as appropriate, the existing and potential impacts of all forms of natural and artificial pollution on the groundwater resources found in the 10-county statutory district.

In recognition of the interrelationship of ground and surface water supplies and the potential degradation of water quality as a result of depleting groundwater supplies, LCRA will promote the conservation of groundwater in the 10-county statutory district.

511.22 Relations with Emerging and Existing Underground Water Districts

LCRA may work with other governmental entities in the 10-county statutory district in efforts to develop underground water districts. In such efforts, LCRA may provide technical information and expertise and may consider joint studies on a cost share basis. LCRA will endeavor to gain agreement with governmental entities and public agencies active in the formation of such districts to assure that there is no unnecessary duplication of efforts or overlapping of powers with LCRA in the legislation creating such districts.

Once such districts are formed, LCRA may enter into interlocal agreements which support LCRA's goals and objectives for groundwater quality protection. Such agreements may include, but are not limited to, programs in support of research and planning, water conservation, water quality protection, education, and the conjunctive use of surface and groundwater supplies.

511.23 Groundwater Resource Planning and Conjunctive Uses of Ground and Surface Water Supplies

LCRA will research and analyze groundwater resources to manage surface water supplies and protect groundwater quality in the 10-county statutory district. Where possible, LCRA will seek to share the cost of such studies with other governmental and private entities.

LCRA recognizes that the conservation, protection, and best use of available water resources, especially in critical use areas, may be achieved through the conjunctive management and use of ground and surface water supplies. LCRA may, at its own initiative, or in association with other entities, plan for, develop, and manage such conjunctive use projects where economically feasible.

511.30 AUTHORITY

Texas Water Code Chapter 52.

LCRA Act, §§ 1, 2(p); 2(q).

This policy supersedes all prior policy statements to the extent inconsistent with this policy statement.

Approved as to legality: Glen E. Taylor

Glen E. Taylor, General Counsel

Recommended for adoption:

Mark Rose, General Manager

Adoption Date: June 27, 1991

APPENDIX B

§ 208.19 Marshall Ford Dam and Reservoir (Mansfield Dam and Lake Travis), Colorado River, Tex.

The Secretary of the Interior, through his agent, the Lower Colorado River Authority (LCRA) shall operate the Marshall Ford Dam and Reservoir in the interest of flood control as follows:

(a) *Water Control Plan*—(1) *General objectives.* The objectives of the Marshall Ford Reservoir (Lake Travis) are the improvement of navigation, flood control, stream regulation, generation of power, irrigation, water supply, and recreation uses.

(2) *Overall plan for water control.* Within the Colorado River Basin, four Federal projects provide flood control protection: Twin Buttes, O. C. Fisher, Hords Creek, Marshall Ford Reservoir. The considerable distance (328 river miles) and large intervening area (19,990 square miles) separating Marshall Ford Reservoir and the three upper basin flood-control projects prevent realizing any significant benefits from coordinating releases to control the inflow into Marshall Ford. Marshall Ford Reservoir is the fifth project in a tandem of six lakes operated and controlled by the Lower Colorado River Authority for the generation of hydroelectric power. These six projects in downstream order are: Lake Buchanan, Lake Inks, Lake Lyndon B. Johnson (Alvin Wirtz Dam), Lake Marble Falls (Max Starcke Dam), Marshall Ford Reservoir (Lake Travis and Mansfield Dam) and Lake Austin (Tom Miller Dam). The releases from each of the six projects are closely coordinated by the LCRA System Operation Control Center. Three of the projects (Lake Inks, Lake Marble Falls, and Lake Austin) are run-of-the-river projects. The capability of the four upstream lakes to control the inflow of flood water into Marshall Ford depends on their antecedent lake elevations. The majority of inflows to Marshall Ford are comprised of the mainstream flows of the Colorado River, the tributary flows of the Llano River (entering the Colorado River between Lakes Inks and Lyndon B. Johnson) and the unregulated tributary flows of the Pedernales River (entering between Lake Marble Falls and Marshall Ford Reservoir). During flood conditions, the following upstream U.S. Geological Survey gaging stations are used as indicators of the magnitude of the inflows to Marshall Ford Reservoir:

(i) Colorado River near San Saba (08147000).

(ii) Pedernales River near Johnson City (08153500).

(iii) Llano River at Llano (08151500).

(3) *Standing instructions to dam tender.* During normal conditions, the dam tender will regulate the project in accordance with instructions received from the LCRA System Operator. During flood conditions, when the Marshall Ford Reservoir level is within the flood control zone, the LCRA System Operator will regulate the project in accordance with instructions received from the Corps of Engineers. In the event of a communication outage, the LCRA System Operator will rely on the Emergency Release Schedule, to make changes in the rate of releases from the lake.

(4) *Flood control regulation*—(i) *General.* At all times, releases shall be coordinated such that the Colorado River, Texas, will be controlled when possible, to remain below control stages at downstream official U.S. Geological Survey (USGS) gaging stations; except that no curtailment of normal hydroelectric turbine releases shall result thereby at any time. The USGS river stations and their control stages are as follows:

KEY DOWNSTREAM CONTROL POINTS

Station	Control stage (feet)	Equivalent cubic feet per second (c.f.s.)
Austin (08158000)	20.6	30,000
	[1] 24.8	[1] 50,000
Bastrop (08159200)	25.1	45,000
	[1] 28.7	[1] 50,000
Columbus (08161000)	25.6	50,000

[1] Control stage when elevation 710 is forecast to be exceeded.

Forecasted reservoir inflows and the upstream USGS gaging stations Pedernales River near Johnson City (08153500), Llano River at Llano (08151500), and Colorado River near

San Saba (08147000) will be considered when scheduling flood releases.

(ii) *Flood control release schedule.* Marshall Ford will be regulated to reduce flooding on the Colorado River below the dam. This plan of regulation will govern flood control releases from Marshall Ford Dam as follows:

(A) *Elevation 681–683.* If the reservoir level is forecast to rise above elevation 681 feet, m.s.l. (top of conservation pool) but not to exceed elevation 683 feet, m.s.l., the releases shall be increased to 3,000 c.f.s. and maintained until the reservoir level recedes to elevation 681 feet, m.s.l. These release rates may need to be reduced due to excessive downstream runoff to prevent exceeding the control stages specified in paragraph (a)(4)(i) of this section.

(B) *Elevation 683–685.* If the reservoir elevation is forecast to rise above elevation 683 feet, m.s.l. but not to exceed elevation 685 the releases shall be increased to 5,000 c.f.s. and maintained until the reservoir level recedes below 683 feet, m.s.l. These release rates may need to be reduced due to excessive downstream runoff to prevent exceeding the control stages specified in paragraph (a)(4)(i) of this section.

(C) *Elevation 685–691.* Seasonal. (*1*) During the months of January through April, July through August, and November through December: If the reservoir elevation is forecast to rise above elevation 685 feet, m.s.l. but not to exceed elevation 691, the releases shall be increased to 5,000 c.f.s. and maintained until the reservoir level recedes below 683 feet, m.s.l. These release rates may need to be reduced due to excessive downstream runoff to prevent exceeding the control stages specified in paragraph (a)(4)(i) of this section.

(*2*) During the months of May, June, September, and October: Should the reservoir elevation be forecast to exceed 685 feet, m.s.l. but not to exceed elevation 691 feet, m.s.l: Releases will be made at 30,000 c.f.s. from the project or at a rate such that, when combined with local inflows below the dam, will equal but not exceed downstream control stages on the Colorado River as specified in paragraph (a)(4)(i) of this section. These release rates will be maintained until the reservoir level falls below elevation 685 feet, m.s.l.

(D) *Elevation 691–710.* Should the reservoir elevation be forecast to exceed 691 feet, m.s.l. (the top of the joint use pool) but not to exceed elevation 710 feet, m.s.l: Releases will be made at 30,000 c.f.s. from the project or at a rate such that, when combined with local inflows below the dam, will equal but not exceed downstream control stages on the Colorado River as specified in paragraph (a)(4)(i) of this section. These release rates will be so controlled until the reservoir level falls below elevation 691 feet, m.s.l.

