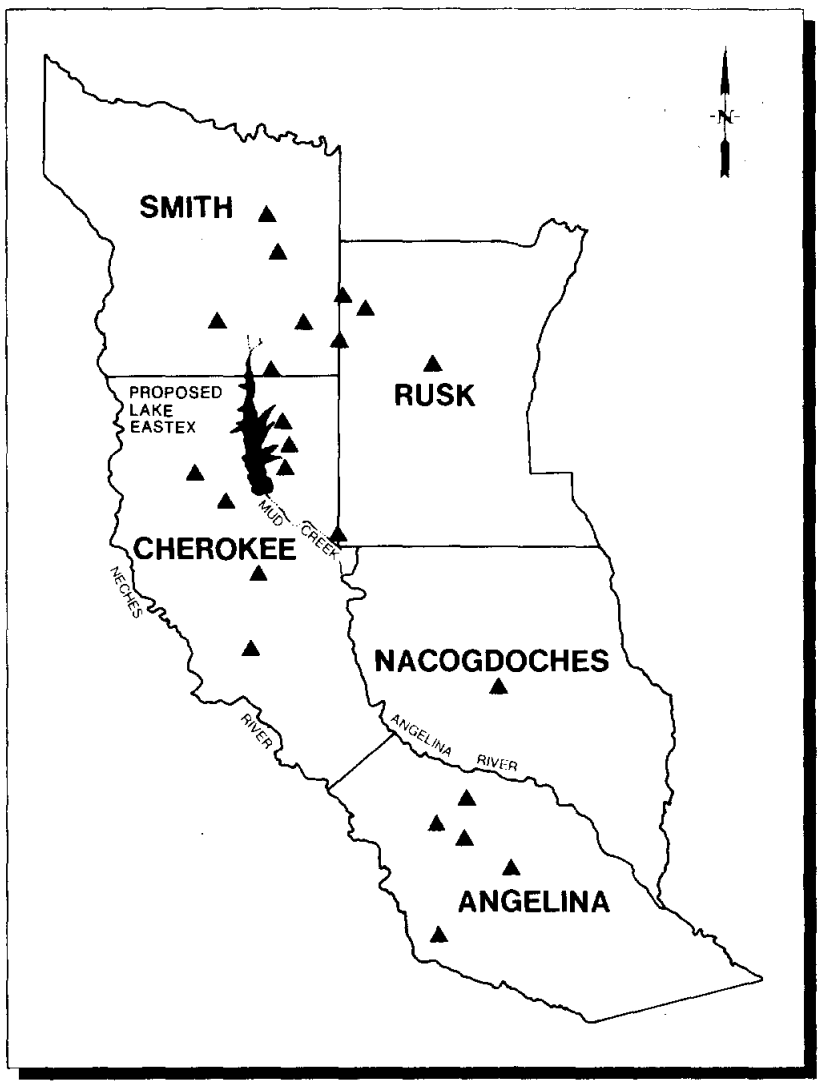
L A K E E A S T E X
REGIONAL WATER SUPPLY PLANNING STUDY



Funding Provided by:

City of Jacksonville
City of Troup
City of New London
City of Arp
City of Lufkin
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City of Rusk
Reklaw Water Supply Corp.
City of Nacogdoches
Jackson Water Supply Corp.
City of Overton
New Summerfield Water Supply Corp.
Angelina Water Supply Corp.
Cherokee County
City of Henderson
Wright City Water Supply Corp.
Star Mountain Water Supply Corp.
Craft-Turney Water Supply Corp.
Woodlawn Water Supply Corp.
Redland Water Supply Corp.
Walnut Grove Water Supply Corp.
Blackjack Water Supply Corp.
Temple-Inland Forest Products, Inc.
The Texas Water Development Board

August 1991

Angelina & Neches River Authority

Volume 1
Engineering and Financial Analysis

Lockwood, Andrews & Newnam, Inc.

Contributing Consultants

Mariah Associates, Inc.
The Frasier Group
Legg Mason Wood Walker, Inc.
John D. Stover P.C.

Lockwood, Andrews
& Newnam, Inc.

September 27, 1991

President and Board of Directors
Angelina and Neches River Authority
210 Lufkin Avenue
Lufkin, Texas 75901

Reference: Lake Eastex Regional Water Supply Planning Study

Gentlemen:

We are pleased to submit the attached Lake Eastex Regional Water Supply Planning Study report, presented as a two volume set. Volume 1, Engineering and Financial Analysis, primarily addresses the project background and setting, water supply alternatives for the region, and specifics about the engineering and financial issues associated with the proposed Lake Eastex. Volume 2, Environmental Inventory and Issues, primarily addresses the baseline environmental data and potential environmental impacts. This report is intended to provide a planning level evaluation of the major engineering and environmental issues, and associated costs in order to provide the Authority and the project participants a better basis on which to make decisions for the future of the Lake Eastex project.

This report represents the culmination of a collaborative effort between the Authority, LAN, Mariah Associates, Inc., Legg Mason Wood Walker, Inc. and John Stover, P.C. We would like to gratefully acknowledge the teamwork and participation of all involved in successfully completing this document.

We appreciate the opportunity to have worked with, and for you on this most important project. We look forward to assisting you further as we move into subsequent phases of the project to hopefully make Lake Eastex a reality for the people of East Texas.

Sincerely,

E. Tyson Thomas

E. Tyson Thomas, P.E.
Project Manager

Daniel D. Clinton

Daniel D. Clinton, Jr., P.E.
Vice President

ETT:lw

Attachment

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LAKE EASTEX
REGIONAL WATER SUPPLY
PLANNING STUDY

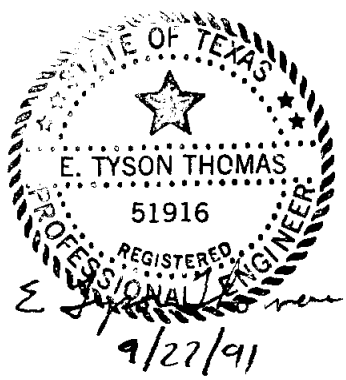
VOLUME 1
ENGINEERING AND FINANCIAL ANALYSIS

Prepared for

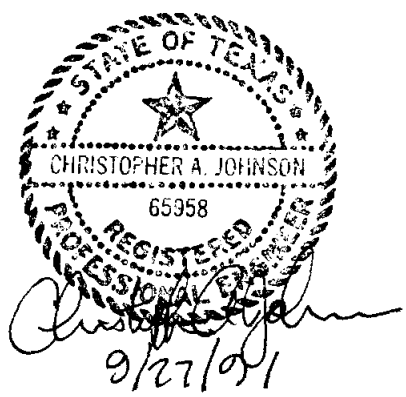
The Angelina and Neches River Authority

by

Lockwood, Andrews & Newnam, Inc.
Mariah Associates, Inc.
The Frasier Group
Legg Mason Wood Walker, Inc.
John D. Stover P.C.



August 1991



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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The Lake Eastex Regional Water Supply Planning Study provides a regional surface water supply plan for Angelina, Cherokee, Nacogdoches, Rusk, and Smith Counties. The purpose of the study includes:

a. An investigation of water supply alternatives for the five county study area.
b. An investigation of the physical conflicts to be expected as a result of the construction of Lake Eastex.
c. An investigation of the environmental and socioeconomic impacts which would result from constructing Lake Eastex.
d. The development of a plan for a water delivery system to supply water from Lake Eastex to each of the project participants.
e. An estimate of the costs associated with the future development and construction of Lake Eastex, the construction of the delivery system, and costs to mitigate any expected adverse environmental impacts.
f. The development of a plan for financing the construction of Lake Eastex and its associated delivery systems.
g. The determination of a unit cost for water delivered to each participant.

The results of this planning study indicate that a surface water supply is needed to meet the short and long term water demands in the five county study area. The investigation of water supply alternatives included consideration of groundwater and surface water resources. The results of the research indicate that groundwater sources must be supplemented with surface water sources, especially in areas with large concentrated demand (urban or industrial areas). Various existing and proposed surface water sources were evaluated. Lake Eastex proved to be the most economical single source to supply the study area. However, utilization of water from Sam Rayburn Reservoir to serve the southern extreme of the study area (Angelina County) may be even more economically efficient.

There are typically many physical conflicts to resolve in the development of any reservoir project. Physical conflicts identified for the Lake Eastex project can be categorized as follows:

a. State and Federal Highways
b. County Roads
c. Railroad
d. Electric Power Lines
e. Oil and Gas Pipeline and Wells
f. Telephone Cables

Representatives with each conflict entity were contacted in order to determine the degree of conflict, the method of resolving the conflict, and an estimated cost for the conflict resolution. The total cost to resolve all identified conflicts has been estimated at $50,343,000.

The investigation of environmental and socioeconomic impacts indicated that, in general, the Lake Eastex project would have a positive impact on the socioeconomic characteristics of the reservoir site vicinity and the region. Benefits include an increase in economic activity due to construction of the lake and related projects, an increase in long term ad valorem tax revenues, and the additional water resources needed for future economic growth in the area.

Environmental investigations performed as a part of the study effort have indicated that the inundation of the Mud Creek floodplain could have potential environmental impacts within the reservoir pool and downstream of the proposed dam. Potential impacts within the reservoir pool include loss of terrestrial vegetation and wildlife habitat, bottomland hardwoods, wetlands, and cultural resources. Potential impacts downstream of the proposed dam include a decrease in instream flows and the resultant impacts on aquatic habitat and species. Additional studies will be required during the permit process in order to quantify existing resources and draw conclusions concerning the amount of impact. It is anticipated that adverse impacts to the environment caused by the proposed Lake Eastex can be mitigated. For planning purposes, a mitigation allowance has been included in the cost estimates for the project to account for all of the impacts discussed above. The amount of this allowance has been estimated based on mitigation requirements for recent similar projects at $15,322,000.

A conceptual plan for a system to treat and deliver water from Lake Eastex to meet the water demands of the project participants was developed. The most economical plan is one which utilizes the primary system components below:

a. One system to serve the group of participants in northern Cherokee, Rusk and southern Smith Counties.
b. One system to serve Temple-Inland Forest Products, Inc. in southern Cherokee County.
c. One system to serve the City of Nacogdoches.
d. One system for the participants located in Angelina County which incorporates the regional system proposed in the Angelina County Regional Water Study.

The costs for the delivery systems include raw water intake and pumping facilities, water treatment, finished water pumping, booster pumps, and transmission pipelines. The total cost for the year 2040 delivery system, in 1990 dollars, is estimated at $76,919,000.

The costs to develop and construct Lake Eastex along with its associated year 2040 delivery system are summarized in Table 1.

Table 1

LAKE EASTEX PROJECT COST SUMMARY

Construction of the Dam and Reservoir	
Dam, Spillways and Outlet Works	$ 20,990,000
Conflict Resolution	50,343,000
Land Acquisition	16,538,000
Mitigation Allowance	15,322,000
subtotal	$103,193,000
Construction of the Delivery System	
Northern System	$ 50,099,000
Southern System	8,155,000
Temple-Inland System	13,131,000
Nacogdoches System	5,574,000
subtotal	76,919,000
Total Project Cost	$180,112,000

The unit cost of raw water in Lake Eastex was determined to be between $0.37 and $0.45 per 1000 gallons, depending on certain assumptions relative to reservoir conflicts and environmental considerations. The unit cost for water delivered to each participant varies depending on location and delivery system phasing, usually between $1 and $2 per 1000 gallons.

This study report is intended to provide the Angelina & Neches River Authority (ANRA) and the project participants with the information needed to make decisions concerning future steps for the Lake Eastex project. The Section 404 permitting process is the next challenge for project supporters.

The permit process is expected to include the preparation of a Section 404 permit application, participation in a series of meetings with State and Federal regulatory agencies to define the scope of environmental studies required, and the preparation of the Environmental Impact Statement expected to be required as a condition of the permit. Assuming the permit is granted for the project, construction of Lake Eastex could be completed by mid 1999 with revenues from water sales realized by the second quarter of the year 2000.

I. INTRODUCTION

I. INTRODUCTION

A. HISTORY

In 1978, as a result of inquiries from community leaders in Cherokee County, principally from Jacksonville, the Angelina and Neches River Authority (ANRA) began the planning for what was then called the Mud Creek Reservoir, now Lake Eastex. The community leaders were motivated by several potential industrial and commercial projects, none the least of which was the Carter Oil Company (subsidiary of Exxon) lignite development project. These leaders realized that while their area had the ingredients for industrial and commercial development such as energy, labor and transportation, it did not have the dependable water supplies needed for their long term municipal needs, much less for a sizeable industrial or commercial development. Carter Oil estimated its annual needs would be between 20,000 and 30,000 acre-feet/year. The first planning work began in 1978 when William A. Elmore, formerly Executive Director of ANRA, and the consulting team consisting of representatives from Lockwood, Andrews & Newnam (LAN), Vinson & Elkins (acting as Bond Counsel), Lovett, Underwood, Neuhaus & Webb, Inc. (formerly Greer, Moreland, Fosdick & Shepherd) and John D. Stover, attorney, met among themselves and then subsequently with representatives of Carter Oil. Though Carter Oil later shelved its plans for the lignite mine (it still maintains the leases and ownership of the lignite deposit), they effectively established in the minds of the community leaders in the Upper Neches River basin that a surface water supply was needed. The region is one of current and projected population growth, and has a great potential for commercial and industrial development because of its resources. Additionally, the increasing demand for surface water downstream by the major metropolitan areas was identified as a threat to surface water being available upstream at some future date. It was also realized that developing water projects was becoming increasingly complex because of regulatory requirements, land costs and construction costs. The additional time, costs, and steps required as a result of the regulatory controls alone was turning an already lengthy process into a nearly impossible task. Otherwise feasible projects were becoming too expensive to pursue due to excessive up-front costs. Initial information from the Texas Water Development Board planning division indicated that the Lake Eastex project had a project cost of water substantially less than any other major project then being planned. While the cost was considerably more than what most water users in the region were paying because of their current and historical dependence on groundwater, it was also recognized that the future cost of groundwater would rise because of the increasing demand and associated declining levels.

In 1981, the Board of Directors of the ANRA established a steering committee of community leaders which began work, along with the Board, to consolidate the support for the project. By the end of 1983, 14 separate entities had committed a total of $100,000.00 to fund the expense of obtaining a permit from the Texas Water Commission for the project. These 14 original participants (Original Participants) are:

a. City of Rusk
b. City of New London
c. City of Troup

d. City of Overton
e. City of Arp
f. City of Jacksonville
g. City of Lufkin
h. City of Henderson
i. Reklaw Water Supply Corporation
j. Angelina County Water Supply Corporation
k. Cherokee County
l. Angelina County
m. Texas Utility Services, Inc.
n. Leo Childs

A permit application report was completed by LAN and a permit application was filed with the Texas Water Commission on September 7, 1984.

On June 4, 1985, the Texas Water Commission issued a permit authorizing the ANRA to build the reservoir and divert water for municipal and industrial use. The ANRA then began working on financing the next phase. The firm of McCall, Parkhurst & Horton was hired as a Bond Counsel in early 1986 and negotiations began with the Original Participants.

During the negotiations with the Original Participants, an impasse was reached because the ANRA was not able to firmly establish the cost of the project and the participants were unwilling to enter into contracts that were open-ended. The difficulty of estimating construction costs centered around the environmental issues that would have to be addressed such as the presence of endangered species, the impact on terrestrial and aquatic habitat, the effects on cultural resources and other similar issues. Additionally, there was the question of the conflicts of the reservoir with road, railroads, pipelines and other existing uses.

The ANRA decided to resolve the impasse by segregating out the planning process from the construction phase so that an informed estimate of construction costs could be made. Planning costs were estimated at approximately $630,000.00 and negotiation began with the Original Participants for funding. Also, the Texas Water Development Board (TWDB) was approached for financial aid for this phase of the project. An application was submitted to the TWDB for a grant for the planning costs and the TWDB subsequently approved a grant for 50 percent of the cost conditioned on the participants providing matching funds. The TWDB subsequently agreed to loan ANRA the matching funds based on an agreement from the participants to repay it. Of the remaining 50 percent matching fund portion of the planning costs, forty one percent has been paid by project participants and the balance was obtained from the TWDB in the form of a loan. The loan was structured so that it can be rolled into the permanent financing of the project.