(E) *Elevation 710–714.* If the reservoir level is forecast to exceed 710 feet, m.s.l. but not to exceed elevation 714 feet, m.s.l: Releases will be made at 50,000 c.f.s. from the project or at a rate such that, when combined with local inflows below the dam, will equal but not exceed the downstream control stages on the Colorado River as specified in paragraph (a)(4)(i) of this section. These release rates will be maintained until the reservoir level falls below elevation 710 feet, m.s.l.

(F) *Elevation 714–722.* If the reservoir level is forecast to exceed 714 feet, m.s.l. but not to exceed 722 feet, m.s.l: Releases will be made at 90,000 c.f.s. from the project. Releases shall not exceed the associated peak flood reservoir inflow.

(G) *Elevation 722 and above.* If the reservoir level is forecast to exceed elevation 722 feet, m.s.l., the Bureau of Reclamation will schedule releases as required for the safety of the structure.

(iii) *Normal flood control regulation schedule.* The following table, Flood Control Regulation Schedule, summarizes the flood control releases schedule for given reservoir levels and river conditions:

MARSHALL FORD DAM AND RESERVOIR NORMAL FLOOD CONTROL REGULATION SCHEDULE

Condition	Reservoir level	Flood control release	Control points
Pool Rising	Forecast: 681–683 [1]	3,000 c.f.s	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Do	Forecast: 683–685	5,000 c.f.s	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Do	Forecast: 685–681:		
	(a) During January, February, March, April, July, August, November, December.	5,000 c.f.s	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
	(b) During May, June, September, October.	30,000 c.f.s	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Do	Forecast: 681–710	30,000 c.f.s	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Do	Forecast: 710–714	50,000 c.f.s	50,000 c.f.s. (24.8 ft.) at Austin. 50,000 c.f.s. (26.7 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Do	Forecast: 714–722 [1]	90,000 c.f.s	No controls.
Do	Forecast: above 722	The Bureau of Reclamation will specify the releases for safety of the structure.	
Pool Falling	Above 722	do	
Do	722–714 [2]	90,000 c.f.s	No controls.
Do	714–710	50,000 c.f.s	50,000 c.f.s. (24.8 ft.) at Austin. 50,000 c.f.s. (26.7 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Do	710–681	30,000 c.f.s	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Do	681–685:	30,000 c.f.s	30,000 c.f.s. (20.5 ft.) at Austin.
	(a) During May, June, September, October.		45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
	(b) During January, February, March, April, July, August, November, December.	5,000 c.f.s	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Do	685–683	5,000 c.f.s	30,000 c.f.s. (20.5 ft.) at Austin. 45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.
Do	683–681	3,000 c.f.s	30,000 c.f.s. (20.5 ft.) at Austin.

MARSHALL FORD DAM AND RESERVOIR NORMAL FLOOD CONTROL REGULATION SCHEDULE—Continued

Condition	Reservoir level	Flood control release	Control points
			45,000 c.f.s. (25.1 ft.) at Bastrop. 50,000 c.f.s. (25.5 ft.) at Columbus.

[1] During flood conditions, when the reservoir level is below elevation 681 ft. m.s.l., the Corps of Engineers will provide recommendations to the Lower Colorado River Authority on flood control releases.
[2] Releases shall not exceed the associated peak flood reservoir inflow.

NOTE: No curtailment of normal hydroelectric turbine releases shall be required due to flood control operations.

(5) *Deviation from normal regulation.* (i) There are occasions when it is necessary or desirable to deviate from the water control plan for short periods of time as indicated in the following paragraphs:

(A) The water control plan is subject to temporary modification by the Corps of Engineers, if found necessary in time of emergency. Requests for and action on such modifications may be made by the fastest means of communication available. The action taken shall be confirmed in writing the same day to the project owner and shall include justification for the action.

(B) The project owner may temporarily deviate from the water control plan in the event an immediate short-term departure is deemed necessary for emergency reasons to protect the safety of the dam, or to avoid serious hazards. Such actions shall be immediately reported by the fastest means of communication available. Actions shall be confirmed in writing the same day to the Corps of Engineers and shall include justification for the action. Continuation of the deviation will require the express approval of the Chief of Engineers, or his duly authorized representative.

(C) Advance approval of the Chief of Engineers, or this duly authorized representative, is required prior to any deviation from the plan of regulation prescribed or approved by the Corps of Engineers in the interest of flood control and/or navigation, except in emergency situations provided for in paragraph (a)(5)(i)(B) of this section. When conditions appear to warrant a prolonged deviation from the approved plan, the project owner and the Corps of Engineers will jointly investigate and evaluate the proposed deviation to insure that the overall intergrity of the plan would not be unduly compromised. Approval of prolonged deviations will not be granted unless such investigations and evaluations have been conducted to the extent deemed necessary by the Chief of Engineers, or his designated representative, to fully substantiate the deviations.

(ii) The Fort Worth District Corps of Engineers will serve as the LCRA contact point for any deviation from or modification of the water control plan. The communication network will be described in the Water Control Manual. The Fort Worth District will notify the Division Engineer, Southwestern Division, Corps of Engineers of any deviations or modifications of the water control plan and request his approval. The Division Engineer has been designated as the authorized representative of the Chief of Engineers in matters relating to projects within the Southwestern Division which are subject to provisions of Section 7 of the 1944 Flood Control Act.

(b) *Reports to the Corps of Engineers.* (1) The Authority shall furnish the District Engineer, Fort Worth District, U.S. Army Corps of Engineers, by 0900 hours daily, with the following:

(i) Project information.

(A) Lake elevations at midnight and 0800 hours.

(B) Uncontrolled spillway, flood-control conduits, and turbine releases: Cubic feet per second at 0800 hours, and day-second-feet average for the previous 24 hours, ending at midnight.

(C) Computed average inflow, in day-second-feet for the previous 24 hours, ending at midnight.

(D) Total precipitation in inches for the previous 24 hours at the dam, ending at 0800 hours.

(E) Summary of streamflow and channel conditions at gages named in paragraphs (a)(2) and (a)(4)(i) of this section.

(ii) Lake Buchanan Pool elevation at 0800 hours.

(2) Whenever flood conditions are imminent, or stages of 16 feet (20,000 c.f.s.) or more at the Austin gage have been reached, the Authority shall report at once to the District Engineer by the fastest means of communications available. Data listed in paragraph (b)(1) of this section shall be reported to, and at intervals prescribed by the District Engineer for the duration of flood surveillance and control operations.

(Sec. 7, Pub. L. 78-534, 58 Stat. 890 (33 U.S.C. 709))

[44 FR 24552, Apr. 26, 1979; 44 FR 29050, May 18, 1979]

§ 208.22 Twin Buttes Dam and Reservoir, Middle and South Concho Rivers, Tex.

The Bureau of Reclamation, or its designated agent, shall operate the Twin Buttes Dam and Reservoir in the interest of flood control as follows:

(a) Whenever the Twin Buttes Reservoir level is between elevations 1,940.2 (top of conservation pool) and elevation 1,969.1 (top of flood control pool) the flood control discharge facilities shall be operated under the direction of the District Engineer, Corps of Engineers, Department of the Army, in charge of the locality, so as to reduce as much as practicable the flood damage below the reservoir. All flood control releases shall be made in amounts which, when combined with releases from San Angelo Reservoir on the North Concho River and local inflow below the dam, will not produce flows in excess of bankful capacities on the South Concho and Concho Rivers downstream of the reservoir. In order to accomplish this purpose, flows shall not exceed a 22.5-foot stage (25,000 c.f.s.) on the USGS gage on the Concho River near San Angelo, Tex. (river mile 60.9); or a 22.8-foot stage (25,000 c.f.s.) on the USGS gage near Paint Rock, Tex. (river mile 19.6).

(b) When the Twin Buttes Reservoir level exceeds elevation 1,969.1 (top of flood control pool), releases shall be made at the maximum rate possible and continued until the pool elevation recedes to elevation 1,969.1 when releases shall be made to equal inflow or the maximum release permissible under paragraph (a) of this section, whichever is greater.