A change in the participants occurred when the contracts were solicited for options to purchase water in return for agreement to repay the planning cost. The pre-construction phase participants are:

a. Cherokee County
b. City of Jacksonville
c. City of Henderson
d. City of Lufkin
e. City of Nacogdoches
f. City of Arp
g. City of New London
h. City of Rusk
i. City of Troup
j. City of Overton
k. Angelina Water Supply Corporation
l. Blackjack Water Supply Corporation
m. Craft-Turney Water Supply Corporation
n. Jackson Water Supply Corporation
o. New Summerfield Water Supply Corporation
p. Redland Water Supply Corporation
q. Reklaw Water Supply Corporation
r. Star Mountain Water Supply Corporation
s. Walnut Grove Water Supply Corporation
t. Woodlawn Water Supply Corporation
u. Wright City Water Supply Corporation
v. Leo Childs
w. Temple-Inland Forest Products, Inc.

The ANRA, through its own staff, now led by Gary Neighbors, General Manager, and through its contractors, LAN; Lovett, Underwood, Neuhaus & Webb, Inc. (formerly Greer, Moreland, Fosdick and Shepherd); and John D. Stover, attorney commenced project planning. In early 1991, financial consultant Lovett, Underwood, Neuhaus and Webb, Inc. was replaced by Legg, Mason, Wood and Walker, Inc. after the former elected to dissolve their public finance division.

B. PURPOSE

In April 1988, the ANRA authorized LAN and its environmental subcontractor, the Frasier Group, Inc., in association with the other aforementioned contractors, to participate in the development of a regional water supply planning study for a five-county study area. The Frasier Group, Inc. ceased operation during the course of this study and was subsequently replaced by Mariah Associates, Inc. in May of 1991. The primary purpose of the study was to provide a regional surface water supply plan for Angelina, Cherokee, Nacogdoches, Rusk, and Smith Counties. Originally, the study was to be based on water to be supplied from the proposed Lake Eastex and a few limited alternatives. However, in its final form, a significant number of additional water supply alternatives were also considered in the study, some generally and some in more detail.

Several different areas of interest were identified to be addressed in this planning effort to answer those questions raised during the negotiations with the original project participants to finance the design and construction phase of the Lake Eastex project. These areas are listed below.

a. Areas of Environmental Impact
b. Terrestrial Biology
c. Aquatic Biology
d. Threatened or Endangered Species
e. Socioeconomics
f. Cultural Resources
g. Water Supply Alternatives
h. Reservoir Conflicts
i. Systems Configuration
j. Financing

Furthermore, the development of this planning study included coordination with a water supply planning study being developed by Everett Griffith, Jr. and Associates, Inc. to address water supply in Angelina County.

C. FUTURE STEPS

The Lake Eastex Regional Water Supply Planning Study addresses the previously unknown costs associated with various environmental and socioeconomic issues. Although most issues will need to be addressed in greater detail during the permitting phase, this planning study will form the basis for identifying and assessing the issues required to be addressed in the Section 404 permit process. The study provides cost estimates for both raw water in Lake Eastex and treated water from Lake Eastex delivered to each participant. This information will allow project participants to make an informed decision about their future role in the development of the Lake Eastex project.

There are several major steps remaining in the Lake Eastex development process. The next milestone, the acquisition of a Corps of Engineers Section 404 permit, could represent the largest challenge supporters of the project will face. In recent years, the increase in environmental awareness has resulted in additional federal regulations and the involvement of several environmental agencies in the permit process. The U.S. Army Corps of Engineers, Texas Parks and Wildlife Department, U.S. Fish and Wildlife Service, and the Environment Protection Agency will each be key players in the permit acquisition process. Although the goals and objectives of the environmental regulations are known, some of the recently adopted environmental procedures are so new, that the impacts they may have on the development process are unknown. Of particular concern are the new, and still evolving, wetlands delineation criteria and the involvement of the EPA and their possible use of the Section 404(c) veto. It should be recognized that it is very unlikely that water supply project development and permitting will become less difficult in the future.

The following paragraphs discuss the steps remaining in the development of the Lake Eastex Project. It must be understood that the time periods and dates mentioned in the discussion have been estimated considering the additional coordination and research expected. However, unforeseen difficulties at any point in the process could delay all subsequent activities.

In view of the complexity of the development process, and the immediate need for the Lake Eastex project, it is recommended that the Section 404 permitting process be initiated immediately. Preliminary discussions with the U.S. Army Corps of Engineers (COE) and environmental consultants indicate that the most effective means of pursuing a permit for a major project such as Lake Eastex is to participate in a series of pre-application meetings with the COE and associated state and federal resource agencies. This meeting will allow the COE to inform the applicant of the kinds of information which should be submitted with the application. These meetings are not required; however, this is generally recognized as the most effective way to get the process started.

Upon receipt of the application, with its associated drawings and land ownership information, the COE has 15 days to send it out for public notice, followed by a 30-day public comment period. Due to the nature of this project, an Environmental Impact Statement (EIS) will likely be required, rather than the less detailed Environmental Assessment (EA). Once that decision is made, the COE will publish a notice of intent to prepare an EIS and a notice of intent to conduct a scoping meeting, which marks the beginning of the scoping process.

The scoping meeting is similar to a public hearing in which the COE invites comments, either verbal or in writing, for a 30-day period following, from anyone who wishes to do so. The purpose is to ensure that all the significant issues and concerns are identified and considered before the EIS preparation begins. The public meeting is then usually followed by a series of meetings with each of the resource agencies involved in the permit review. These agency meetings are not mandatory, but are again recommended as the most effective way to fully and firmly develop the EIS scope. These agencies include the U.S. Fish and Wildlife Service (USFWS), the Texas Parks and Wildlife Department (TPWD), the U.S. Environmental Protection Agency (EPA), and the Texas Historical Commission (THC). This series of public and agency meetings will result in the full definition of issues that will be addressed in the EIS and the level of detail required.

After the scoping process is concluded, the EIS preparation begins. There are two ways to proceed with the EIS, as follows:

a. The applicant may contract with a third party to prepare the document for review. The applicant may select this party, subject to approval by the COE. This method has not been used in the Fort Worth District of the COE and in that sense would be breaking some new ground. This method may be quicker since the applicant can more directly control the document preparation; however, it is still subject to COE review.

b. Preparation by the COE. This may be a little less expensive but will most likely take longer since this project will be competing for COE staff time. As with the first alternative, the applicant must still provide all data and may facilitate the preparation by submitting drafts of the text for use by the COE.

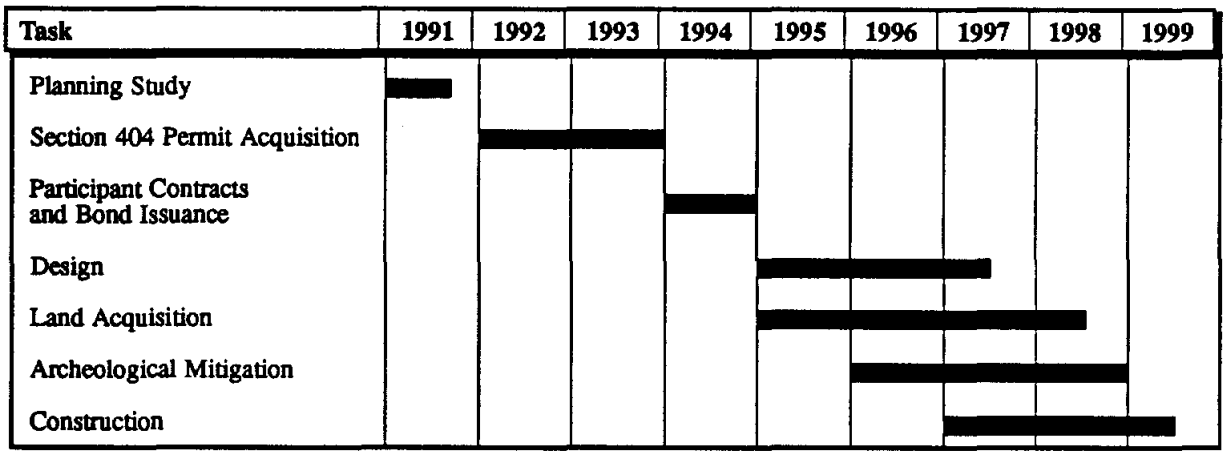
After the draft EIS is complete, it will be published, followed by a public hearing and a written comment period. The COE will take these comments, prepare the final EIS and publish it again for public comment. Final comments will be considered and the COE will then prepare a record of decision (ROD) with any conditions which may be applied to the project. The COE can grant the permit as proposed, grant the permit with special conditions, or deny it. The applicant may withdraw the permit application at any point during the process. The process may or may not be subject to changes at any point during the process and policy changes by the COE are usually effective immediately.

The total permitting process, from pre-application to ROD, can be expected to take a minimum of two years. This should be considered an optimistic "best case" based on the full attention and cooperation of the various agencies involved in the process, and minimal outside opposition. It is very possible that the permitting process will take longer than two years and the project participants are advised to plan accordingly. Two recent examples, Applewhite Reservoir in San Antonio and O. H. Ivie Reservoir in West Texas, have taken as long as six to seven years. On the other extreme, Justiceburg Reservoir near Lubbock took only about one year. In this case, however, an EIS was not required and the decision was based on an acceptable environmental document prepared by the consultant. Also, there was little or no public opposition to the project.

Upon issuance of the federal permit, all costs associated with environmental mitigation can be identified and a Certified Engineer's Estimate can be prepared. Contracts with the project participants will be negotiated and bonds issued for design services, hopefully within one year, by late 1994. The schedule then allows for design and land acquisition to be active concurrently, with design efforts being completed in mid 1997 and land acquisition being completed in mid 1998. Archeological testing and mitigation, anticipated to be required as a condition of the Section 404 permit can commence during land acquisition and run concurrently with construction. Construction, anticipated to be accomplished in phases, could be started immediately following the completion of the design of the first phase. The dam, spillways and outlet works will be designed and constructed first, assuming the dam site has been acquired and archeological testing and mitigation completed. It is anticipated that construction on all phases will be completed by mid 1999. A summary of the Lake Eastex project schedule is shown on Exhibit I.1. This schedule was developed to compress the design and construction phases in order to minimize the impact of capitalized interest. While attainable, total project completion by mid 1999 will require careful management and control to ensure the critical path is followed. Due to the nature of the tasks, their relationship and sequence, a setback during any phase has the potential to affect the final completion date.

Exhibit I.1

LAKE EASTEX PROJECT SCHEDULE



II. PHYSICAL SETTING

II. PHYSICAL SETTING

A. TOPOGRAPHY AND GEOGRAPHY

1. The Gulf Coastal Plains

The proposed Lake Eastex reservoir and five county study area are located in Northeast Texas and are wholly within the Gulf Coastal Plain (Exhibit II.1). The Coastal Plain is characterized by rolling to hilly features inland and gently sloping to virtually flat terrain along the coastline. The proposed reservoir lies within the hilly region about 85 miles north-northwest of the Kisatchie Escarpment which generally defines the transition between the hillier interior area and the flatter coastland. The Kisatchie Escarpment is also coincident with the southern boundary of the study area. A heavy cover of soft (pine) and hardwoods is typical of the coastal plain until one leaves the Pine Belt extending into East Texas and approaches the more arid interior region of Central Texas where prairie and brushlands eventually predominate. In East Texas, streams tending toward the southeast have cut wide, shallow valleys with slopes of approximately 250 to 550 feet per mile. Floodplains occur 100 to 150 feet below the surrounding uplands and may be from one to ten miles wide.

2. The Upper Neches River Basin

The Upper Neches River Basin is distinguished from the total Neches River basin as that portion upstream of the confluence with and including the Angelina River tributary. The confluence with the Angelina River is twelve miles west of Jasper (Jasper County) just south of the southern boundary of the study area. Combined, the two rivers drain approximately 7400 square miles. The basin is about 70 miles wide at its maximum point and narrows to about eight miles near the mouth. In length, about 150 miles of the Neches River's 220 mile course are upstream of the Angelina River confluence. Headwaters of the rivers are in southeast Van Zandt County (Neches River) and southwest Rusk County (Angelina River). The Trinity River drainage basin borders on the west and the Sabine River basin to the north and east. Elevations within the basin vary in range by about 600 feet with an upper limit of over 700 feet to about 100 feet at the confluence.

a. Geology

The study area in East Texas is part of a much larger region known as the Gulf of Mexico Basin which encompasses a number of interesting features. Principle structures include the Sabine Uplift and the East Texas Embayment (Exhibit II.2). Beginning in south-central Cherokee County near Redlawn, the axis of the embayment runs northward through Smith and Wood Counties before curving off to the east-northeast. Concentrated along this axis are domal structures related mainly to salt intrusion. These salt structures are of considerable geologic and economic importance. A massive bed of Louann salt occurs more than 15,000 feet below the deeper parts of the East Texas Embayment. Slightly less dense than the overlying rocks and subject to flow under pressure, the salt became buoyant and rose through overlying rocks in a

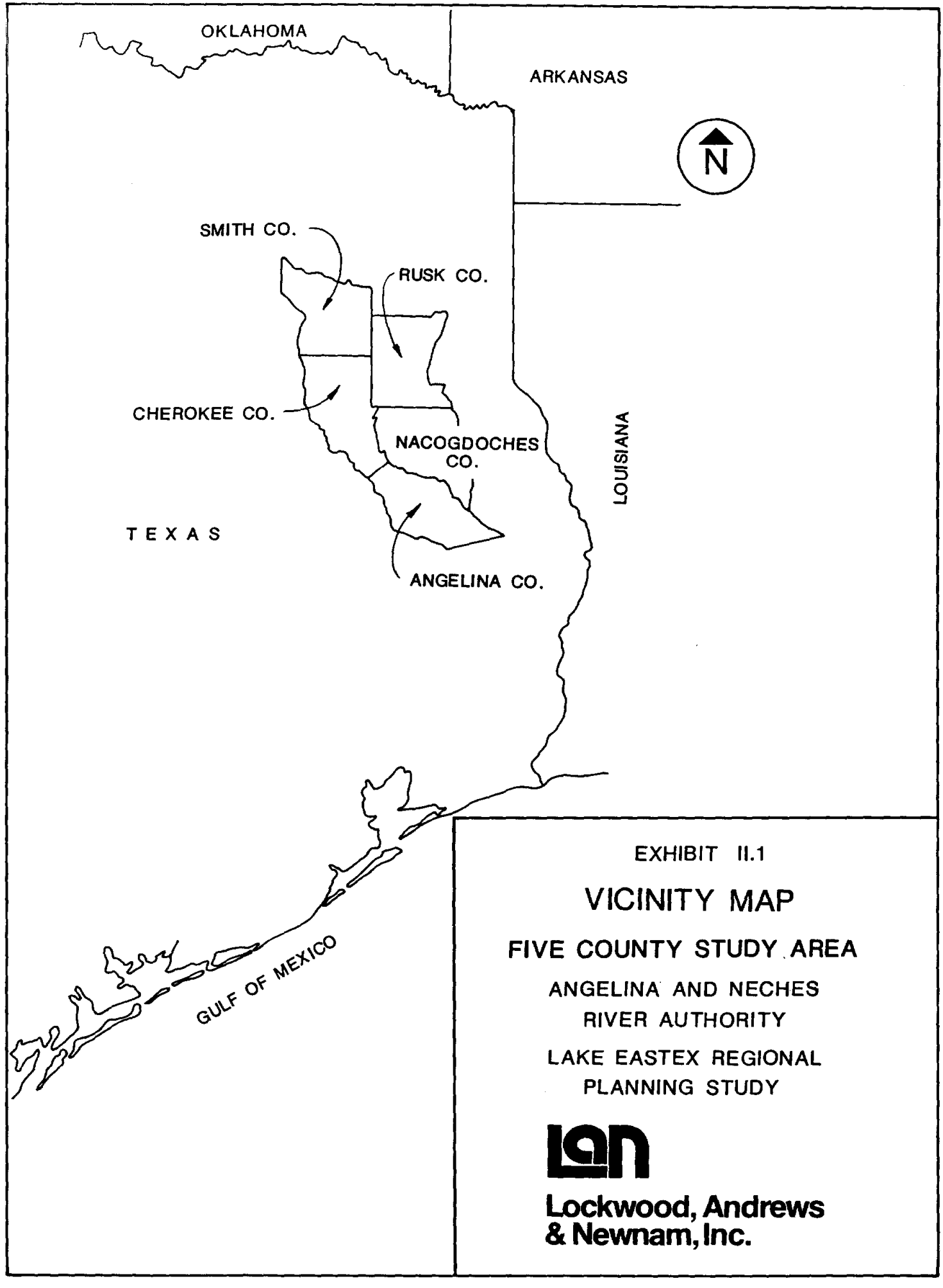


EXHIBIT II.1

VICINITY MAP

FIVE COUNTY STUDY AREA

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

Lockwood, Andrews & Newnam, Inc.

LEGEND

SALT DOME

Te_2 FORMATION SYMBOL

FIVE COUNTY STUDY AREA

EXHIBIT II.2

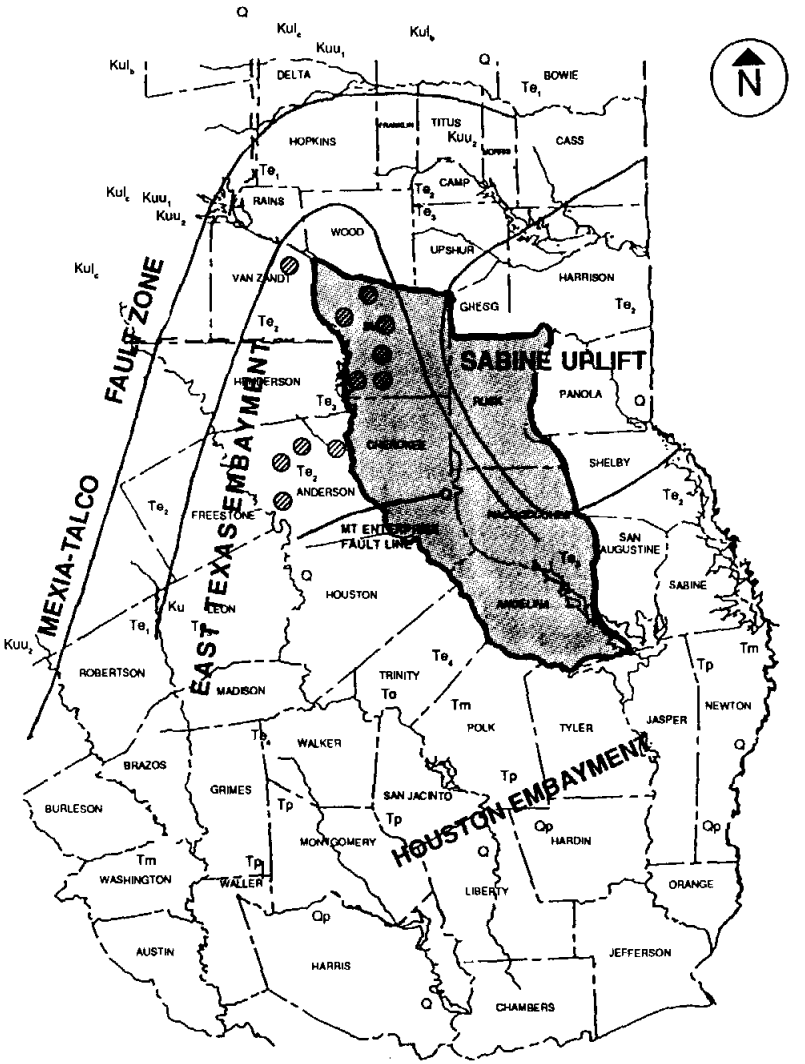
GEOLOGIC MAP AND FORMATIONS

EAST TEXAS

ANGELINA AND NECHES

ERA	SYSTEM	SERIES		TIME MILLIONS OF YEARS	MAP SYMBOL	FORMATION		GROUP
CENOZOIC	QUATERNARY Q	HOLOCENE		0	Qn			
		PLEISTOCENE		3	Qp	DEWEYVILLE; BEAUMONT, MONTGOMERY, LISSIE, BENTLEY, WILLIS; CITRONELLE		
	TERTIARY	PLIOCENE		11	Tp	GOLIAD		
		MIOCENE		25	Tm	LAGARTO, FLEMING, OAKVILLE	SUBSURFACE	FLEMING
		OLIGOCENE		40		ANAHUAC, CATAHOULA, FRIO	SUBSURFACE	CATAHOULA
					To	VICKSBURG (Subsurface only)	SUBSURFACE	VICKSBURG
		EOCENE		60	Te4	WHITSETT, MANNING, MCELROY, WELLBORN, CADELL-MOODY'S RANCH		JACKSON
					Te3	YEGUA-COCKFIELD, COOK MOUNTAIN, STONE CITY, SPARTA, WECHES, QUEEN CITY, REKLAW, CARRIZO		CLAIBORNE
					Te2	WILCOX: CALVERT BLUFF-SABINETOWN, SIMSBORO-ROCKDALE-PENDLETON		WILCOX
		PALEOCENE		70	Te1	MIDAY: HOOPER-SEGUIN, WILLSPOINT, KINCAID		MIDWAY
MESOZOIC	CRETACEOUS K1	UPPER	GULFIAN KU		Kuu2	NAVARRO: KEMP, CORSICANA, NACATOCK		NAVARRO
					Kuu1	TAYLOR: ANNONA, MARLBROOK, PECAN GOP, WOLFE CITY, OZAN		TAYLOR
					Kulc	AUSTIN: TOKIO, GOBER, BROWNSTOWN, BLOSSOM, BONHAM, SOUTH BOSQUE		AUSTIN
					Kulb	EAGLE FORD, LAKE WACO		EAGLE FORD

GEOLOGIC FORMATIONS



GEOLOGIC MAP

N.T.S.

series of piercement domes. Where the salt reached the surface, it is commercially mined. Those structures that were unable to reach the surface possess considerable economic importance because, during the upward thrust, surrounding rock units were tilted and fractured, forming stratigraphic traps for the accumulation of oil and natural gas. Toward the south end of the axis, the domes veer to the southwest and follow the Elkhart-Jarvis-Mt. Enterprise fault system.

Centered near the Sabine River at the Texas-Louisiana border, the Sabine Uplift is a generally flat-topped expanse of high ground. Typically, the rock units dip radially away from the center of the uplift.

The Mexia-Talco and Elkhart-Jarvis-Mt. Enterprise are the primary fault systems with the minor Rodessa system bordering the Sabine Uplift on the north (Exhibit II.2). All three are comprised of step-patterned segments. Only the Elkhart-Jarvis-Mt. Enterprise is of importance to the immediate study area as it bisects Cherokee County just south of Jacksonville on its eastward course across southern Rusk County.

Causes of the faulting are uncertain since the area is not near any active tectonic plate boundary (e.g. Pacific Coast). To account for the enormous sedimentary accumulation in the Gulf Geosyncline, however, a rapid sinking of the sea floor along the continental margin has been postulated, suggesting that the fault zones represent areas along the earth's crust that are flexing downward. The faulting might be gravity induced or more properly termed slumping. Total vertical motion or throw, in these zones approaches 350 feet. Considerable sedimentary accumulation usually occurs across the faults Gulfward. The faults near the study area are probably related to nearby uplifts and have not shown motion since the Miocene (Exhibit II.2).

Earthquake records of Texas were examined back to 1928 from the U.S. Department of Commerce publications. Earlier records were obtained from published historical summaries. Not only are apparent earthquake epicenters removed from the study area, but seismic activity from surrounding areas is seldom felt in the study area. However, the New Madrid earthquake of 1812 did affect the area, reaching inferred Mercalli Intensities of V-VI (16). In more recent times, a number of minor quakes have been recorded within 50 miles of the project area. Regional studies of seismicity (Algermissen, 1969) confirm the low seismic risk of the study area (Exhibit II.3).

Surface stratigraphy discloses a large number of geologic units. Mention is made here of only the best known or those most important for their resources. Among the oldest exposed rocks (Upper Cretaceous) are the Woodbine and Austin Groups. The Woodbine Group is made up of porous sands and shales and is an important oil and gas reservoir in East Texas. The Austin Group is primarily chalk with lesser amounts of shale, sandstone, and marl. Sand units appear throughout the Upper Cretaceous sequence including several of specific importance locally for their oil and gas resources.

Newer groups (Early Cenozoic or Paleocene rocks) include the Wilcox, Claiborne, and Jackson. These groups include the only significant water-bearing (aquifer) formations - namely

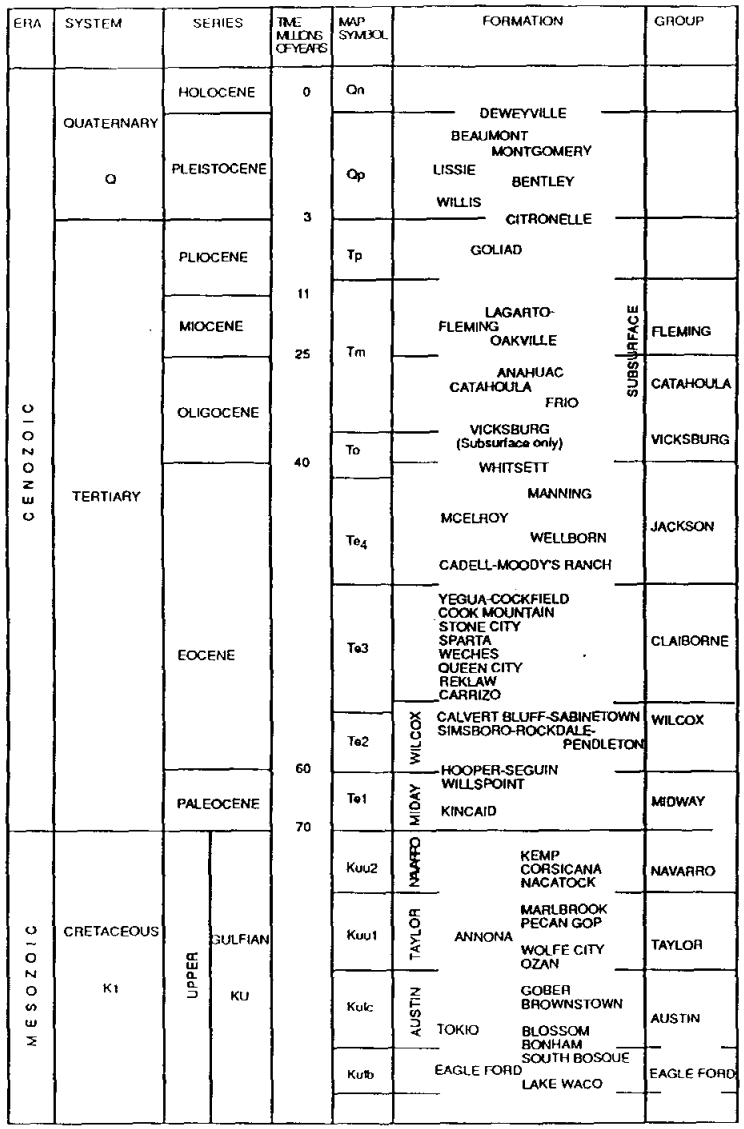


EXHIBIT II.3

GEOLOGIC FORMATIONS

EAST TEXAS

ANGELINA AND NECHES
RIVER AUTHORITY

LAKE EASTEX REGIONAL
PLANNING STUDY

Lockwood, Andrews
& Newnam, Inc.

the Wilcox group itself, then the Carrizo, Queen City, Sparta, and Yegua formations, which are part of the Claiborne group.

b. Soils

A soil profile is composed of a vertical succession of horizons with specific soil series grouped into associations whereby the sola have developed from similar materials and under similar environmental conditions. All soils in an association possess a common parent material and sequence of horizons within their respective profiles.

The study area is composed of coastal plain sediments forming the parent material for the present associations. Other soils were formed in alluvium that has transported characteristics from upstream and upslope sources. In places where slopes are steep, soils are generally thin because of erosional processes. On more level sites, soils are relatively thick. The soils in the study area have been classified and grouped into soil series and associations because Cherokee, Rusk, and Smith Counties do not have up-to-date published soil surveys.

It should be recognized that the same soil series may appear repeatedly within different associations due to its varying proportions. In order to retain consistency, some descriptions are therefore repetitious. The soil groups within the study area have been divided into type, position and area where possible.

Loamy upland soils are predominantly fine sandy loams with subsoils ranging from fine sandy loam,loam, clay loam to clay. These associations and their county locations are presented in Table II.1. A portion of these associations and groups have sandstone (e.g., Fuller-Keltys), siltstone and sandstone (e.g., Keltys-Kurth and Rosenwall), shale (e.g., Woodtell) and combinations of the aforementioned (e.g., Rayburn-Corrigan-Stringtown) relating to the parent material.

Loamy and sandy upland soils include the Bowie-Fuquay, Cuthbert-Tenaha and Letney-Springtown-Tehran which possess sandy clay loam subsoils and loamy fine sands to fine sandy loam A horizons. Sandy upland soils include fine sandy soils (e.g., Tonkawa) and loamy fine sand comprising the residuum of the groups which overlay sandy clay loam to clay loam subsoils.

c. Unique Soils and Prime Farmlands

Prime farmlands are defined by the U.S. Department of Agriculture as those soils which are best suited to producing food, feed, forage, fiber and oilseed crops. These lands produce the highest yields with minimal inputs of energy and economic resources. Limited by areal extent, prime farmlands are important to the nation's requirements for food and fiber. Potential prime farmlands are found on areas of prime farmland soils; however, the designation of prime farmland depends upon the amount and type of the specific soil units' use within the previous three years.

Table II.1

SOIL GROUPS AND ASSOCIATIONS WITHIN THE FIVE-COUNTY STUDY AREA

Soil Group	County				
	Angelina	Cherokee	Nacogdoches	Rusk	Smith
Loamy Upland Soils					
Bowie					X
Bowie-Cuthbert		X			
Diboll-Keltys	X				
Freestone-Woodtell					X
Fuller-Keltys	X				
Keltys-Kurth	X				
Kirvin					X
Kirvin-Bowie-Cuthbert				X	
Nacogdoches-Alto		X			
Nacogdoches-Trawick		X	X		
Raybum-Corrigan-Stringtown	X				
Redsprings-Alto				X	
Rosenwall	X				
Sacul					X
Sacul-Bowie		X			
Sacul-Cuthbert			X	X	
Sacul-Cuthbert-Kirvin	X				
Sacul-Kirvin			X		
Woodtell	X				
Woodtell-Garner		X			
Woodtell-Lacerda			X		
Loamy and Sandy Upland Soils					
Bowie-Fuquay		X			
Cuthbert-Tenaha		X	X		
Letney-Springtown-Tehran	X				
Sandy Upland Soils					
Darco-Tenaha			X		
Fuquay-Darco		X			
Lilbert-Darco			X	X	
Pickton					X
Tonkawa			X		
Tonkawa-Darco				X	
Wolfpen					X
Loamy to Sandy Terrace Soils					
Alazan-Moswell	X				
Attoyac-Bernaldo-Besner			X		
Besner-Mollville-Bienville	X				
Bernaldo-Keithville-Sawton	X				
Keithville-Eastwood-Sawton				X	
Moswell-Bernaldo	X				
Moten-Multey	X				
Level to Nearly Level Floodplain Soils					
Estes-Mooreville				X	
Gladewater					X
Hannahatchee		X			
Koury	X				
Mantachie-Marietta	X	X			
Marietta-Mooreville-Tuka			X	X	
Ozias-Popher	X				
Tuscosso-Hannahatchee			X		

A list of the prime farmland soils may be found in Table II.2; however, exact acreage represented by these soil units cannot be accurately calculated due to the age of soil surveys in Smith and Cherokee Counties and the lack of a soil survey in Rusk County. Prime farmland soils may be found in pasture, cropland, or woodland use presently. These soils characteristically possess sufficient moisture with acceptable limits of both acidity or alkalinity. They do not possess excessive amounts of rocks and typically have slopes of less than six percent. Prime farmland soils, therefore, reflect only the potential area of prime farmlands.