(c) The representative of the Bureau of Reclamation in immediate charge of operation of the Twin Buttes Dam shall furnish daily to the District Engineer, Corps of Engineers, Department of the Army, in charge of the locality, a report, on forms provided by the District Engineer for this purpose, showing (1) for Twin Buttes Reservoir, the elevation of the reservoir level; number of river outlet works gates in operation with their respective openings and releases; uncontrolled spillway releases; storage; reservoir inflow; available evaporation data; and precipitation in inches; and (2) for Nasworthy Reservoir, the elevation of the reservoir level; irrigation outlet works and controlled spillway releases; storage; tailwater elevation; and reservoir inflow. Normally, one reading at 8 a.m. shall be shown for each day. Readings of all items except evaporation shall be shown for at least three observations a day when the Twin Buttes Reservoir level is above elevation 1,940.2. Whenever the Twin Buttes Reservoir level rises to elevation 1,940.2 and releases for flood regulation are necessary or appear imminent, the Bureau representative shall report at once to the District Engineer by telephone or telegraph and, unless otherwise instructed, shall report once daily thereafter in that manner until the reservoir level recedes to elevation 1,940.2. These latter reports shall reach the District Engineer by 9 a.m. each day.

(d) The regulations of this section insofar as they govern use of the flood control storage capacity in Twin Buttes Reservoir above elevation 1,940.2 are subject to temporary modification in time of flood by the District Engineer, if found desirable on the basis of conditions at the time. Such desired modifications shall be

APPENDIX C

TEXAS WATER COMMISSION

IN RE: CONSIDERATION OF THE LOWER COLORADO RIVER AUTHORITY'S WATER MANAGEMENT PLAN AND AMENDMENTS TO CERTIFICATES OF ADJUDICATION NOS. 14-5478 AND 14-5482	§ § § § § §	BEFORE THE TEXAS WATER COMMISSION

ORDER APPROVING LOWER COLORADO RIVER AUTHORITY'S WATER MANAGEMENT PLAN AND AMENDING CERTIFICATES OF ADJUDICATION NOS. 14-5478 AND 14-5482

On the 7th day of September, 1989, the Texas Water Commission ("Commission") held a public hearing to consider the Lower Colorado River Authority's Water Management Plan and applications to amend Certificates of Adjudication Nos. 14-5478 and 14-5482. At the hearing, the following were named as parties: the Lower Colorado River Authority; the Texas Parks and Wildlife Department; the City of Austin; the Garwood Irrigation Company; the Sierra Club, Lone Star Chapter; the Texas Farm Bureau; the Matagorda County Water Council; Houston Lighting and Power Company as Project Manager for the South Texas Project; Clear, Clean Colorado River Association; Pierce Ranch; the Village of Lakeway; the Executive Director of the Texas Water Commission; and the Public Interest Counsel of the Texas Water Commission. Having considered the evidence and arguments presented, the Commission makes the following Findings of Fact and Conclusions of Law:

FINDINGS OF FACT

1. Notice of the adjudicative public hearing was published on July 26, 1989, in the Blanco County News, Austin American-Statesman and the Colorado County Citizen, newspapers regularly published and generally circulated in Blanco, Travis and Colorado Counties, Texas, respectively; on July 27, 1989, in the San Saba News and Star, Llano News, Highlander and the Bay City Daily, newspapers regularly published and generally circulated in San Saba, Llano, Burnet, and Matagorda Counties, Texas, respectively; on July 28, 1989, in the Fayette County Record, a newspaper regularly published and generally circulated in Fayette County, Texas; on July 29, 1989, in the Wharton Journal-Spectator, a newspaper regularly published and generally circulated in Wharton County, Texas, and on July 31, 1989 in the Bastrop Advisor, a newspaper regularly published and generally circulated in Bastrop County, Texas, the only counties in which persons reside who may be affected by action taken as a result of the hearing. Said notice was published not less than thirty days before the date of the hearing.

2. On July 26, 1989, notice of the public hearing was sent by first-class mail to persons who may be affected by action taken as a result of the hearing and to each person as required by law.

3. The Lower Colorado River Authority (LCRA) is requesting approval of its Water Management Plan for the Lower Colorado River, Colorado River Basin in accordance with the Court's Final Judgment and Decree entered in Cause No. 115,414 A-1, 264th Judicial District, In Re: The Exceptions of the Lower Colorado River Authority and the City of Austin to the Adjudication of Water Rights in the Lower Colorado River Segment of the Colorado River Basin, and is further requesting approval of amendments to Certificates of Adjudication Nos. 14-5478 and 14-5482 to authorize LCRA to divert, release and use the water in Lakes Buchanan and Travis for additional beneficial uses including domestic, recreation, instream flow and bays/estuary purposes.

4. LCRA's Water Management Plan consists of two volumes. Volume I, Policies and Operations, describes the issues and conflicts in the demands on the Colorado River system and lays out the policies and management actions LCRA will use to accommodate the variety of demands on the system. Volume II, Technical Report, describes the models and data sources and the process used for the determination of the Combined Firm Yield and the Annual Rule Curve methodology. Volume II includes a set of Appendices consisting of the Court's Final Judgment and Decree, and the detailed data used to support the recommendations and conclusions discussed in Volumes I and II.

5. The Highland Lakes Reservoirs are operated by LCRA as a system for flood control and water supply. Mansfield Dam is the only structure with a dedicated flood pool and is operated during flooding according to flood-control regulations as published in the Code of Federal Regulations and under the supervision of the U.S. Corps of Engineers.

6. LCRA has a remote data acquisition system referred to as "Hydromet." The Hydromet allows for remote interrogation of a networked system of twenty-one self-reporting rainfall gages, twenty-two remotely monitored streamflow gages and six reservoir elevation gages. Twenty of the streamflow gages also gather rainfall information, giving a total of forty-one rainfall sites. The network is polled each hour, and all data is verified and stored in a real-time data base on a central computer system. Communications are a combination of microwave and UHF radio. The relational data provided by the Hydromet monitors flows above and below the lakes.

7. LCRA has a central computer system that is composed of two Digital Equipment Corporation MicroVAX II mini computers, one

of which is designated as an operations system located at the LCRA System Operations Control Center, and the other designated as a development system located at the Water Resources office. Real time data is logged and maintained on an on-line historical data base for one year. This is available for access by operations models, historical analyses, or other needs.

8. LCRA has developed several hydrologic models that are models used for routine operations of the system. Each model was developed to meet specific operational needs. The Daily Operations Model, analyzes the downstream inflow and demands by accessing streamflow data, totalling demands, and making multiple computer runs of the Model. The Flood Management Model is a user oriented operation tool which accesses real-time data and routes flood flows through the Highland Lakes. The Storage Projection Model uses historical inflow data to estimate the reliability of reservoir system storage subject to storage conditions and water demands.

9. The Daily Allocation Model will determine the extent to which releases from storage are diverted. It will perform a water balance every twenty-four hours at each river gage below Tom Miller Dam, and will allocate the natural flow of the river (whether or not it originated upstream or downstream of the lakes) to major water rights holders to the extent it is available. The remaining portion, if any, of each diversion is assumed to have been from water released from storage. Each amount is then totaled for the week, month and year to determine the total demand on storage.

10. Daily Operations are a joint effort between the System Operations Control Center (SOCC), Hydro Operations personnel located at the dams, and Water Operations personnel located at the Central Office complex. Water Operations personnel determine the required release by contacting downstream customers, operating the Daily Operations Model, and posting the daily release schedule. The SOCC then determines the optimum time and during the day to release the water based on the daily power peak demand, and orders the hydro generation units to begin and end at the necessary times. Hydro Operations personnel at each dam determine which unit to run at each dam.

11. The standard operating levels for the Highland Lakes are: Lake Buchanan, 1020.35 feet; Inks Lake, 887.30 +/- 0.4; Lake LBJ, 824.70 +/- 0.3; Lake Marble Falls, 736.60 +/- 0.4; Lake Travis, 681.00; and Lake Austin, 492.30 +/- 0.5. All levels are referenced to mean sea level.

12. The U. S. Corps of Engineers is evaluating potential flood damages to areas both upstream and downstream of Mansfield

Dam. LCRA is cooperating in this study. The Corps is also performing a reconnaissance study of possible additional flood control and water supply reservoirs. LCRA is cooperating in this study as well.

13. The Highland Lakes System consists of Lakes Buchanan, Inks, LBJ, Marble Falls, Travis and Austin.

14. LCRA's water rights for Lakes Buchanan, Inks, LBJ, Marble Falls and Travis are set forth in Certificates of Adjudication Nos. 14-5478, 14-5479, 14-5480, 14-5481 and 14-5482. LCRA operates Tom Miller Dam (the dam creating Lake Austin) pursuant to agreement with the City of Austin. Austin's water rights for Lake Austin are set forth in Certificate No. 14-5471.

15. LCRA's water rights on the Colorado River below the City of Austin are set forth in Certificates of Adjudication Nos. 14-5437, 14-5473, 14-5474, 14-5475, and 14-5476.

16. LCRA's right to use the waters of the Highland Lakes is subject to the terms and conditions as set out in the final judgment and decree dated April 20, 1988, in Cause No. 115, 414-A-1.

17. LCRA is committed to following the terms and conditions of the final judgment and decree dated April 20, 1988 in Cause No. 115, 414-A-1.

18. LCRA's first step in development of its Water Management Plan was a comprehensive review of LCRA's Board policies and existing programs that guide and shape the way LCRA manages the river system. The LCRA Board of Directors held a series of monthly public meetings and received testimony from LCRA staff, outside experts, and numerous representatives of diversified constituencies including state agencies, environmental groups, business, industry, agricultural interests, and wholesale electric customers. Based upon the evidence the Board received new comprehensive water policies were adopted by the LCRA Board. These policies form the foundation of the Plan.

19. LCRA's next step was the formulation of a Public Task Force. The LCRA staff and public task force met and worked together over a 6 month period.

20. A draft of the Technical Report (Volume II) of the Water Management Plan was transmitted to the Commission on December 30, 1988. A draft of both Volumes I and II of the Plan was submitted to the Commission's staff and distributed to the public in February 1989 for public comment, LCRA held public workshops followed by local meetings in Bay City, Eagle Lake

and at Buchanan Dam. Additionally, public discussions during LCRA Board meetings were held in March, April and May 1989. LCRA formally adopted the Plan in May 1989.

21. LCRA's proposed Water Management Plan was filed with the Commission on July 7, 1989. The Commission acknowledged receipt of LCRA's proposed Plan on July 18, 1989.

22. LCRA's Water Management Plan has essentially four criteria. One is that the Highland Lakes and the Colorado River downstream will be managed together as a single system for downstream water supply purposes. The second is that the beneficial use of the water derived from inflows below the Highland Lakes will be maximized. The third is that LCRA will stretch and conserve the waters stored in the Highland Lakes and advance water quality. The fourth is that adequate flows will be provided to maintain, and where reasonably possible, improve, fish, wildlife, and recreation resources in the Lower Colorado River and to maintain a proper ecological environment and health of related living marine resources in the Lavaca-Tres Palacios Estuary, to the extent it is affected by the lower Colorado River watershed.

23. LCRA will follow five guidelines in implementing its Water Management Plan including:

    a. All demands for water from the Colorado River downstream of the Highland Lakes will be satisfied to the extent possible by run-of-river flows of the Colorado River;

    b. Inflows will be passed through the Highland Lakes to honor downstream senior water rights only when those rights cannot be satisfied by the flow in the river below the Highland Lakes;

    c. The firm, uninterruptible commitments of water from Lakes Travis and Buchanan will not exceed the Combined Firm Yield;

    d. Water from Lakes Travis and Buchanan will be available on an interruptible basis only as long as LCRA's ability to meet the demand for uninterruptible water is not impaired;

    e. Water shall not be released through any dam solely for hydroelectric generation, except during emergency shortages of electricity, and during other times that such releases will be needed for another beneficial purpose.

24. LCRA has the ability to constantly monitor the amount of water in the river available to meet demands through the Hydromet

System which should allow full utilization of the flows originating below Lake Travis prior to making any releases from storage or passing inflows through the reservoirs.

25. Under the Water Management Plan the four downstream irrigation operations (Gulf Coast, Lakeside, Garwood, and Pierce Ranch) will have first priority for the interruptible water in the annual allocation process. This priority will be set by establishing a Conservation Base for LCRA's two irrigation districts. LCRA intends to negotiate a contract which will include a Conservation Base acreage with Pierce Ranch. The Conservation Base acreage for Gulf Coast, Lakeside and Pierce Ranch was determined on the basis of a ten-year (1976-1985) historical average of actual production acreage. The allocation of water for these three users is based on a duty of 5.25 acre-feet of water per acre irrigated. The priority allocation and terms governing the interruption of supply of stored water for Garwood are based upon a contract between Garwood and LCRA. The 5.25 acre-foot-per-acre duty also applies to Garwood irrigated acreage. In the annual allocation process Lakeside has a priority to interruptible stored water in an amount necessary to firm up run-of-river rights to 136,500 acre-feet per year; Gulf Coast an amount necessary to firm up run-of-river rights to 194,250 acre-feet per year and Garwood an amount necessary to firm up run-of-river rights to 168,000 acre-feet per year.

26. When the federal allocation for the number of acres of rice that can be grown exceeds the Conservation Base acreage of Lakeside and Gulf Coast, then in that year LCRA will provide back up stored water for up to 28,300 acres at Lakeside and 42,800 acres at Gulf Coast. These limits represent the maximum number of acres served by each of the two divisions during the 10 year historic period that was used to establish the Conservation Base. For the Lakeside Division, any acreage over 25,000 and up to 28,300 can be served from an alternate source.

27. Lake levels follow an annual cycle--that of filling the conservation storage space in the winter and spring months of the year to be drawn down by larger water uses during the summer months.

28. Because these multiple purpose reservoirs were not constructed for recreational use, the demands for stability in the reservoir levels by recreation interests present conflicts which are extremely difficult to accommodate. If limits are to be placed on how far down the reservoirs' water levels are allowed to decline, a corresponding limitation on the amount of water that is available to supply the other demands on the reservoir system must also be agreed to.

29. To the extent that the annual analysis of the amount of water in storage reveals that there are interruptible water supplies available after meeting the demands of the irrigation operations, interruptible water may be held in the reservoirs to better ensure the security of supply or to maintain lake levels.

30. If additional sales of interruptible water exceed the Conservation Base amounts and the priority allocation for Garwood would draw the lakes below these minimum levels the LCRA Board will not declare any additional interruptible water available for sale in that year. Those levels are 660 feet msl for Lake Travis and 1012 feet msl for Lake Buchanan. LCRA is not guaranteeing minimum lake levels.

31. Another item to help keep the levels of Lakes Buchanan and Travis as high as possible is the agreement that no maintenance, except for emergencies, which would require the lowering of Lakes LBJ, Marble Falls, and Inks will be permitted if the refilling of those lakes would draw the levels of Lakes Travis and Buchanan below the minimum levels. Periodic lowering and refilling of Lake Austin will be done pursuant to the Settlement Agreement (December 10, 1988) between LCRA and the City of Austin.

32. Downstream recreation interests may be enhanced by LCRA's commitment to maintain minimum instream flows. LCRA will develop additional boat launches and recreation areas on the river through LCRA's 10-county district in order to give the public better access to the Colorado River.

33. Hydroelectric power plants located in each of the dams owned and operated by LCRA total 242 megawatts of capacity. Hydropower generally has been subordinated to be a by-product of the release of water for other purposes. LCRA retains the right to make releases solely for hydropower production in times of emergency as part of the Water Management Plan operating policies.

34. LCRA and Texas Parks and Wildlife Department (TPWD) have entered into a Memorandum of Understanding (MOU), wherein the LCRA and TPWD have agreed that LCRA's Water Management Plan would have a goal of maintaining, and where reasonably possible, improving fish, wildlife, and recreation resources in the Lower Colorado Watershed and of maintaining a proper ecological environment and health of related living marine resources in the Lavaca-Tres Palacios Estuary, to the extent that it is affected by that watershed. Some of the provisions addressed in the MOU have been included in LCRA's Water Management Plan.

35. LCRA and TPWD currently are studying the instream flow issue. These studies are scheduled for completion in March 1991.

36. Until the instream flow studies are complete, LCRA will commit to maintaining a minimum monthly mean flow of 200 cfs throughout the lower basin. This flow may, at times, be satisfied from inflows into the river channel and releases made by LCRA to satisfy the demands of downstream users. To assure that sufficient water will be available to satisfy this instream flow demand, LCRA has allocated 25,000 acre-feet of firm water supply to back up this demand on the system and the demand for inflows into the bays and estuaries.