Potential prime farmland within the normal pool of the proposed Lake Eastex reservoir is represented by Alazan, Bowie and Iuka fine sandy loam soil units. The Iuka soil unit is the primary unit that will be flooded and comprises an estimated 712 acres. The Bowie and Alazan soil units account for 346 and 183 acres respectively of the prime farmland soil within the normal pool area. These are, however, only potential areas of prime farmlands as previously stated.

Table II.2

PRIME FARMLAND SOILS
WITHIN THE FIVE COUNTY STUDY AREA

Soil Series	County				
	Angelina	Cherokee	Nacogdoches	Rusk	Smith
Alazan (Caddo)*	X	X			
Alazan-Besner	X			X	
Alto					X
Attoyac (Amite)	X	X	X	X	X
(Cahaba)		X			
Bernaldo	X		X	X	X
Bernaldo-Besner	X		X		
Bowie		X	X	X	X
Chireno			X		
Derly-Besner					X
Derly-Raino					X
Elrose (Magnolia)		X			
Freestone					X
Gallime					X
Hannahatchie		X			
Iuka	X	X	X		
Keithville	X			X	
Keithville-Sawtown	X			X	
Keltys	X				
Koury	X				
Kullit			X		X
Kurth	X				
Latex				X	
Marietta	X			X	
Mollville-Besner**			X	X	
Moten-Multy**	X				
Nacogdoches		X	X		
Oakwood					X
Owentown					X
Raino					X
Redsprings		X	X	X	
Ruston			X		
Woden				X	

* Series name in parentheses refers to soil series prior to standardization by Unified Soil Classification.
**These complexes would only become prime farmland soils if drained.

d. Water Resources

The East Texas region as a whole is uniquely fortunate in the state in that it enjoys a significant supply of water. Abundant rainfall, a large number of streams and reservoirs, and extensive aquifers contribute to the general region. Runoff annually averages about 500 acre-feet per square mile of basin drained but ranges from a low of 300 for the Brazos River on the west to 1000 for the Sabine River on the east. The 1988-89 Texas Almanac lists nine lakes and reservoirs, with more than 5000 acre-feet of storage each, within the five county study area impounding water for the use of local municipalities and utilities. The nine are: Lake Cherokee, Lake Jacksonville, Lake Kurth, Martin Lake, Lake Nacogdoches, Lake Palestine, Sam Rayburn Reservoir, Striker Creek Reservoir, Lake Tyler and Lake Tyler East. Sam Rayburn Reservoir is by far the largest of these.

One major aquifer, the Carrizo-Wilcox, and two minor aquifers, the Queen City and Sparta sands provide useable quality groundwater over a large majority of the study area. In addition, the Yegua Formation, an undelineated aquifer provides a locally important source at the southern end of the study area. The study area is part of a six-county region (Gregg County is the sixth) identified in response to State legislative action in 1985 as one of ten areas experiencing or expected to experience within the next twenty years, critical groundwater problems. Declining water levels and some water quality problems associated with naturally occurring acidity and high iron concentrations are the primary concerns threatening this critical groundwater management area. The Texas Water Development Board and Texas Water Commission have recently completed studies which: (1) address occurrence and availability of both ground and surface water, (2) identify present and potential water resource problems, (3) project water supply and groundwater quality for the next twenty years, and (4) estimate future demands which will be placed on these resources. The study results did not recommend forming a groundwater district at this time. There is sufficient concern, however, to recommend that groundwater levels be monitored for five years and to have a portion of the five-county study area re-evaluated at that time. These studies, along with local experiences, raise questions in the minds of the project participants concerning the long-term reliability of groundwater from the minor aquifers and in major urban areas such as Tyler, Lufkin, Nacogdoches, Jacksonville, etc.

e. Divisions and Resources

The division of land into areas distinguished by their function or use is often related to the natural occurrence of resources within those areas. Other than the occurrence of natural resources, many land uses are distinguished by the activities of man within an area. Within the study area, there are three resources and land uses of primary importance both historically and for their potential for continued productivity. These are the agricultural and forestry land uses and fossil fuels (oil, gas, lignite) resources. The following paragraphs attempt to briefly state the resources that occur and activities which take place within the study area.

Natural resources are divided into two main groups. First are the mineral resources which are further divided into the fossil fuels mentioned above and then non-fossil resources such as iron, gravel, clays and numerous others. The second natural resource is the extensive pine wood forest covering most of East Texas [65% in 1965 according to one report (Fisher, 1965)].

Discovery in 1931 of the large East Texas Oil Field has contributed more to the economic growth of the area than anything else. The major deposits of oil and gas occur in Nacogdoches, Rusk, and Smith Counties with other large deposits to the west in counties bordering the study area (Van Zandt, Henderson, Anderson). Lignite occurs in both surface (less than 500 feet deep) and deep basin deposits. Increasing costs and depletion of oil and gas reserves act to increase the economic feasibility of lignite mining. Deposits in northern Nacogdoches and in Cherokee and Rusk Counties are potentially the most accessible as well as being of high quality. Present technology does not allow for economical recovery of deep basin lignite.

Non-fossil resources occur throughout the study area. They are, however, so diverse and scattered that no comprehensive accounting of them is possible here. More than one dozen may be readily identified including: clays, sands, gravels, salt, and iron. These non-fossil resources are often found in the same general areas as the oil, gas, and lignite reserves.

Forestry and the associated water intensive timber industry are important throughout the Pine Belt of East Texas. The Pine Belt within Texas is the primary source of the states' commercial timber production.

From Lake Palestine on the Neches River and the Tyler Lakes on Mud Creek (tributary to the Angelina River) to B. A. Steinhagen Lake, forestry and the timber industry dominate land use within the study area. Another evidence of this fact is that several East Texas timber company headquarters are located within the Neches River watershed.

Agriculture is certainly the oldest use of land in the study area, having been settled early in Texas' history. Although agricultural lands would historically have been primarily cropland, recent years have witnessed large increases in land devoted to pasture for both beef and dairy cattle production, as well as poultry raising and nurseries, especially in Smith County.

The only areas where agricultural land use may predominate over forestry are the nursery industry, particularly roses in Smith County and the Attoyac Bayou drainage basin of eastern Nacogdoches and southeastern Rusk Counties.

Conservation and recreation are two land uses which, for various reasons, often occur in the same area. Several State and National Parks and Forests occur within or immediately adjacent to the study area. The Davy Crockett National Forest and parts of the Angelina and Sabine National Forests are within the study area. Forests, including parts of timber company holdings set aside for public use, provide recreational areas in the form of trails, picnic and camping areas for local residents as well as tourists. Another important form of conservation and recreation activity is the development of a number of lakes within or immediately surrounding the study area. At the northern end of the study area, Lake Palestine, Lake Jacksonville, Lake Tyler and Lake Tyler East are the primary recreation spots with private and public parks and camp grounds. Lake Sam Rayburn to the south is the largest lake in the study area and attracts urban residents from as far away as Houston and Dallas. The U.S. Army Corps of Engineers, U.S. Forest Service and private citizens operate over two dozen parks and marinas around the lake. Obviously, there are other recreation activities which accompany lakes, and the adjacent properties are also developed to some degree as vacation and retirement housing.

Population centers are scattered throughout the study area. Many have very old histories and few have populations of more than one thousand though their population density may equal that of the larger cities. By county, cities with populations greater than one thousand in 1985 are shown in Table II.3.

Table II.3

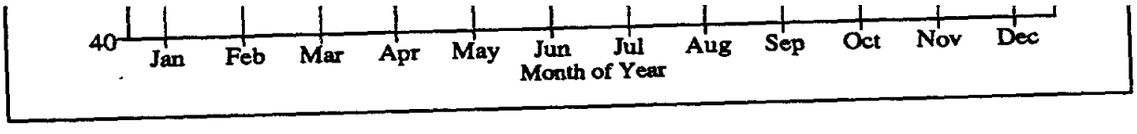
CITIES WITH POPULATION GREATER THAN 1000

County	City
Angelina	Lufkin (County Seat) Diboll Huntington Hudson
Cherokee	Jacksonville Rusk (County Seat)
Nacogdoches	Nacogdoches (County Seat) Garrison
Rusk	Henderson (County Seat) New London Tatum (Partly in Panola County) Kilgore (Mostly in Gregg County) Overton (Partly in Smith County)
Smith	Tyler (County Seat) Whitehouse Lindale Arp

B. CLIMATOLOGY

1. Location

The proposed Lake Eastex Reservoir is centrally located within the "East Texas" climatological region of the state as established by the National Weather Service. The East Texas region and the reservoir, at approximately 32 degrees latitude, lie toward the north of the subtropical zone (20-35 degrees latitude) which is generally characterized as mild, having hot, humid summers of moderate length and short, mild winters. Strong winds occur occasionally and in association with seasonal tornadoes and thunderstorms which can be quite intense. Average annual evaporation is high (52 inches) and the monthly average typically exceeds rainfall seven months out of the year. The Gulf of Mexico, 175 miles to the south-southeast, is a significant factor in the local climatology though continental influences dominate. The following data from



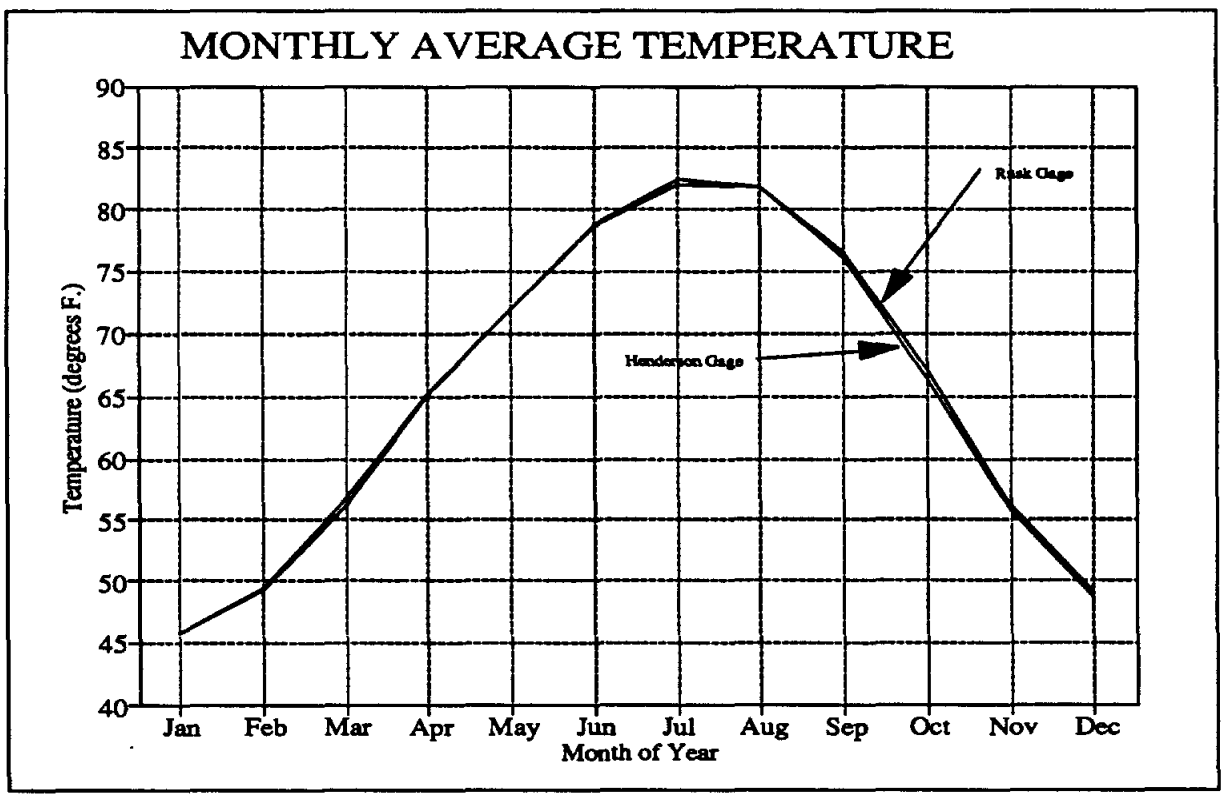
various sources describe some parameters of climate for the region and the reservoir site specifically in greater detail.

2. Temperature

Temperatures are relatively uniform though sufficient variation exists to produce four distinct seasons. Extreme temperatures are rare, but rapid temperature changes are frequent. However, they are less common in the summer.

From National Oceanic and Atmospheric Administration (NOAA) data for the nearby Rusk and Henderson stations, average monthly temperatures range from 82 degrees F in July and August to just under 46 degrees F in January; with an average annual temperature of 65 degrees F (Exhibit II.4). Average summer (July and August) afternoon highs reach the 90 to 95 degree range while average December and January highs reach just over 60 degrees. Average minimum temperatures vary from 75 degrees F in July to about 40 degrees F in December and January. About 30 days per year will experience a minimum temperature equal to or less than 32 degrees F. The 1988-89 Texas Almanac cites record high temperatures for the periods of record for the Rusk and Henderson stations as 108 and 107 degrees F. Record low temperatures are two and one degrees F, respectively.

Exhibit II.4



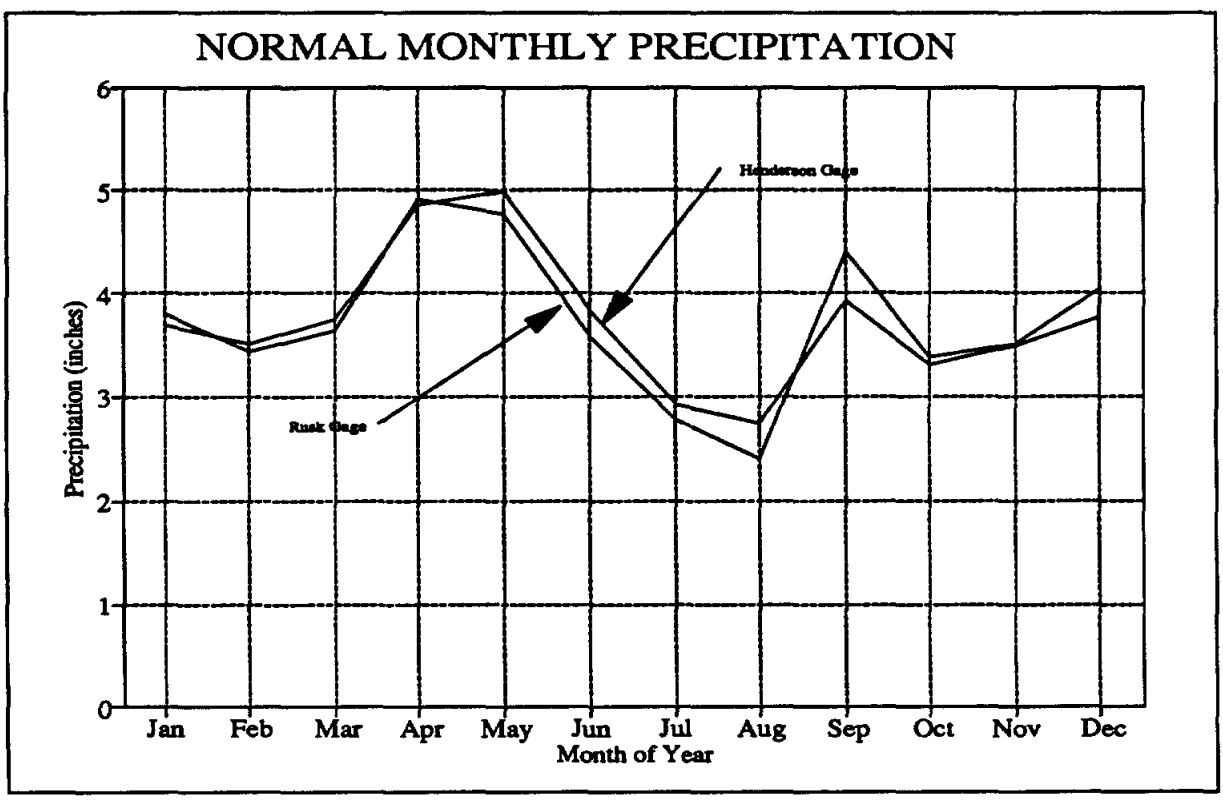
3. Relative Humidity

Mean monthly relative humidity was reported in the Climatic Atlas of the United States as varying between about 65 and 75 percent. Recorded 6:00 a.m. readings average about 85 percent and noon readings about 60 percent.

4. Precipitation

Lengthy periods of widespread precipitation are usually the result of one of two mechanisms. Either slow moving, cold northern air forces the resident, warmer air aloft or the same cold air masses become stationary, wedging incoming moist, Gulf air upward. Both mechanisms cause cooling of the moister, warm air resulting in abundant precipitation throughout the area. The Rusk and Henderson stations agree closely regarding normal monthly and total annual precipitation (Exhibit II.5). Seasonal distribution of rainfall peaks in the Spring months of April and May with a smaller peak occurring in September. Winter rainfall is moderate while the least rainfall occurs in the Summer months of July and August. The average annual precipitation amounts to about 45 inches. One to two inches of snow may fall during the year.

Exhibit II.5



5. Surface Winds

Based on information from the Climatic Atlas for stations in Dallas and Shreveport for the period 1951 to 1960, the windiest season is spring, with an average speed of about 10.5 miles per hour. The annual prevailing wind direction is from the south to southeast, occurring almost 40 percent of the time. There is, however, a large variation in the monthly distribution. Winter months experience the most even distribution of winds with a near equal division between north to northwest and south to southeast winds of an estimated 45 percent of the time each. Summer heavily favors the prevailing south to southeast winds 45 percent of the time. Calm conditions prevail only about three percent of the time. Potentially damaging winds occur with intense thunderstorms and seasonal tornado activity. Winter cold air is often brought by strong, but usually non-destructive winds.

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III. WATER SUPPLY ALTERNATIVES

III. WATER SUPPLY ALTERNATIVES

A. WATER DEMAND AND PROJECT JUSTIFICATION

1. Introduction

To efficiently and effectively plan to meet future water needs on a regional basis, an evaluation of current and future demands compared to supplies is necessary. This section on water demand and project justification compares the projected water demand for the five county study area through the year 2040 to the water supplies currently available to meet that demand. If the current sources of water supply are inadequate to meet projected demands, it is understood that some type of water supply project is justified. The comparison which follows utilizes the resources listed below:

a. Current or most recent literature regarding groundwater availability in the five county study area
b. Discussions with staff members of the Texas Water Commission (TWC) and the Texas Water Development Board (TWDB)
c. Discussions with local professional engineering consultants
d. Discussions with local public works officials
e. Review of surface water rights adjudications

A complete list of references is included at the end of this section.

2. Water Demand

The Texas Water Development Board water use projections were used as a basis for the projections developed for this study. Specifically, the high per capita water use (acre-feet/year) without additional conservation, high population series (October 1989 draft) were selected. In keeping with accepted water supply planning theory and criteria, this group of projections was used to form the basis for the planning study analysis in order to assure an adequate water supply during years of low precipitation or drought. The TWDB projections, developed for each county, have been grouped into several water use categories including municipal, manufacturing, irrigation, mining, livestock, and steam electric. Additionally, the municipal water use category is further divided by cities within the county and a category called "other" which includes rural users and cities with a population of less than 1000.

Some revisions to the TWDB projections were made for the purposes of this planning study. Therefore, the totals for some of the counties may be different from those given by the TWDB. Revisions to the TWDB projections include:

a. The demand projections for the City of Kilgore have been shown entirely within Smith County. The TWDB projections account for the portion of

the City of Kilgore's demand within Rusk County only. Since the City of Kilgore represents a possible regional participant, and has all of its groundwater wells within Smith County, the entire City of Kilgore demand has been accounted for in the Smith County projections.

b. The demand projections for the City of Overton have been shown entirely within Rusk County. The demand projections for the City of Troup have been shown entirely within Smith County. These revisions represent very minor changes from the TWDB projections. The demand projections for the Cities of Overton and Troup are normally divided by the TWDB to account for the fact that each of these two cities is located in two counties, both of which are part of the five-county study area. For simplicity, this study assigns the entire demand for each of these cities to one county only.

c. An additional demand has been considered within the region to account for the desire of the communities within the area to attract industry.

The most significant revision to the TWDB projections is the additional industrial demand. Research conducted in order to quantify future industrial demands indicated that the TWDB projections do not specifically account for large industrial water users which may not currently exist within the five county study area, or do not currently have specific plans to expand or locate in the area. These major industries could potentially be attracted to the area provided that an adequate water supply is available. This planning study recognizes the demand needed to attract major industries to the area in order to allow for economic development. Correspondence with community leaders and officials in the study area indicates that, since the recession of the early 1980's, there is a greater emphasis on the diversification of the local economy. Many area Chambers of Commerce have recently developed aggressive plans to attract industries to the study area. Furthermore, though community officials have indicated a desire to attract additional industry, they have also acknowledged the lack of a large surface water supply which is necessary to accomplish this goal. Participants in this study have indicated that they feel that the supply must be reserved now in order to assure future growth. It is important to recognize that due to the time required to develop a large surface water supply, it must often be in place before a specific user can be identified. A large industry will not be willing to wait ten or twenty years until this can be accomplished. Slow economic growth will become a self fulfilled prophecy if the resources are not allowed to be developed. In order to quantify this industrial demand, historical water use for large industries in the study area was researched. It was discovered that a single, large manufacturer could easily require 10,000 acre-feet of water per year.

Water demand projections for this study have been developed which recognize some uncertainty in total demand projections and in the availability of supplies from future groundwater or surface water sources. Therefore, the various demand projections given in this study will be presented in terms of a range bounded by maximum and minimum limits. The range given for the total five-county study area demand is defined as follows:

Minimum	10,000	10,000	10,000	10,000	10,000	10,000
Maximum	20,000	20,000	20,000	20,000	20,000	20,000
Total						
Minimum	164,465	189,073	242,593	262,767	285,644	304,526
Maximum	174,465	199,073	252,593	272,767	295,644	314,526

3. Groundwater Supply

The total demand, presented in Table III.1, is expected to be met from both groundwater and surface water sources. It is generally recognized, however, that groundwater is a less expensive source than surface water. Therefore, groundwater has been projected as the first choice to meet demands, according to its availability, as based on the research described below. For the purpose of this study, groundwater use within the five county stud

Maximum study area demand - TWDB demand projections for the five counties adjusted as described above, and including a 20,000 acre-feet/year allowance for new industries which could locate within the study area prior to the year 2040.

Minimum study area demand - TWDB demand projections for the five counties adjusted as described above, and including a 10,000 acre-feet/year allowance for new industries which could locate within the study area prior to the year 2040.

Table III.1 presents the Total Demand Projections for the five county study area through the 50-year planning period.

Table III.1
TOTAL WATER DEMAND PROJECTIONS
FIVE COUNTY STUDY AREA
(acre-feet/year)

County	1990	2000	2010	2020	2030	2040
Angelina	43,610	43,477	51,753	60,350	70,605	80,148
Cherokee	17,263	30,015	31,087	32,333	33,494	34,091
Nacogdoches	12,879	14,615	30,147	32,248	34,302	52,271
Rusk	38,511	39,524	46,725	48,652	50,772	51,781
Smith	42,202	51,442	72,881	79,184	86,471	76,235
Regional Demand for New Industries						
Minimum	10,000	10,000	10,000	10,000	10,000	10,000
Maximum	20,000	20,000	20,000	20,000	20,000	20,000
Total						
Minimum	164,465	189,073	242,593	262,767	285,644	304,526
Maximum	174,465	199,073	252,593	272,767	295,644	314,526

3. Groundwater Supply

The total demand, presented in Table III.1, is expected to be met from both groundwater and surface water sources. It is generally recognized, however, that groundwater is a less expensive source than surface water. Therefore, groundwater has been projected as the first choice to meet demands, according to its availability, as based on the research described below. For the purpose of this study, groundwater use within the five county study area is a function of groundwater availability in the area. The availability of groundwater in the study area is based

primarily on a literature search which included previous studies of the area by the State, studies conducted for the State by consultants, and studies by other consultants for various local governments. Also included in the research effort, were conversations with area water supply corporation managers and representatives for cities within in the study area. A complete list of references is given at the end of this section.

In general, it can be concluded from the research that rural water demands through the year 2040 can be met by groundwater sources and urban water demands will need surface water sources to meet additional demands after 1990. It should be noted, however, that there are a few exceptions to this conclusion. The information referenced as a part of this effort indicates that large concentrated demands, typically present in urban areas, have caused the large water level declines and cones of depression observed in recent years. Rural groundwater users have smaller, more evenly distributed wells which have less overall adverse impacts on groundwater levels. Exceptions to this general conclusion are steam electric uses and a few of the smaller urban areas. Because steam electric facilities generally require a large and concentrated water supply, and will impact the aquifers in the same manner as a concentrated municipal use, projections for this use are reflected as surface water demand. Water demands of several smaller urban areas, whose increase in water demands through the year 2040 are relatively small, are projected to be met by groundwater sources since it is expected that adequate groundwater supplies are present in the vicinity of these cities. However, this general conclusion should not be interpreted to mean that every water supply corporation or small city will necessarily have adequate water supplies in the future. Groundwater may be present but its availability to each water supplier may be limited by poor quality, inability to gain access to optimum well locations, prohibitive costs in developing wells, transporting the water, or other similar economic constraints and poor reliability of supply due to areal variability. For example, research indicates that southern Angelina County is experiencing high total dissolved solids, and northwest Rusk County (Striker Creek watershed) is experiencing some quality problems, apparently due to nearby oil fields. Therefore, each water supplier should be considered individually with regard to specific local problems and limitations on expansion. This especially applies to those water supply corporations with wells located close to a large urban area or other users pumping large quantities of water from groundwater aquifers.

The following is a brief summary of information used to develop the above conclusions.

a. There are four major aquifers underlying the five county study area. They are the Carrizo, Wilcox, Queen City, and Sparta (Guyton, 1970; Guyton, 1972; TWDB, 1988; Sandeen, 1987).

b. Literature research indicates additional development of groundwater in the Nacogdoches area will cause irreparable damage to the Carrizo aquifer which is the source of this city's groundwater (KSA, 1988; Guyton, 1970; Weegar, 1990). Significant water level declines have taken place in the Nacogdoches area to the point where water levels are approaching the top of the sands (Preston, 1989; KSA, 1988; Guyton, 1970; Weegar, 1990; Guyton, 1981; Guyton, 1985; Guyton,

1988). Continued correspondence with KSA, who is currently preparing a regional water supply plan for Nacogdoches County, confirms this information.

c. The Cities of Hudson and Huntington also draw their groundwater from the Carrizo (KSA, 1985; KSA, 1988) and should also limit any increase in groundwater pumpage.

d. Research shows that the water quality in the Diboll vicinity is highly variable. Some wells in the Yegua formation in this area have dissolved solids concentrations well over 1000 parts per million (ppm) (Guyton, 1970). In their published "Drinking Water Standards," the State Department of Health (TDH, 1989) recommends that alternate sources of water be developed if the dissolved solids concentration is above 1000 ppm.

e. Research shows that the faults and fractures in the subsurface formations in the vicinity of Jacksonville in Cherokee County cause transmissibility problems in the aquifer which limits the groundwater yield (Guyton, 1972). Additionally, a representative for the Craft-Turney WSC, currently supplied by Jacksonville, said that the WSC had tried to drill wells in the past but was unsuccessful.

f. The Cities of Henderson and Overton in Rusk County are located in an area designated as "most unfavorable" for additional groundwater development. This is due to poor water quality and water level declines in the vicinity of these cities (Sandeen, 1987). The City of Henderson is in fact already experiencing a significant deterioration in groundwater supply and is projecting critical water supply problems in the next five years.

g. Significantly low water levels have also occurred throughout Smith County (Preston, 1989; TWDB, 1988; Weegar, 1990). Wells in the Tyler vicinity are in danger of failing unless groundwater pumpage is decreased. The City of Tyler has stated it plans to phase out significant pumpage of groundwater over the next 10 to 15 years, such that groundwater is used only during peak periods (Weegar, 1990).

h. A conversation with a representative for the Walnut Grove WSC in Smith County expressed concern about dropping water levels (five to ten feet/year) and the expense of drilling new (and often unproductive) wells. They anticipate critical supply problems in the next ten years.

i. The City of Whitehouse in Smith County has already experienced problems with their groundwater supply, has turned to the City of Tyler (Austin Pub., Inc., 1990) as their current source.

j. The City of Zavalla is experiencing a critical shortage of groundwater supply and has found that its cost of transporting groundwater from the closest source is prohibitive (EGA, 1990).

k. Research indicates that there should be adequate groundwater supplies for non-concentrated rural uses throughout the five county study area provided that the practical limitations on the availability discussed earlier do not have a major impact (Preston, 1989; Guyton, 1972; Guyton, 1970; Sandeen, 1987).

As a result of the literature research described above, conversations with local water suppliers, and in recognition of the variables involved in projecting future groundwater use, the groundwater use for the study area has been projected in terms of maximum use and minimum use (Table III.2).

Differences between maximum groundwater use and minimum groundwater use result from differences in the assumptions made concerning the ability of the aquifers in the study area to meet the demands of various water use categories. Primary areas of difference include the following:

a. The split between future groundwater and surface water use is based, to a large extent, on historical splits between the two sources under the assumption that recent historical use, to some degree, reflects the availability of groundwater. If both groundwater and surface water sources are available, the less expensive source (usually groundwater) will be utilized. The maximum use projections utilized an average of the historical splits for years 1980 and 1985. The minimum use projections utilized the 1985 historical split. Exceptions were made in some areas in which historical data was judged to be not representative of current or expected future conditions, or in which large discrepancies or anomalies appeared to exist between the data.

b. The availability for aquifers in the study area to meet rural demands was considered two ways. Minimum groundwater use projections incorporate a supply reduction factor to account for "real-world" supply considerations which, in all practicality, limit groundwater use. These considerations include poor water quality in local areas, improper well construction and spacing, prohibitive costs in transporting water from remote well fields, impacts on well levels from nearby urban users, and the uncertainty and associated costs of finding and developing new wells. Maximum groundwater use generally assumes all rural demands, except in a few specific locations, can be met from existing groundwater sources.

Table III.2

TOTAL GROUNDWATER DEMAND PROJECTIONS
FIVE COUNTY STUDY AREA
(acre-feet/year)

County	1990	2000	2010	2020	2030	2040
Angelina						
Minimum	31,070	23,708	23,516	23,928	25,128	25,625
Maximum	35,843	35,402	36,915	37,511	39,250	39,971
Cherokee						
Minimum	7,118	7,411	7,789	8,410	8,899	9,111
Maximum	7,508	7,817	8,223	8,880	9,390	9,613
Nacogdoches						
Minimum	7,183	7,072	7,102	7,140	7,162	7,194
Maximum	7,456	7,342	7,370	7,407	7,427	7,460
Rusk						
Minimum	7,516	8,053	8,170	9,328	10,600	11,010
Maximum	7,825	8,529	8,780	10,119	11,586	12,139
Smith						
Minimum	18,076	22,985	25,136	27,772	30,902	32,267
Maximum	19,382	25,076	43,135	45,732	48,880	35,155
Regional Demand for New Industries						
Minimum	0	0	0	0	0	0
Maximum	0	0	0	0	0	0
Total						
Minimum	70,963	69,229	71,713	76,578	82,691	85,207
Maximum	78,014	84,166	104,423	109,649	116,533	104,338

c. The groundwater use projections for the City of Henderson, in the maximum groundwater use scenario, assume that the projected 1990 pumping rate remains constant through 2040. In the minimum use scenario, a decline of 20 percent was projected by the year 2040 from the 1990 pumping rate. The second scenario is based on level declines and production rate declines documented in recent years.

d. Manufacturing demand, for the maximum groundwater use scenario, was based primarily on the historical split between groundwater and surface water supplies. The minimum groundwater use scenario further recognizes major manufacturers in the area by identifying the probable use of surface water by these entities to meet the relatively large concentrated demands.