37. Fresh water inflows are essential to maintenance of the productivity of the bays and estuaries. Preliminary data indicate that the amount of inflows needed for the Lavaca-Tres Palacios Estuary may represent the largest single demand on the system. TPWD and the Texas Water Development Board (TWDB) are currently studying the issue of how much fresh water is necessary to maintain the productivity of the bays and estuaries. The study is scheduled for completion by the end of 1989 with public review scheduled during 1990.

38. Until the bays and estuaries study is completed, LCRA has committed to a minimum monthly mean flow of 200 cfs, a minimum seasonal mean flow of 375 cfs, and a minimum annual flow of 272,121 acre-feet for the bays and estuaries. Measurements are to be made at the USGS gage at Bay City. This flow may at times be satisfied from inflows into the river channel, releases of stored water by LCRA for downstream uses and runoff or tailwaters from the rice irrigation operations. These flows will be backed up with 25,000 acre-feet of firm supply water which is also available for instream flow demands.

39. The Texas Water Development Board (TWDB) and the U.T. Bureau of Economic Geology are currently studying the Carrizo-Wilcox and Gulf Coast Aquifers. LCRA is studying the feasibility of the use of groundwater resources in conjunction with interruptible surface water supplies including the evaluation of artificial recharge of depleted aquifer storage space.

40. Under the existing LCRA Water Pricing Policy the rates for purchasing water must recover the costs associated with the Water Management Plan including necessary funds for water quality and conservation activities.

41. The water to be captured by the Stacy Reservoir are waters that otherwise would have flowed into Lake Buchanan. LCRA determined that the appropriate approach at this time was to calculate the firm yield of the Stacy reservoir separately

from the Highland Lakes, then add it back in, to give the total combined firm yield for Lakes Buchanan and Travis.

42. LCRA used a standard single reservoir operation model to determine the firm yield of the Stacy Reservoir. Inputs to the model included: inflow, net evaporation, monthly water demand distribution, and area/capacity curve for the reservoir.

43. LCRA used a multiple reservoir operations model to determine the combined firm yield of Lakes Buchanan and Travis. User defined local water demands were assumed at each of the reservoirs. Inputs to the model included: inflows, net evaporation, local water demands, monthly water demand distribution, minimum and maximum allowable contents, and area/capacity curves for each reservoir.

44. The period of 1941-1965 was used in the determination of the combined firm yield which includes the worst drought of record encountered.

45. Hydrologic data was related to reservoir inflow. The inflow that actually occurred in the record drought was adjusted to simulate a future time period. The monthly values of inflow to Lakes Buchanan and Travis for the period of January 1940 through December 31, 1972 provided to LCRA by TWC water availability model were adjusted. Under the approach used at this time by LCRA to determine the combined firm yield, the simulated operations of Stacy Reservoir did not pass flow to fulfill downstream senior run-of-the-river water rights.

46. LCRA determined how much water was necessary to satisfy daily water demands at a specific location to the extent that flow is available in the river at that point on that specific day. LCRA found that the average annual unsatisfied demand was 520,657 acre-feet; the maximum annual unsatisfied demand was 674,095 acre-feet; and minimum annual unsatisfied demand was 340,500 acre-feet.

47. LCRA determined that the firm yield of the Stacy Reservoir is 90,546 acre-feet. The combined firm yield of Lakes Buchanan and Travis without inflow from upstream of Stacy Reservoir is 445,266 acre-feet/year. Adding the firm yield of Stacy Reservoir results in the combined firm yield for Lakes Buchanan and Travis of 535,812 acre-feet/year which represents the maximum average annual demand that can be met by these two lakes during a repetition of the most critical drought of record on the lower Colorado River. The combined firm yield may also be expressed as a total of 2,679,060 acre-feet over any five consecutive calendar-year period.

48. LCRA developed a rule curve which defines the ability of Lakes Buchanan and Travis to meet annual demands in excess of the combined firm yield, while reserving an adequate supply to meet firm demands.

49. Starting with the reservoirs full, various demands ranging from .781 million acre-feet to 1.5 million acre-feet were placed on the system for the period. It was found that even at a demand of 1.5 million acre-feet per year 100% of the demand was met in 46% of the years; 75% of the demand was met in 63% of the years; and the amount of .781 million acre-feet was met in 80% of the years.

50. This annual rule curve is considered conservative to the degree that the effect of a critical short-term drought equal to or less severe than historical will be negligible only if total firm demands are less than the combined firm yield.

51. The annual operations rule curve will analyze projected annual demands and based on October 1 lake levels will guarantee the supply of water for firm demands and identify an annual amount of water which may be used for non-firm purposes. It will be modified as firm demands increase, and as hydrologic conditions change in the Colorado River Basin.

52. The operational rule curve will be applied to the system on a monthly basis to determine how the system is responding to current conditions as compared to historical operations. This will allow LCRA to optimize reservoir operations on a real time basis and to determine if adjustments to the amount of interruptible water are necessary. This monthly analysis will help LCRA detect early signs of drought and allow LCRA to timely develop and implement drought contingency measures.

53. The amount of water required to meet the firm demand within the system for the preceding year will be calculated in early October. This amount will be compared to the projections for that year, and any variations will be noted and documented. LCRA will solicit information and projections of use from all of its firm supply contract holders and other firm uses provided for by resolution of the LCRA Board. This information will be used to develop a projection of firm demands for the coming year.

54. LCRA will assess the contents of Lakes Travis and Buchanan as of October 1 to project the storage levels for January 1 of the next year. Inflows into Lakes Travis and Buchanan from the upstream tributaries will be added to this preliminary storage level based on the minimum annual inflow from the period of drought. This process will allow LCRA to reserve sufficient water in the system to meet all firm demands for one year beyond the year being considered for allocations.

Estimates for firm demand commitments for the next year will be subtracted from the total water supply available. The amount of water remaining will then be available for interruptible allocation for that year.

55. In October, LCRA will publish the results of the allocation process, notify the LCRA Board, firm contract holders, the Texas Parks & Wildlife Department and any existing or potential interruptible contract holders. During the October LCRA Board meeting information will be presented to the Board and discussed.

56. The recommended annual allocation plan will be published and LCRA will consider public comments and will take into account any significant water events that may have occurred up to the date of publication. The annual allocation plan will be submitted as a recommendation for LCRA Board approval in November of each year.

57. The portion of the combined firm yield that is not yet committed and the firm uninterruptible water that is committed but not yet being used increases the interruptible water that is available each year. The water that is captured and stored from flood flows also adds to the amount of interruptible water that is available. Over time, as the current contracts draw fully on their commitments and the remainder of the firm yield is contracted for, there will be less interruptible water available on an annual basis.

58. LCRA has committed the following amounts out of the combined firm yield amount:

    a. Stacy Reservoir - the maximum impact of Stacy Reservoir on the firm yield of Lakes Travis and Buchanan is an average of 90,546 acre-feet per year.

    b. City of Austin - LCRA has agreed to firm up or supplement Austin's independent water rights to the extent of 290,156 acre-feet per year. A commitment of an average of 148,300 acre-feet per year of stored water is necessary to meet this demand.

    c. Highland Lakes Water Sale Contracts - municipal and industrial contracts total 104,754 acre-feet per year.

    d. Cooling Water for LCRA Power Plants - LCRA Board Resolution of January 22, 1987 committed 15,000 acre-feet for Ferguson; 10,750 acre-feet for Sim Gideon and 38,101 acre-feet for Fayette Power Project for a total of 63,851 acre-feet per year.

e. South Texas Project (STP) - LCRA has a contract to supply industrial water to STP in an amount up to 102,000 acre-feet per year. The commitment is met first by run-of-river water, firmed-up by stored water from Lakes Buchanan and Travis. Simulated operations through the drought of record showed a demand for stored water in one year of 51,700 acre-feet. A commitment of an average of 5,680 acre-feet per year of stored water is necessary to meet this demand.

f. Instream Flows and Bay/Estuary Needs - LCRA is also committing (reserving) 25,000 acre-feet out of the combined firm yield to meet instream flows and bay and estuaries' needs.

59. LCRA is reserving 50,000 acre-feet of the remaining combined firm yield for future uses under LCRA's certificates of adjudication. This reservation will be until water supply and demand assessments for LCRA's 10-county district are completed or within three years whichever is sooner.