4. Surface Water Demand

The surface water demand for the five county study area is defined as the remaining portion of total water demand which cannot be met by groundwater sources. As discussed previously, both demand and groundwater use are given in terms of a range bounded by maximum and minimum limits. Consistent with this approach, the surface water demand for the study area is also presented as a maximum and a minimum. The maximum surface water demand is the difference between the maximum total demand and the minimum groundwater use scenario. Conversely, the minimum surface water demand is the difference between the minimum total demand and the maximum groundwater use scenario. Surface water demands for the study area are presented in Table III.3, and are illustrated in Exhibits III.1 and III.2.

5. Surface Water Supply

There are seven water supply reservoirs which exist within the study area. They include Lake Tyler, Lake Tyler East, Lake Jacksonville, Lake Acker, Striker Creek Reservoir, Lake Nacogdoches, and Kurth Reservoir. Four reservoirs exist along the perimeter of the study area. They include Lake Palestine, Lake Cherokee, Martin Lake, and Sam Rayburn Reservoir. With the exception of Sam Rayburn Reservoir, these are the only lakes that currently supply surface water to the study area.

The total quantity of water that the above mentioned reservoirs can provide to the study area, either by permit or contract is 222,825 acre-feet per year. However, the total surface water which is available within the study area must be appropriately accounted for. Taking this quantity as a lump sum and applying it as "available" to meet all demands of the entire study area, as done in previous studies, does not give a true indication of actual supply and demand since ownership of water rights and contracts has not been considered. A more appropriate planning approach recognizes that the permit or contracted quantities as described in the Final Determination of All Claims of Water Rights granted by the Texas Water Commission are available only to the entity specified. If that entity does not use its entire contracted amount, the remaining amount should not be considered available for use until its owner sells the excess amount to a user. Texas Water Commission approval will be required. The change in point of

Table III.3

TOTAL SURFACE WATER DEMAND PROJECTIONS
FIVE COUNTY STUDY AREA
(acre-feet/year)

County	1990	2000	2010	2020	2030	2040
Angelina						
Maximum	12,540	19,769	28,237	36,422	45,477	54,523
Minimum	7,767	8,075	14,838	22,839	31,355	40,177
Cherokee						
Maximum	10,145	22,604	23,298	23,923	24,595	24,980
Minimum	9,755	22,198	22,864	23,453	24,104	24,478
Nacogdoches						
Maximum	5,696	7,543	23,045	25,108	27,140	45,077
Minimum	5,423	7,273	22,777	24,841	26,875	44,811
Rusk						
Maximum	30,995	31,471	38,555	39,324	40,172	40,771
Minimum	30,686	30,995	37,945	38,533	39,186	39,642
Smith						
Maximum	24,126	28,457	47,745	51,412	55,569	43,968
Minimum	22,820	26,366	29,746	33,452	37,591	41,080
Regional Demand for New Industries						
Maximum	20,000	20,000	20,000	20,000	20,000	20,000
Minimum	10,000	10,000	10,000	10,000	10,000	10,000
Total						
Maximum	103,502	129,844	180,880	196,189	212,953	229,319
Minimum	87,451	104,907	138,170	153,118	169,111	200,188

MAX 229 319
Max 104 338
333 657

Exhibit III.1

WATER DEMAND PROJECTIONS

Maximum Surface Water Demand

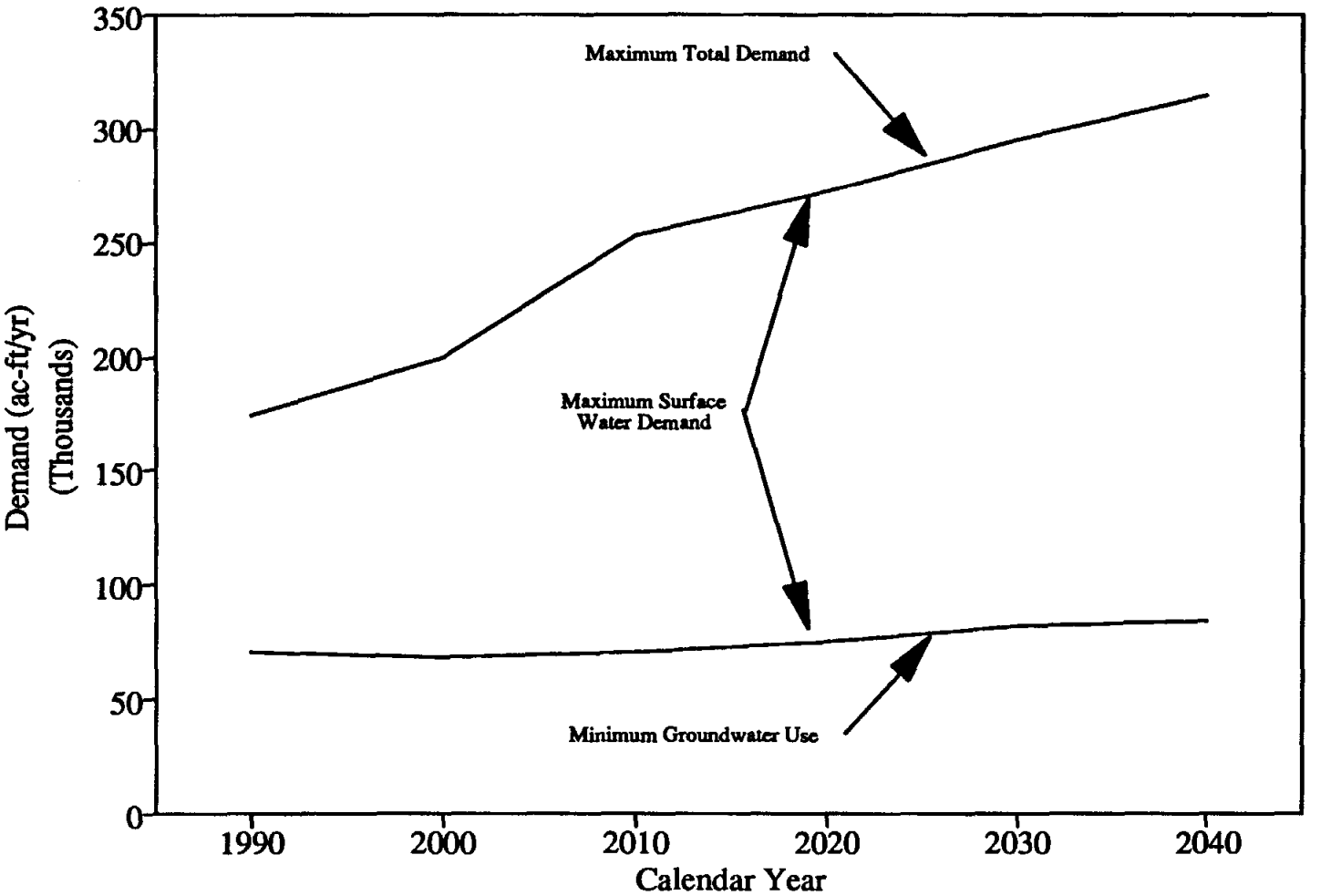
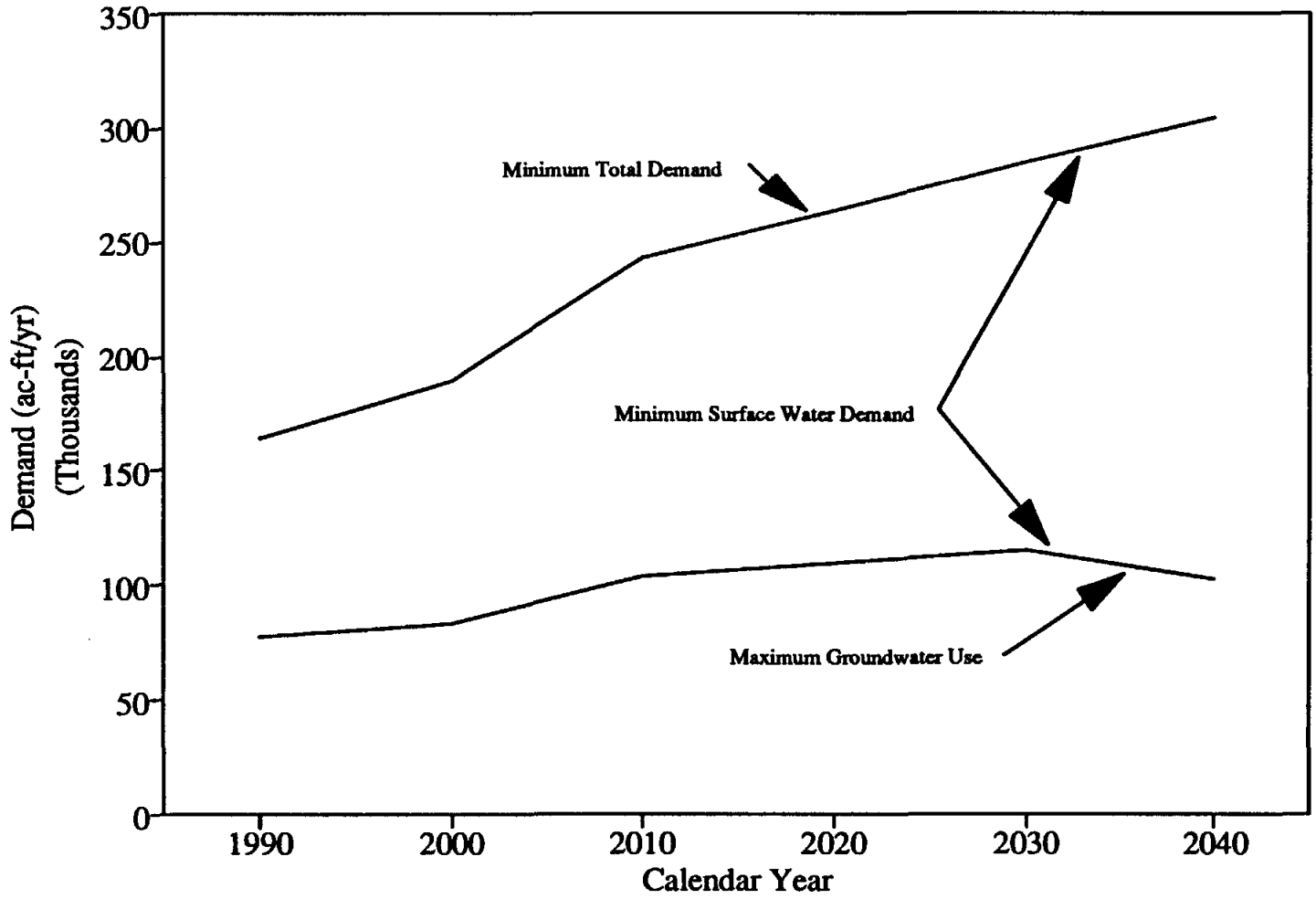


Exhibit III.2

WATER DEMAND PROJECTIONS

Minimum Surface Water Demand



use required in this approval process could trigger environmental concerns such as instream flow requirements. The tables which follow (Tables III.4 and III.5) present the permit or contract holders for water supplied from the above listed eleven water supply reservoirs, along with the projected demands which can practically be met by the permit or contract amount. Two tables have been developed to be consistent with the approach of identifying the maximum and minimum demand. The demand which can be met by existing sources has been projected to be a maximum of 119,217 acre-feet/year and a minimum of 118,006 acre-feet/year in the year 2040.

In conclusion, the 222,825 acre-feet/year surface water supply to the study area can only meet demands of 119,217 acre-feet/year by the year 2040, unless or until these entities with rights and/or contracts for the excess agree to make that excess available. Entities other than those listed in Tables III.4 and III.5 do not currently have a long term surface water supply.

6. Determination of Net Surface Water Demand

By recognizing the permitted rights as specified in Tables III.4 and III.5, a net (unmet) surface water demand can then be developed for the study area. Net surface water demand is defined, for the purpose of this study, as the total surface water demand for the five county study area less the surface water demands of entities met by presently available committed water. The resultant net surface water demand projections(maximum and minimum) for the five county area are presented in Table III.6.

From the tables above, it can be seen that there is a deficit of surface water supplies available to the study area as early as 1990. By the year 2040, the net surface water demand for the study area is projected to be 82,182 acre-feet per year as a minimum and 110,102 acre-feet per year as a maximum. Net surface water demands for the 50 year planning period are presented graphically on Exhibits III.3 and III.4. Finally, Exhibit III.5 presents the maximum and minimum net surface water demand relative to the anticipated yield and availability of Lake Eastex.

Table III.4

MAXIMUM EXISTING SURFACE WATER SUPPLIES FIVE COUNTY STUDY AREA

County and Entity	Source	Permit or Contract (Ac-Ft/Yr)	Demand Which Can Be Met by Existing Supplies Assuming Minimum Groundwater Supply (Ac-Ft/Yr)					
			1990	2000	2010	2020	2030	2040
Angelina								
Champion International Corp.	Striker Creek	10,000	11,000	16,827	22,987	29,100	29,100	29,100
Champion International Corp.	Angelina River/Lake Kurth	19,100						
City of Lufkin	Sam Rayburn Reservoir	28,000	0	880	2,016	3,346	4,902	6,033
Rural Uses	Miscellaneous Private Sources and/or Rights	N/A(2)	45	45	45	45	45	45
Cherokee								
City of Jacksonville	Lake Acker & Lake Jackson	6,200	1,314	2,330	2,837	3,190	3,571	3,799
TP&L	Striker Creek Reservoir	5,000(1)	6,500	6,500	6,500	6,500	6,500	6,500
Rural Uses	Miscellaneous Private Sources and/or Rights	N/A(2)	222	222	222	222	222	222
Nacogdoches								
City of Nacogdoches	Lake Nacogdoches	22,000	1,894	3,106	4,454	5,861	7,253	8,312
Rural Uses	Miscellaneous Private Sources and/or Rights	N/A(2)	222	222	222	222	222	222
Rusk								
Texas Utilities Electric Company	Lake Martin	25,000(1)	28,500	28,500	28,500	28,500	28,500	28,500
Rural Uses	Miscellaneous Private Sources and/or Rights	N/A(2)	265	265	265	265	265	265
Smith								
City of Kilgore	Lake Cherokee	Purchased from Longview	1,646	1,717	1,993	2,293	2,618	2,863
City of Tyler	Lakes Tyler & Tyler East	40,325	18,423	21,014	23,800	26,856	30,277	33,190
City of Tyler	Lake Palestine	67,200						
Rural Uses	Miscellaneous Private Sources and/or Rights	N/A(2)	166	166	166	166	166	166
TOTAL		222,825	70,197	81,794	94,007	106,566	113,641	119,217

(1) The actual water demand for power companies can be met by the permitted or contracted diversion amounts shown. Demands exceed diversion amounts due to the evaporation of cooling water. The actual diversion quantity is less than or equal to the permit or contract amount.
(2) This volume is not assignable to a single specific source or right holder.

Table III.5

MINIMUM EXISTING SURFACE WATER SUPPLIES
FIVE COUNTY STUDY AREA

County and Entity	Source	Permit or Contract (Ac-Ft/Yr)	Demand Which Can Be Met by Existing Supplies Assuming Maximum Groundwater Supply (Ac-Ft/Yr)					
			1990	2000	2010	2020	2030	2040
Angelina								
Champion International Corp.	Striker Creek	10,000	6,869	5,863	11,016	17,134	23,446	29,100
Champion International Corp.	Angelina River/Lake Kurth	19,100						
City of Lufkin	Sam Rayburn Reservoir	28,000	0	880	2,016	3,346	4,902	6,033
Rural Uses	Miscellaneous Private Sources and/or Rights	N/A(2)	44	44	44	44	44	44
Cherokee								
City of Jacksonville	Lake Acker & Lake Jackson	6,200	1,171	1,717	2,139	2,405	2,687	2,830
TP&L	Striker Creek Reservoir	5,000(1)	6,500	6,500	6,500	6,500	6,500	6,500
Rural Uses	Miscellaneous Private Sources and/or Rights	N/A(2)	214	214	214	214	214	214
Nacogdoches								
City of Nacogdoches	Lake Nacogdoches	22,000	1,894	3,106	4,454	5,861	7,253	8,312
Rural Uses	Miscellaneous Private Sources and/or Rights	N/A(2)	189	189	189	189	189	189
Rusk								
Texas Utilities Electric Company	Lake Martin	25,000(1)	28,500	28,500	28,500	28,500	28,500	28,500
Rural Uses	Miscellaneous Private Sources and/or Rights	N/A(2)	241	241	241	241	241	241
Smith								
City of Kilgore	Lake Cherokee	Purchased from Longview	1,646	1,717	1,993	2,293	2,618	2,863
City of Tyler	Lakes Tyler & Tyler East	40,325	17,921	20,840	23,627	26,682	30,103	33,017
City of Tyler	Lake Palestine	67,200						
Rural Uses	Miscellaneous Private Sources and/or Rights	N/A(2)	163	163	163	163	163	163
TOTAL		222,825	65,352	69,974	81,096	93,572	106,860	118,006

(1) The actual water demand for power companies can be met by the permitted or contracted diversion amounts shown. Demands exceed diversion amounts due to the evaporation of cooling water. The actual diversion quantity is less than or equal to the permit or contract amount.
(2) This volume is not assignable to a single specific source or right holder.

Table III.6

MAXIMUM NET SURFACE WATER DEMAND
FIVE COUNTY STUDY AREA
(acre-feet/year)

	1990	2000	2010	2020	2030	2040
Total Surface Water Demand (from Table III.3)	103,502	129,844	180,880	196,189	212,953	229,319
Less Total Surface Water Demand Met by Existing Sources (from Table III.4)	70,197	81,794	94,007	106,566	113,641	119,217
Equals Maximum Net Surface Water Demand	33,305	48,050	86,873	89,623	99,312	110,102

Table III.7

MINIMUM NET SURFACE WATER DEMAND
FIVE COUNTY STUDY AREA
(acre-feet/year)

	1990	2000	2010	2020	2030	2040
Total Surface Water Demand (from Table III.3)	87,451	104,907	138,170	153,118	169,111	200,188
Less Total Surface Water Demand Met by Existing Sources (from Table III.5)	65,352	69,974	81,096	93,572	106,860	118,006
Equals Maximum Net Surface Water Demand	22,099	34,933	57,074	59,546	62,251	82,182

Exhibit III.3

MAXIMUM NET SURFACE WATER DEMAND

Five County Study Area

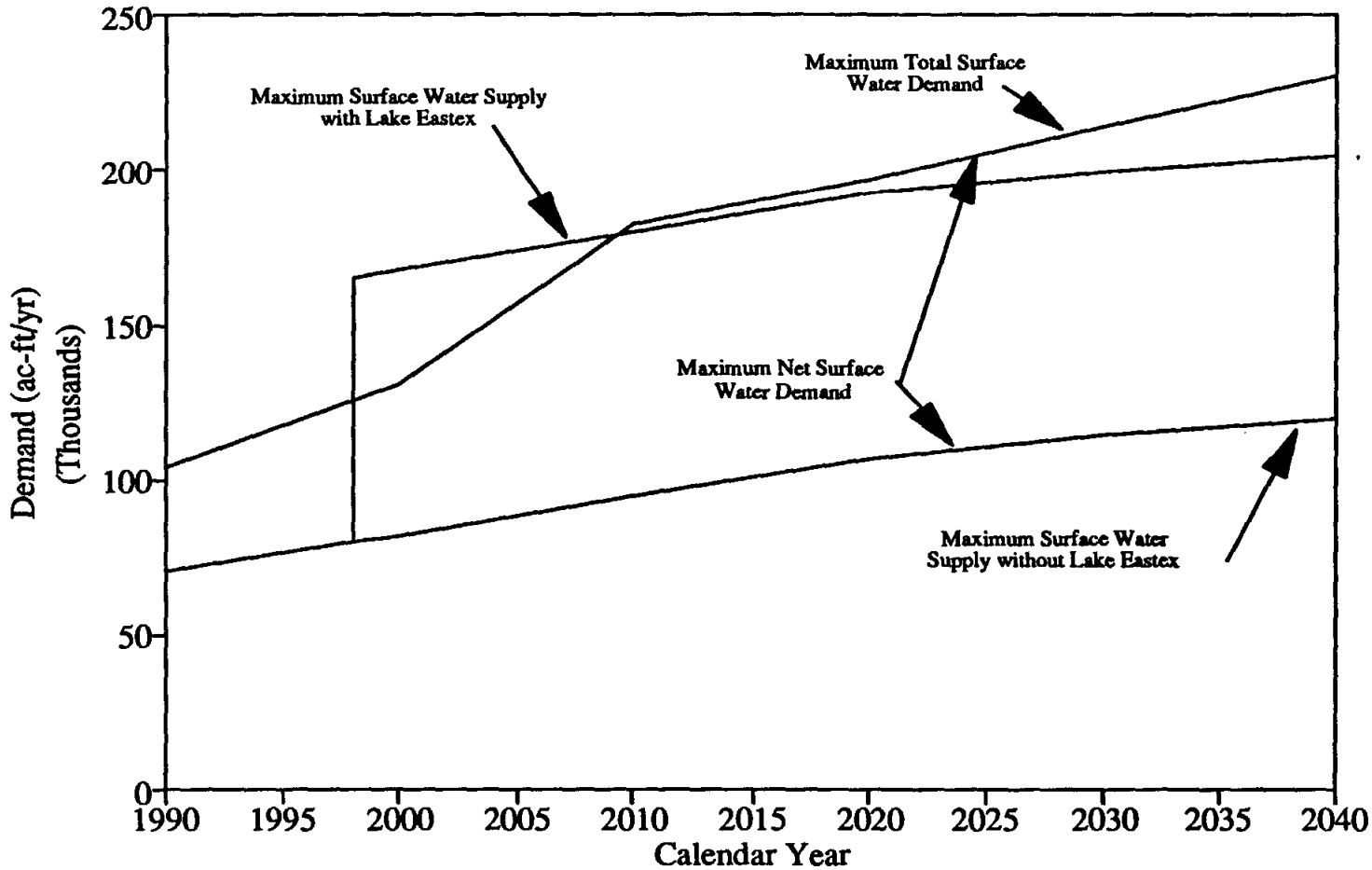


Exhibit III.4

MINIMUM NET SURFACE WATER DEMAND

Five County Study Area

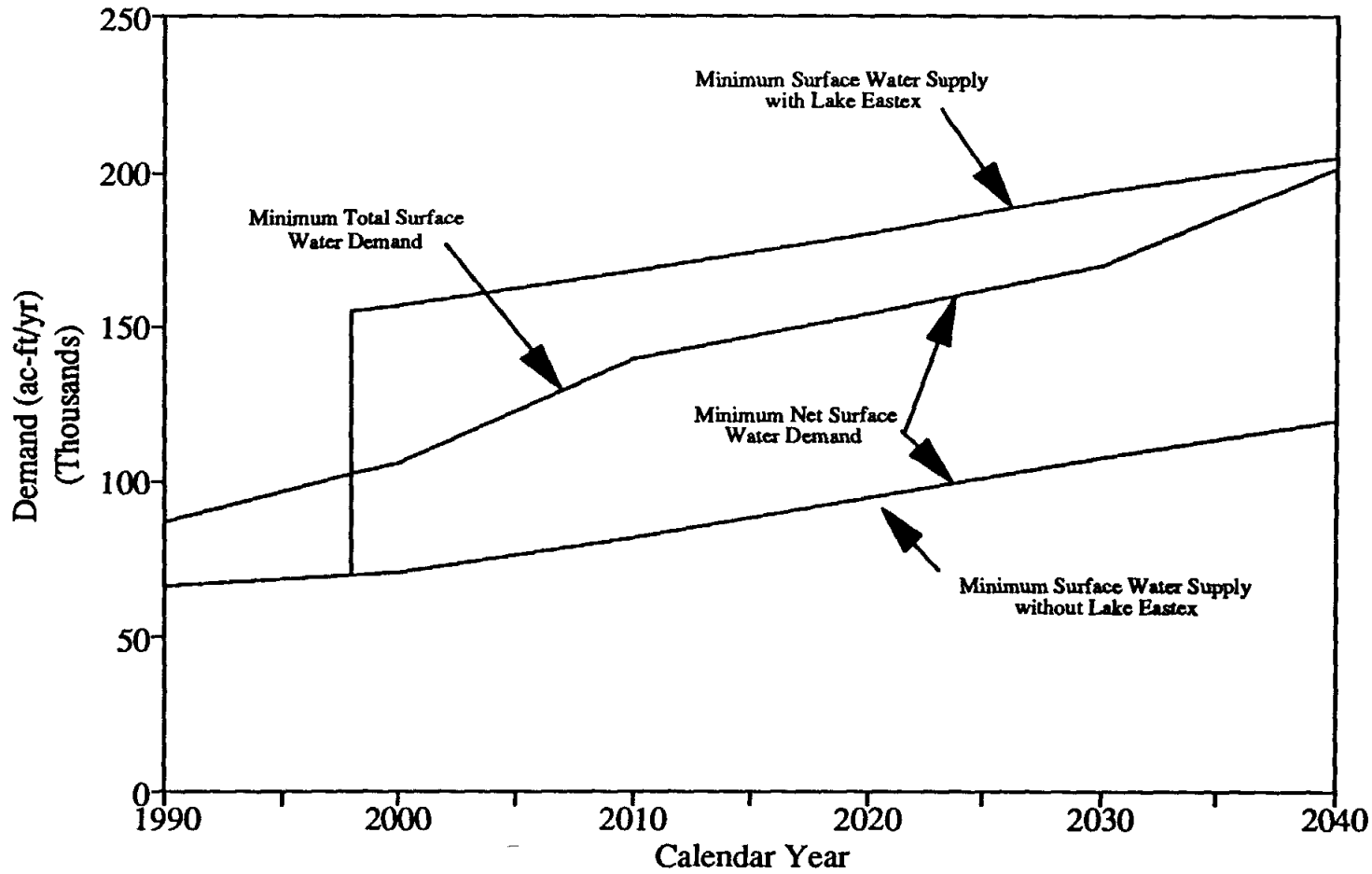
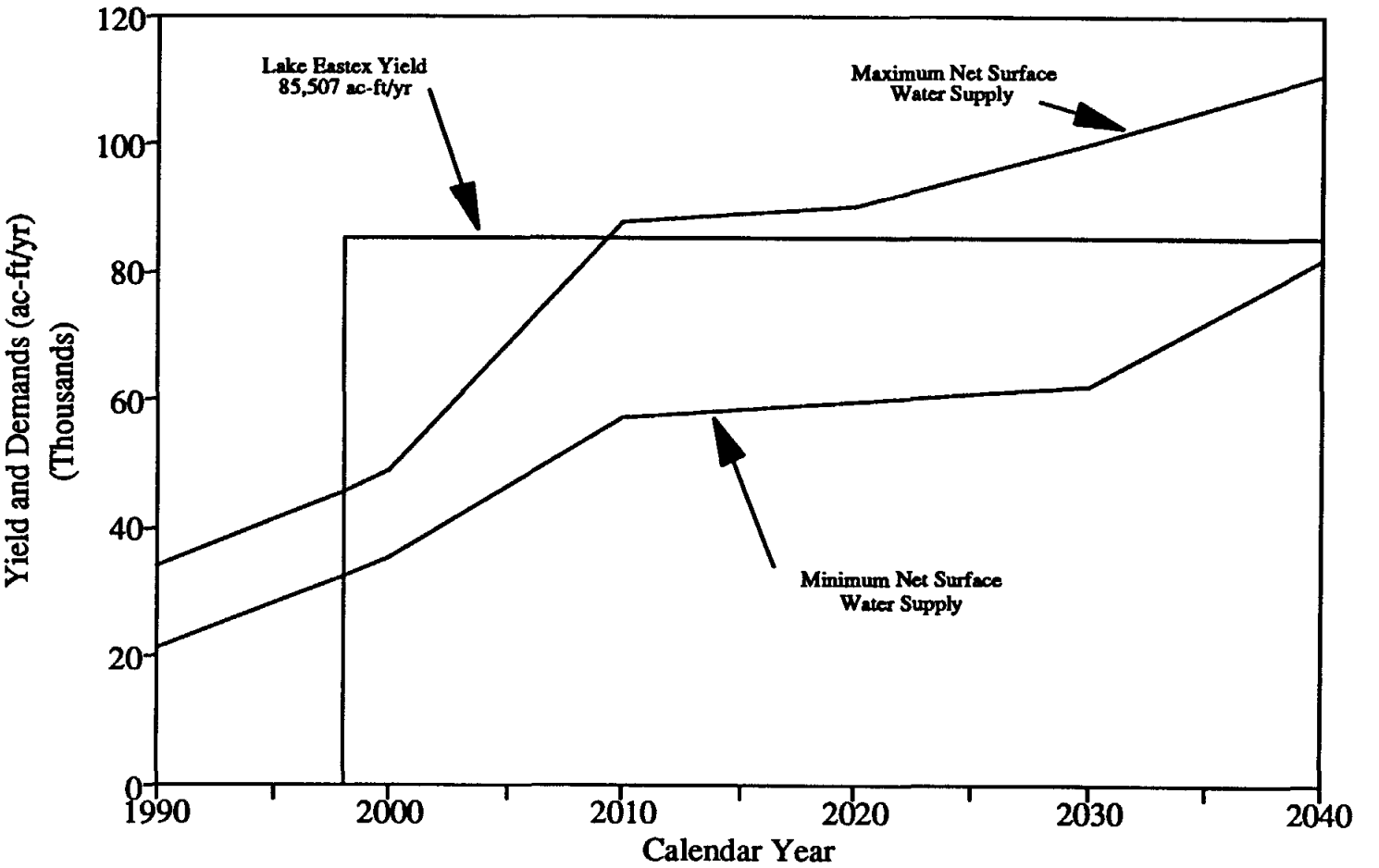


Exhibit III.5

LAKE EASTEX SUPPLY
w/Respect to Net Surface Water Demand



B. WATER SUPPLY ALTERNATIVES

1. Introduction

In the previous section on water demand and project justification, it is projected that by the year 2040, water demands for the five county study area could exceed available water supplies from current sources by 110,102 acre-feet/year. Due to the limitations in groundwater availability, especially in urban areas, these unmet demands will need to be addressed by surface water sources. The surface water deficit in the region indicates that some type of water supply project is needed. It is the purpose of this section of the report to identify and evaluate water supply alternatives which will meet projected needs.

The discussion which follows addresses several potential alternatives including no action, existing, and proposed surface water alternatives. An attempt was made to consider all possible existing and proposed surface water projects in the Neches and adjacent river basins within a reasonable distance from the five county study area. Each of these surface water projects were considered in enough detail to determine if it would be a feasible alternative worthy of additional evaluation. This determination was based on literature research and conversations with representatives from the following:

a. Trinity River Authority (TRA)
b. Tarrant County Water Control and Improvement District (TCWCID#1)
c. Upper Neches Municipal Water Authority (UNMWA)
d. Lower Neches Valley Authority (LNVA)
e. Sabine River Authority (SRA)
f. Little Cypress Utility District (LCUD)
g. U.S. Army Corps of Engineers (COE)

All alternatives, which remained after this initial screening process, are evaluated in sufficient detail to select the most favorable alternative.

2. No Action

The no action alternative consists of no development of new surface water facilities within the basin or importing of water from surrounding basins. This would require that water users in the five county study area rely on groundwater and surface water already developed within the area. As previously discussed in Section III.A., using the water sources available in the study area to their maximum potential with due consideration to water rights, a water deficit exists as soon as 1990. Table III.6 indicates a potential need of as much as 33,305 acre-feet/year of water in 1990 which increases to a need of up to 110,102 acre-feet/year of water by 2040, assuming the City of Lufkin is served by water from the Sam Rayburn Reservoir. The 110,102 acre-feet/year need in year 2040 represents about 35 percent of the maximum total demand in the year 2040 for the five county study area, and over 50 percent of all current existing supply sources to the area. If Lufkin is not served by water from Sam Rayburn due to economic or other

reasons, the additional need of water could increase to approximately 116,158 acre-feet/year by the year 2040. If no action is taken to develop additional supplies, the additional water needs will not be met. In addition to the obvious problems this poses for meeting the basic needs of the regional population, this limited water supply would create a stagnant economy and in turn create a zero or negative growth rate in the five county study area.