60. The uncommitted balance of the combined firm yield of Lakes Buchanan and Travis is 47,681 acre-feet per year.

61. LCRA is in the process of developing a drought management plan and will be submitting the plan to the Commission in 1990.

62. LCRA is conducting county-by-county assessments of alternative water supply sources. This data will be useful in the development of local drought management plans.

63. The goal of LCRA's conservation programs is to promote the development and application of practices and technologies that will improve water use efficiency, increase the beneficial re-use of water, and minimize the waste of water.

64. LCRA's water conservation programs are directed at the two largest users of water, irrigated agriculture and municipal.

65. LCRA's goal for conservation of water used by irrigated agriculture is to reduce agricultural demands for stored water from the Highland Lakes and reduce costs associated with the operation of LCRA-owned irrigation water delivery systems in Colorado, Wharton and Matagorda Counties.

66. LCRA's current irrigated agriculture conservation programs consist of activities aimed at improving the operating efficiency of irrigation water delivery systems and improving on-farm water use efficiency.

67. The major elements of the irrigation canal rehabilitation program include: improved operational control and management

of the system; vegetation removal and control; improved hydraulics characteristics of canals; installation of water control and measurement structures; and automation of water diversion facilities.

68. The irrigated canal rehabilitation program is expected to reduce water use by 30 percent within the Gulf Coast canal system. Preventive maintenance at Lakeside is expected to maintain canal efficiency.

69. The major elements of the on-farm water conservation program include: Direct support through funding and staff for the Cooperative Rice Water Management Research Program; assistance with the transfer of information from the research arena to the rice producer; conservation demonstrations such as the development and testing of an automated levee gate; and the inclusion of water conservation stipulations in LCRA's standard irrigation water sale contract.

70. Preliminary results indicate that on-farm water use can be reduced by 25 to 30 percent.

71. LCRA's municipal water conservation programs are directed towards implementation of urban water conservation and water re-use. Focus is towards encouraging and supporting local level initiatives by more than 300 public water utility systems within LCRA's statutory district.

72. The five major elements of LCRA's municipal water conservation programs are:

    a. Direct technical assistance with the development and implementation of local water conservation programs including public awareness and education; water efficiency standards and guidelines for new construction (e.g., plumbing fixture efficiency standards); retrofit programs to improve water efficiency in existing developments; conservation-oriented water rates and other economic incentives; low-water-use landscaping (i.e., Xeriscape); and water re-use and recycling.

    b. Distribution system audit and leak detection services for local water utilities serving fewer than 10,000 connections.

    c. Integration of water conservation and re-use measures, as appropriate, with other LCRA programs and projects including LCRA water sale contracts; water resource planning and demand forecasting; water and wastewater utility service studies, projects, and service agreements; water rate design; environmental programs; and energy conservation programs.

d. Public awareness and education on the water conservation opportunities, benefits, and measures. On-going activities include distribution of brochures, fact sheets, and videos on water conservation; media promotion (e.g., news articles, public service announcements, talk shows, etc.); presentations to civic and service organizations; and workshops, seminars, and special events.

e. Demonstrations of advanced water conservation and re-use technologies and low-water-use landscaping techniques.

73. LCRA will no later than December 31, 1991 reference and summarize existing information on point and nonpoint pollution sources and loading on the Colorado River including inputs of nutrients, metals, pesticides, oxygen demanding substances and other contaminants that may affect water quality, fish wildlife and recreation resources in accordance with the MOU with TPWD.

74. LCRA will no later than December 31, 1991 identify new data needed to determine the effect of water quality on revision of minimum flow schedule and as soon as reasonably possible will modify its existing monitoring programs or new programs to collect such new data.

75. LCRA is evaluating the potential problems associated with anoxic hypolimnetic releases from reservoirs and the potential for related fish kills due to resulting low dissolved oxygen levels downstream. LCRA will no later than December 31, 1991 reference and summarize this evaluation.

76. LCRA has also applied to the Commission for an amendment to the Certificates of Adjudication Nos. 14-5478 and 14-5482 relating to Lakes Buchanan and Travis.

77. Certificates of Adjudication Nos. 14-5478 (Lake Buchanan) and 14-5482 (Lake Travis) authorize LCRA to divert and use water from Lakes Buchanan and Travis for municipal, industrial, irrigation and mining purposes. LCRA is authorized to use the water impounded in Lakes Buchanan and Travis for recreation purposes with no right of diversion or release. LCRA is authorized to use the bed and banks of the Colorado River, below Lakes Buchanan and Travis to convey water released from Lakes Buchanan and Travis for use by LCRA or others entitled to use such water in the amounts and for the purposes authorized in the Certificates. LCRA is also authorized to divert and use water through Buchanan Dam and Mansfield Dam for the purpose of hydroelectric power generation.

78. The Water Management Plan submitted by LCRA to the Commission for its consideration includes proposed reservoir operating

procedures whereby LCRA will divert or release waters stored in Lakes Buchanan and Travis for several additional purposes of use including domestic, recreation, instream flow and bays/estuary purposes.

79. In order to manage Lakes Buchanan and Travis as proposed in the Water Management Plan, LCRA's Certificates of Adjudication Nos. 14-5478 and 14-5482 need to be amended to authorize LCRA to divert, release and use the water in Lakes Buchanan and Travis for additional beneficial uses including domestic, recreation, instream flow and bay/estuary purposes.

80. As part of these amendments, LCRA is not requesting an additional amount of water. The proposed amendments will not result in an additional consumptive use of state water.

81. A "firm" demand is a contractual obligation or other commitment of LCRA's which must be met 100% of the time through the drought of record. Total firm demands will need to be less than or equal to the combined firm yield to be protected throughout recurrence of the drought of record.

82. Interruptible or "nonfirm" demands are LCRA's contractual obligations or other commitments for stored water which contractually do not have to be met 100% of the time. They will be met to the extent additional water is available each year after firm demands are satisfied.

83. LCRA has formally adopted standard water sale contract forms, and procedures and rules for administering water sale contracts. Existing contracts are written for firm supply of water, subject only to the general laws of availability. A second standard form contract for interruptible supply is presently being developed.

84. LCRA currently has no contracts upstream from the Highland Lakes, except those with upstream reservoirs with junior rights to the Highland Lakes which are more or less operation agreements.

85. Existing upstream operating agreements should be considered firm contracts, and their effect on the combined firm yield should be quantified as was Stacy Reservoir's effect.

86. Junior rights senior to November 1, 1987, will be honored as required by the Court's Judgment and Decree with interruptible supplies. Their diversions will be allocated similar to downstream senior rights.

87. A report which documents LCRA's compliance with the Water Management Plan during the previous year will contain information regarding the adequacy of the hydrologic and

hydraulic data monitoring system as to intensity and accuracy; accuracy of reported or monitored activities; adequacy of the operating rule curve and the adequacy of the daily allocation model and any additional information the Executive Director may request.

88. Under the approach used by LCRA at this time, the combined firm yield of Lakes Buchanan & Travis is 535,812 acre-feet/year. This amount may also be expressed as an average of a total of 2,679,060 acre-feet per year over any five consecutive calendar-year period.

89. LCRA's proposed Water Management Plan does not presently propose any new projects taking, storing or diverting water in excess of 5,000 acre-feet per year.

90. The use of an operational rule curve, as developed by LCRA, is an acceptable approach to insure utilization of the lakes' storage while at the same time guaranteeing that firm demands will be met dependably year after year.

91. LCRA's procedures and guidelines for the allocation of firm water and interruptible water supplies are acceptable, with the understanding that the allocation procedures may be amended at a later time to reflect the results of the instream flow and bay/estuary studies; provided, however, that the Commission shall retain jurisdiction to resolve all disputes regarding allocation of stored water that may arise in the future.

92. LCRA's initiatives regarding point and non-point sources of pollution are commendable.

93. The priorities in LCRA's Water Management Plan for interruptible water are subject to changes after the completion of the studies on the instream flows and bays/estuaries.

94. LCRA's proposed system operations under LCRA's Water Management Plan are consistent with the special conditions set forth in the Court's Final Judgment and Decree regarding LCRA's rights to use the waters of Lakes Buchanan and Travis.

CONCLUSIONS OF LAW

1. The public hearing was held under the authority and in accordance with Chapter 11 of the Texas Water Code, as amended and the Texas Water Commission Permanent Rules.

2. The Texas Water Commission has jurisdiction to consider LCRA's proposed Water Management Plan and applications to amend its Certificates of Adjudication.

3. LCRA's proposed Water Management Plan recognizes the necessity of beneficial inflows from the Colorado River into the Lavaca-Tres Palacios Estuary consistent with Section 11.147 of the Texas Water Code.

4. LCRA's proposed Water Management Plan recognizes the necessity of providing for the protection of fish and wildlife habitats and the water quality of the river as required by Section 11.147 of the Texas Water Code.

5. LCRA's proposed Water Management Plan recognizes the Commission's statutory authority to require water conservation and provides for water conservation consistent with Section 11.134(b)(4) of the Texas Water Code.

6. LCRA's applications to amend its Certificates of Adjudication Nos. 14-5478 and 14-5482 authorizing LCRA to use the waters of Lakes Buchanan and Travis for additional beneficial purposes do not contemplate an additional consumptive use of state water or an increased rate or period of diversion.

7. In order to effectuate the policies of this State relating to the conservation and best utilization of the water resources of this State as set forth in Chapter 11 of the Texas Water Code, LCRA's proposed Water Management Plan should be approved and LCRA's applications to amend Certificates of Adjudication Nos. 14-5478 and 14-5482 should be granted.

NOW, THEREFORE, BE IT ORDERED BY THE TEXAS WATER COMMISSION THAT:

1. LCRA's proposed Water Management Plan is approved with the following conditions:

   a. The Water Management Plan shall be subject to the continuing right of supervision of the Commission, and the Commission, on its own motion, may reconsider any element of the plan at any time in the future.

   b. LCRA's responsibility and authority under the Water Management Plan is limited to operational control of the Highland Lakes and LCRA's facilities downstream, and is limited by the terms of this Order.

   c. LCRA's responsibility and authority under the Water Management Plan is subject to and shall not conflict with the authority of any watermaster operation the Commission may establish on the Colorado River.

   d. LCRA shall make available to the Commission all real-time, historical or allocated streamflow data collected by LCRA.

e. LCRA shall supply interruptible water, in accordance with the provisions and conditions specified in the Final Judgement and Decree, to any downstream water right with a priority date junior to December 1, 1900 and senior to November 1, 1987 that authorizes the diversion of not more than 3000 acre-feet of water per year. Priority shall be given to these water rights in the same manner that LCRA allocates water to the major irrigation operations downstream (Lakeside, Gulf Coast, Garwood and Pierce Ranch).

f. All sales, agreements or LCRA Board commitments for the use of water in or from the Highland Lakes shall be submitted to the Commission within 45 days of the effective date of the document.

g. LCRA shall submit a drought contingency plan within one year from the date the Commission signs this order approving the Water Management Plan. Such plan shall be subject to the review and approval of the Commission.

h. LCRA shall allocate 25,000 acre-feet per annum of its firm water supply to supplement and maintain a minimum monthly mean flow of 200 cfs throughout the lower Colorado River measured at the USGS gage at Bastrop for instream flow purposes and a minimum monthly mean flow of 200 cfs, a minimum seasonal mean flow of 375 cfs and a minimum annual flow of 272,121 acre-feet measured at the USGS gage at Bay City for freshwater inflow to the Lavaca-Tres Palacios estuarine system.

i. Prior to any diversion of surface water for recharge purposes, LCRA shall obtain the necessary authorizations from the Commission.

j. LCRA shall prepare and submit to the Commission, on or before March 1 of each year beginning with March 1, 1990, a report which documents compliance with the approved Water Management Plan and any special conditions thereto during the previous year. Such report shall be in a form approved by the Executive Director.

k. After the instream study by LCRA and TPWD is completed, but in any event no later than March, 1992, LCRA will submit an application to amend its Water Management Plan to reflect the results of the instream flow studies and the studies and evaluations referenced in Findings of fact #73, 74, & 75 above. LCRA shall do all things necessary to ensure that such application is administratively and technically complete within 6 months of submission. The Commission agrees to hold a hearing within one year of the date of LCRA's submission to

consider the amendments of the Plan, or, if the studies are not complete, to determine why such studies are not complete.

l. After completion of the TWDB and TPWD study on freshwater inflows into the bays and estuaries, as applicable to the Lavaca-Tres Palacios Estuary, and in any event no later than March, 1993, LCRA will submit an application to amend its Water Management Plan to reflect the results of the bays/estuary study. LCRA shall do all things necessary to ensure that such application is administratively and technically complete within 6 months of submission. The Commission agrees to hold a hearing within one year of the date of LCRA's submission to consider the amendments of the Plan, or, if the studies are not complete, to determine why such studies are not complete.

m. The combined firm yield as found by the Commission in this Order is subject to adjustment and refinement from time to time as additional studies and simulations are developed that more accurately reflect assumptions and operations as required by law.

n. The Commission retains jurisdiction to resolve any and all disputes regarding the allocation of stored water from Lakes Travis and Buchanan, notwithstanding the procedures and guidelines set forth in the Water Management Plan.

2. LCRA's applications to amend Certificates of Adjudication Nos. 14-5478 and 14-5482 are granted with the following conditions:

a. LCRA's certificates of adjudication shall reflect the combined annual firm yield of Lakes Travis and Buchanan to be as found by the Commission in this Order, and as may be modified by the Commission from time to time.

b. For purposes of perfection, LCRA's authorization to divert, release or use water for recreation purposes is limited to that quantity of water actually sold for that purpose whether used in, or released, or diverted from Lakes Buchanan and Travis.

3. The Chief Clerk of the Texas Water Commission forward a copy of this Order, subject to the filing of motions for rehearing, to all parties.

4. If any provision, sentence, clause or phrase of this Order is for any reason held to be invalid, the invalidity of any portion shall not affect the validity of the remaining portions of the Order.

5. Nothing in the Water Management Plan or this Order shall be construed to impair, or to authorize LCRA or any other person or entity to impair, senior or superior water rights in the Colorado River Basin.

Signed this 20th day of September, 1989.

TEXAS WATER COMMISSION

Buck J. Wynne, III, Chairman

(SEAL)

Brenda W. Foster, Chief Clerk

APPENDIX D

THE STATE OF TEXAS
COUNTY OF TRAVIS

I, [illegible] certify that this is a true and correct copy of a Texas Water Commission document, the original of which is filed in the permanent records of the Commission.

Given under my hand and the seal of office on JAN 6 1992

Gloria A. Vasquez, Chief Clerk
Texas Water Commission

TEXAS WATER COMMISSION

CONSIDERATION OF THE	§	BEFORE THE
LOWER COLORADO RIVER	§	TEXAS WATER COMMISSION
AUTHORITY'S DROUGHT	§	
MANAGEMENT PLAN	§	

ORDER APPROVING LOWER COLORADO RIVER AUTHORITY'S DROUGHT MANAGEMENT PLAN

On the 18th day of December, 1991, the Texas Water Commission ("Commission") held a public hearing to consider the Lower Colorado River Authority's ("LCRA") proposed Drought Management Plan. At the hearing, the following were named as parties: the Lower Colorado River Authority; the Texas Parks and Wildlife Department ("TPWD"); the City of Austin; Garwood Irrigation Company; the Sierra Club, Lone Star Chapter; the Matagorda County Water Council; Houston Lighting and Power Company as Project Manager for the South Texas Project; the Executive Director of the Texas Water Commission; and the Public Interest Counsel of the Texas Water Commission. Having considered the proposed agreed order of the parties, the Commission makes the following Findings of Fact and Conclusions of Law:

FINDINGS OF FACT

1. Notice of the public hearing was published on October 10, 1991 in the Blanco County Record Courier, a newspaper regularly published and generally circulated in Blanco County, Texas; October 9, 1991 in the Austin American-Statesman, a newspaper regularly published and generally circulated in Travis County, Texas; on October 9, 1991 in the Colorado County Citizen, a newspaper regularly published and generally circulated in Colorado County, Texas; on October 10, 1991 in the San Saba News and Star, a newspaper regularly published and generally circulated in San Saba County, Texas; on October 10, 1991 in the Llano News, a newspaper regularly published and generally circulated in Llano County, Texas; on October 10, 1991 in the Highlander, a newspaper regularly published and generally circulated in Burnet County, Texas; on October 10, 1991 in the Bay City Daily Tribune, a newspaper regularly published and generally circulated in Matagorda County, Texas; on October 8, 1991 in the Fayette County Record, a newspaper regularly published and generally circulated in Fayette County, Texas; on October 5, 1991 in the El Campo Leader-News, a newspaper regularly published and generally circulated in Wharton County, Texas; and on October 7, 1991 in the Bastrop Advertiser, a newspaper regularly published and generally circulated in Bastrop County, Texas. These ten counties are

the only counties in which persons reside who may be affected by action taken as result of the hearing. Said notice was published not less than thirty (30) days before the date of the hearing.

2. On September 26, 1991, notice of the public hearing was sent by first-class mail to persons who may be affected by action taken as a result of the hearing and to each person as required by law.

3. LCRA is requesting approval of its Drought Management Plan for the Lower Colorado River, Colorado River Basin, in accordance with the Commission's September 7, 1989 Order approving LCRA's Water Management Plan and amending Certificates of Adjudication Nos. 14-5478 and 14-5482. LCRA's Water Management Plan was developed and submitted by LCRA in accordance with the Final Judgment and Decree entered by the court in Cause No. 115,414 A-1, 264th Judicial District, In Re: The Exceptions of the Lower Colorado River Authority and the City of Austin to the Adjudication of Water Rights in the Lower Colorado River Segment of the Colorado River Basin.

4. LCRA's proposed Drought Management Plan was filed with the Commission on October 19, 1990.

5. LCRA's procedures and guidelines set forth in the Water Management Plan and the Drought Management Plan for the allocation of firm water and interruptible water supplies are acceptable as conditioned by the provisions of this Agreed Order and with the understanding that the allocation procedures may be amended by the Commission at a later time for any justifiable reason including, but not limited to, an amendment to reflect the results of the instream flow and bay and estuary studies; provided, however, that the Commission shall retain jurisdiction to resolve all disputes regarding allocation of stored water that may arise in the future.

6. The priorities in LCRA's Water Management Plan and Drought Management Plan for interruptible water are subject to change after the completion of the studies on the instream flows and bays and estuaries required by conditions (k) and (l) of the September 7, 1989 Order.

7. Because of the water-availability and water-demand conditions that presently exist, it appears that 25,000 acre-feet of stored water per year probably will be adequate in the near future to firm up the minimum flows for instream flows and bays and estuaries set forth in condition (h) of the Commission's September 7, 1989 Order. Pursuant to conditions (k) and (l) of the Commission's September 7, 1989 Order, LCRA is required to submit applications to amend the Water Management Plan and the Drought Management Plan following completion of studies on instream flows and bays and estuaries

required by March 1992, and March 1993, respectively. Accordingly, it is unnecessary for the Commission to determine at this time whether the Commission, by its September 7, 1989 Order or otherwise, intended to give LCRA the authority or impose upon it the obligation to release more than 25,000 acre-feet of stored water in any one year to firm up those minimum flows.

8. Based on available studies and information, it is uncertain whether LCRA's proposed plan to begin curtailment of interruptible stored water supplies at a January 1 trigger level of 1.4 million acre-feet of water in storage is appropriate, in that it may provide more protection to firm supplies of stored water than is necessary. However, because of the water-availability and water-demand conditions that presently exist, it is likely that such level will not be reached in the near future. Accordingly, it is unnecessary for the Commission to determine at this time whether, or to what extent, such trigger level provides more protection to firm supplies than is necessary.

9. LCRA asserts that nothing in the Drought Management Plan should be construed to modify or impair in any way any contractual obligation of LCRA to supply water.

CONCLUSIONS OF LAW

1. The public hearing was held under the authority and in accordance with Chapter 11 of the Texas Water Code, as amended and the Texas Water Commission Permanent Rules.

2. The Texas Water Commission has jurisdiction to consider and take action on LCRA's proposed Drought Management Plan.

3. It is unnecessary at this time to determine whether the Commission, by its September 7, 1989 Order or otherwise intended to give LCRA the authority or impose upon it the obligation to release more than 25,000 acre-feet of stored water in any one year for instream flows and bays and estuaries. By approving the Drought Management Plan and entering this Order, the Commission specifically is not deciding these issues.

NOW, THEREFORE, BE IT ORDERED BY HE TEXAS WATER COMMISSION THAT:

1. LCRA's proposed Drought Management Plan is approved with the following conditions:

   a. LCRA's Drought Management Plan is subject to LCRA's Water Management Plan and all findings, conclusions and conditions contained within the Commission's September 7, 1989 Order approving the Water

Management Plan including, without limitation, any findings, conclusions and conditions contained in this Order that are also contained within the September 7, 1989 Order.

b. The Drought Management Plan shall be subject to the continuing right of supervision of the Commission, and the Commission, on its own motion, may reconsider any element of the plan at any time in the future.

c. LCRA's responsibility and authority under the Drought Management Plan is limited to operational control of the Highland Lakes and LCRA's facilities downstream, and is limited by the terms of this Order and the Commission's September 7, 1989 Order.

d. LCRA is required to pass all inflows to the Highland Lakes to the extent necessary to satisfy the demands of all downstream senior rights, and nothing in the Drought Management Plan or this order shall be construed to modify or impair this obligation.

e. LCRA shall prepare and submit to the Commission, on or before March 1 of each year beginning with March 1, 1992, a report which documents compliance with the approved Drought Management Plan and any special conditions thereto during the previous year. Such report shall be in a form approved by the Executive Director.

f. After the instream study by LCRA and TPWD is completed, but in any event not later than March, 1992, LCRA shall submit an application to amend its Water Management Plan and its Drought Management Plan to reflect the results of the instream flow studies and the studies and evaluations referenced in Findings of Fact Nos. 73, 74, and 75 of the Commission's September 7, 1989 Order. Such application shall also propose conditions for implementing or cancelling the declaration of a drought to be worse than the drought of record. LCRA shall do all things necessary to ensure that such application is administratively and technically complete within six months of submission. The Commission agrees to hold a hearing within one year of the date of LCRA's submission to consider the amendments of the Plans, or if the studies are not complete, to determine why such studies are not complete.

g. After completion of the Texas Water Development Board ("TWDB") and TPWD study on freshwater inflows into the bays and estuaries, as applicable to the Lavaca-Tres Palacios Estuary, and in any event not later than March, 1993, LCRA shall submit an application to amend its Water Management Plan and its Drought Management Plan to reflect the results of the bays/estuary study. LCRA shall do all things necessary to ensure that such application is administratively and technically complete within six months of submission. The Commission agrees to hold a hearing within one year of the date of LCRA's submission to consider the amendments of the Plans, or, if the studies are not complete, to determine why such studies are not complete.

h. The combined firm yield as found by the Commission in Finding of Fact No. 47 of its September 7, 1989 Order is subject to adjustment and refinement from time to time as additional studies and simulations are developed that more accurately reflect assumptions and operations as required by law.

i. LCRA's proposed plan to begin curtailment of interruptible stored water at a January 1 trigger level of 1.4 million acre-feet of water in storage, and other aspects of LCRA's proposed curtailment plan, are subject to adjustment from time to time as additional studies and simulations may be developed that more accurately address the need to curtail interruptible supplies.

j. The Commission retains jurisdiction to resolve any and all disputes regarding the allocation of stored water from Lakes Travis and Buchanan, notwithstanding the procedures and guidelines set forth in the Water Management Plan and/or the Drought Management Plan.

2. The Chief Clerk of the Texas Water Commission shall forward a copy of this Order subject to the filing of motions for rehearing, to all parties.

3. If any provision, sentence, clause or phrase of this Order is for any reason held to be invalid, the invalidity of any portion shall not affect the validity of the remaining portions of the Order.

4. Nothing in the Drought Management Plan or this Order shall be construed to impair, or to authorize LCRA or any other person or entity to impair, senior or superior water rights in the Colorado River Basin.

Issued: DEC 2 3 1991

TEXAS WATER COMMISSION

John Hall, Chairman

ATTEST:

Gloria A. Vasquez, Chief Clerk