3. Existing Surface Water Alternatives

An inventory was made of all the existing water supply reservoirs in the study area and surrounding river basins. Each of the reservoirs was considered with regard to suitability to meet the projected water demands of the five county study area. Some of the important factors for consideration include water availability, location, cost of raw water, and needs local to the particular reservoir or basin. A complete list of the existing water supply reservoirs considered is shown in Table III.8. A summary of the results of the inventory is presented below.

a. Sabine River Basin

All existing water supply reservoirs in the Upper Sabine Basin were eliminated from further consideration. This decision was made based on discussions with the Sabine River Authority(SRA). Those discussions revealed that only a small amount of water is currently uncommitted from these reservoirs and that the SRA plans to reserve that amount to meet future local needs. In the Lower Sabine Basin, Lake Toledo Bend is the only existing water supply reservoir within a reasonable distance from the five county study area. Lake Toledo Bend does have water available in quantities able to serve the study area's need and therefore, has been identified as a feasible surface water supply alternative. The Toledo Bend alternative will be considered in the Evaluation of Existing and Proposed Surface Water Alternatives presented in Section III.B.5.

b. Trinity River Basin

All of the existing water supply reservoirs in the Trinity River Basin were eliminated from further consideration. Discussions with the Trinity River Authority (TRA) and the Tarrant County Water Control and Improvement District #1 (TCWCID#1), along with other research, revealed that for all sources except Cedar Creek and Richland-Chambers Reservoirs, the water is either already committed to other entities, or the distance from the demand centers of the study area make those sources economically prohibitive. The Cedar Creek and Richland-Chambers Reservoirs are economically not feasible due to the relative high cost of raw water and the fact that the TCWCID#1 is presently conducting a long range planning study and has expressed that it would be unwilling to export water to the Neches Basin. The district is presently reserving uncommitted water to meet local needs.

Table III.8

EXISTING SURFACE WATER ALTERNATIVES

Basin and Reservoir	Owner	Permitted Diversion (ac-ft/yr)	Uncommitted Water (ac-ft/yr)	Status/Comments
NECHES BASIN				
Sam Rayburn Reservoir/ B.A. Steinhagen Lake	LNVA/COE	820,000	370,000	Available from LNVA via Lake Steinhagen
Lakes Jacksonville & Acker	City of Jacksonville	6,200	0	Committed to Jacksonville
Lake Nacogdoches	City of Nacogdoches	22,000	0	Committed to Nacogdoches
Lake Palestine	U.N.M.W.A.	238,110	5,000	Available with approval of UNMWA
Lakes Tyler and Tyler East	City of Tyler	40,325	0	Committed to Tyler
Lake Athens	Athens MWA	8,500	0	Committed to Athens
Lake Striker	Angelina-Nacogdoches Cos. WCID #1	20,600	5,600	Not Available-TP&L & Champion have first options to buy
Lake Pinkston	City of Center	3,800	0	Committed to Center
Lake Kurth	Champion International Corp.	19,100	0	Committed to Champion
SABINE BASIN				
Lake Cherokee	Cherokee Water Company	62,400	0	Committed to Longview & SW Electric Co.
Lake Gladewater	City of Gladewater	1,679	0	Committed to Gladewater
Lake Martin	Texas Utilities Elec. Co.	25,000	0	Committed to TU Electric
Lake Tawakoni	S.R.A.	230,750	N/A	Some small amount uncommitted but is reserved for local needs
Toledo Bend Reservoir	S.R.A.	750,000	375,000	Available with approval from SRA
Lake Fork	S.R.A.	164,940	0	Committed to Dallas, Longview, Tenneco, TUGCO, & Phillips Coal
Lake Murvaul	Panola County FWSD	22,400	0	Committed to Carthage
TRINITY BASIN				
Cedar Creek Reservoir	Tarrant County WCID #1	175,000	N/A	Some amount uncommitted, but reserved for in-basin needs
Richland-Chambers Reservoir	Tarrant County WCID #1	210,000	N/A	Some amount uncommitted, but reserved for in-basin needs
Bardwell Lake	TRA/COE	9,600	0	Committed to Ennis, Flood Control
Benbrook Lake	City of Ft. Worth/COE	2,371	0	Committed to Benbrook W.S.A. & Ft. Worth, Flood Control
Grapevine Lake	Grapevine, Dallas COE	161,250	0	Committed to Grapevine & Dallas, Flood Control
Joe Pool Lake	TRA/COE	17,000	0	Committed to local needs, Flood Control
Lavon Lake	Texas MWD/COE	104,000	0	Committed to Texas MWD, Flood Control
Lewisville Lake	Dallas & Denton/COE	598,900	0	Committed to Dallas & Denton, Flood Control
Navarro Mills Lake	TRA/COE	19,400	0	Committed to Dawson, Corsicana, Post Oak WSC, Texas Industries
Ray Roberts Lake	Dallas & Denton/COE	799,600	0	Committed to Dallas and Denton
Lake Brideport	Tarrant County WCID #1	93,000	0	Committed to Brideport, Texas Industries, Wise Co. WSD, West Wise Rural WSC, Gifford-Hill
Eagle Mountain	Tarrant County WCID #1	159,600	0	Committed to Tarrant Utility Co., Tarrant Co. MUD #1, Tesco, Lone Star Ind., Community WSC
Lake Livingston	T.R.A. & City of Houston	1,254,000	0	Committed to TP&L & Houston
Mountain Creek Lake	TP&L	6,400	0	Committed to TP&L
Lake Ray Hubbard	City of Dallas	89,700	0	Committed to Dallas
Lake Worth	City of Fort Worth	13,393	0	Committed to General Dynamics
Houston County Reservoir	Houston County WCID #1	7,000	0	Committed to Crockett, Grapeland, Lovelady, Southwest Chemical, & Consolidated WSC
Lake Fairfield	TP&L, DP&L, TESCO	14,150	0	Committed for Power Generation
Forest Grove	Texas Utilities Services	9,500	0	Committed to Texas Utilities for Power Generation

c. Neches River Basin

All of the water supply reservoirs in the Neches River Basin were eliminated from further evaluation, except Lake Palestine and Lake Sam Rayburn. These two sources are the only reservoirs with a quantity of uncommitted water. Lake Sam Rayburn, as a water source alternative, can be considered three ways.

a. Utilization of a reportedly available uncommitted amount of 1673 acre-feet/year directly from the body of the lake.

b. Utilization of about 370,000 acre-feet/year currently available uncommitted water to be diverted downstream of the Lake Sam Rayburn dam from B.A. Steinhagen Lake.

c. Potential utilization of water from the body of the lake through a reallocation of lake storage from flood control use to municipal water supply use.

Approaches a. and b. represent existing alternatives, while approach c. represents a potential alternative. The reallocation of flood control storage approach will be discussed in more detail under Section III.B.4., Proposed Surface Water Alternatives.

A description for the history behind approaches a. and b. can be summarized as follows:

a. Lake Sam Rayburn provides storage for municipal, industrial, and irrigation supplies, as well as storage for hydroelectric power generation and flood control. Storage capacities are specified by the Corps of Engineers for each type of use. Diversion of water for municipal, industrial, and irrigation uses occurs at B.A. Steinhagen Lake downstream, following its use for power generation through the Sam Rayburn Reservoir.

b. The Lower Neches Valley Authority has rights to water in Sam Rayburn Reservoir, to be diverted from B.A. Steinhagen Lake, as follows:

municipal use - 50,000 acre-feet/year
industrial use - 660,000 acre-feet/year
irrigation use - 110,000 acre-feet/year

c. In 1969, the COE reallocated 45,588 acre-feet of flood control storage as municipal water supply storage. This reallocation increased the conservation pool elevation from 164.0 to about 164.4.

d. At the time of the storage reallocation, the City of Lufkin contracted for 43,000 acre-feet of storage from the COE which translates to about 28,000 acre-feet/year of yield contracted from the Lower Neches Valley Authority. About 2588 acre-

feet of the storage reallocated by the COE (about 1673 acre-feet/year yield) was not contracted for and is reportedly available today.

However, conversations with representatives of the City of Lufkin and the Lower Neches Valley Authority, and a review of the final adjudications for water rights in the Neches River Basin provided no evidence that the existing state water rights permit was ever amended to allow for the increase in reservoir storage capacity or the diversion of water directly from Lake Sam Rayburn. Although, the practical availability of this water to be diverted from Lake Sam Rayburn is in question, it has generally been represented in recent studies as being readily available.

The storage capacity and yield estimates presented herein are assumed, for the purpose of this evaluation, to be permittable and therefore represent a feasible source alternative. However, it should be noted that the acquisition of a state water rights permit requires involvement from regulatory agencies and could trigger a study of environmental impacts. Significant changes in the permitting process, particularly with regard to environmental impacts, have occurred since 1969. As a result, until a permit or other right to take the water is obtained, the water cannot, and should not, be depended on as a water source.

e. Local COE representatives have the authority to reallocate the lesser of 50,000 acre-feet of storage or 15% of the total reservoir storage (in this case 50,000 acre-feet). Reallocation of reservoir storage above this amount requires the approval of the Secretary of the Army, or Congress.

f. The amount which could be reallocated without approval from Washington is 50,000 - 45,588 = 4412 acre-feet (about 2850 acre-feet/year of yield).

Although some unquantifiable amount of water supply could possibly be reallocated from flood control storage, only 1673 acre-feet/year has been considered available to be diverted upstream of the Sam Rayburn Reservoir dam, subject to a review of state permit requirements. About 370,000 of the 820,000 acre-feet/year permitted diversion remains available today for a point of diversion at B.A. Steinhagen Lake.

Utilization of the current water availability of 1673 acre-feet/year will not be considered in detail due to the fact that it would meet less than two percent of the 2040 demands for the study area. Instead, the existing surface water alternative for Sam Rayburn Reservoir will be represented by a plan which utilizes a portion of the 370,000 acre-feet/year available from B.A. Steinhagen Lake.

Lake Palestine and Sam Rayburn Reservoir have been identified as feasible water supply alternatives and will be considered in detail in the Evaluation of Existing and Proposed Surface Water Alternatives presented in Section III.B.5.

4. Proposed Surface Water Alternatives

There are several proposed reservoir projects within a reasonable distance from the five county study area. An evaluation has been made of proposed projects surrounding the study area which considers various factors that affect the suitability and reliability of those projects to meet the needs of the five counties. When considering the possibilities of a proposed water supply to meet the short and long term water demands for the area, project reliability is an extremely important factor. This is particularly true if one is relying on the schedule and funds of another entity to pursue the development of a surface water supply. In recent years, development of projects of this type has become increasingly difficult due to various environmental constraints. Recently completed projects have shown that much more time and expense is required to acquire the necessary state and federal permits than those developed years ago, project development time for water supply projects continues to increase. For the purposes of this study, proposed projects which are not currently being pursued, which cannot be developed in the next 10-15 years or which have environmental conflicts that could seriously impair development of the project will be considered unreliable alternatives and, therefore, eliminated from further consideration.

Several of the proposed reservoir projects are discussed with reference to bottomland forest sites which have been identified by the U.S. Fish and Wildlife Service (USFWS) for preservation consideration (USFWS, 1984). The USFWS identified 62 bottomland sites and prioritized each based on the quality of bottomland habitat they contain. The six priority categories used by USFWS are defined below:

Priority 1 - Excellent quality bottomlands of high value to key waterfowl species (i.e., wood duck and mallard).

Priority 2 - Good quality bottomlands with moderate waterfowl benefits.

Priority 3 - Excellent quality bottomlands with minor waterfowl benefits because of small size, lack of management potential, or other factors.

Priority 4 - Moderate quality bottomlands with minor waterfowl benefits.

Priority 5 - Sites eliminated from further study because of poor quality and/or no waterfowl benefits.

Priority 6 - Sites recommended for further study.

The results of this research of proposed water supply reservoir is presented below. A complete list of proposed projects considered in this section is presented in Table III.9.

Table III.9

PROPOSED SURFACE WATER ALTERNATIVES

Basin and Reservoir	Sponsor	Proposed Yield or Storage (ac-ft/yr)	Status/Comments
NECHES BASIN			
Lake Neches		y = 249,000	Inactive - site on environmentally sensitive area
Rockland Reservoir	COE	s = 3,287,300	Deauthorized fed. project - environmentally sensitive area
Lake Ponta	Ang. & Nacog. Co. WCID #1/ ANRA/COE	y = 300,000	Inactive - site on environmentally sensitive area
Lake Eastex	ANRA	y = 85,507	Active - has State permit
SABINE BASIN			
Carl L. Estes Lake	SRA/COE	s = 393,000	Inactive - extensive lignite reserves underlying site
Big Sandy Lake	SRA/COE	s = 221,200	Not currently active, depends on Water's Bluff outcome
Prairie Creek Reservoir	City of Longview	y = 40,000	Inactive - envisioned to supply local needs only - not Regional
Lake Carthage	SRA	N/A	Inactive - large oil and gas reserves underlying site
Big Cow Creek Reservoir	SRA	y = 34,000	Inactive - not needed because Toledo Bend has water surplus
Bon Weir Reservoir	SRA/COE	y = 441,500	Inactive - not needed because Toledo Bend has water surplus
Water's Bluff/Brazoria Landing Reservoir	SRA	y = 344,000	Active - conservation easement conflict
TRINITY BASIN			
Tennessee Colony Lake	TRA/COE	y = 276,640	Inactive - extensive lignite reserves underlying site
Hurricane Bayou Reservoir	TRA	N/A	Inactive - envisioned to supply local needs only
CYPRESS BASIN			
Little Cypress	LCUD	y = 129,000	Active - may have 40,000 ac-ft/yr available to Texas but currently offered to Shreveport, La. Has State permit; Federal permit application on hold.

a. Sabine River Basin

Carl L. Estes Lake - Carl L. Estes Lake is an authorized federal project. It is planned to be located immediately downstream of the existing Lake Tawakoni on the Sabine River. The conservation pool has been planned at elevation 379.0, creating a surface area of 24,900 acres and a storage volume of 393,000 acre-feet. Preconstruction planning studies completed in 1979 revealed that construction of the lake should be delayed until the extensive lignite deposits underlying the lake area are mined. Therefore, this project was classified as inactive by the COE in April 1979 (COE, 1989). Presently there are no ongoing mining operations and no known plans for such mining. Furthermore, it is assumed that, once lignite mining becomes economically feasible, it would take about 20 years to deplete the reserves. As a result of the development constraints described above, Carl L. Estes Lake is considered an unreliable alternative and has been eliminated from further consideration.

Big Sandy Lake - The Big Sandy Lake site is located on Big Sandy Creek, a tributary of the Sabine River, upstream of Longview. This project was originally planned to serve as a COE flood control project. The lake was to have a surface area of 10,180 acres and a volume of 221,200 acre-feet at the conservation pool elevation of 367.5. It was identified as an authorized federal project in 1970. The project had been included in preconstruction planning in 1979. Following that, the COE determined that the project was not feasible for flood control purposes and the project was terminated by the COE in 1982. Since that time, the SRA discussed the possibility of the site being developed for water supply purposes with the Bureau of Reclamation. The Bureau of Reclamation initiated studies of the site in 1983. This study was scheduled for completion in 1990 (COE, 1989). Although the SRA still considers this project a viable one to meet future needs in the Sabine Basin, there are several reasons why it should not be considered a reliable alternative to address the water supply needs of the five-county study area.

a. There have been no state or federal permits obtained for the Big Sandy project.

b. The Big Sandy Lake site has potential environmental conflicts with two of the 62 bottomland hardwood priority sites identified by the USFWS described above. The reservoir site covers one USFWS Priority 2 site completely and about ten percent of a second Priority 2 site. The first site, known as the Upper Big Sandy Creek and Glades Site, reportedly possesses the largest freshwater marsh in Texas; a 200 acre "floating glade". It is estimated that a total of about 4240 acres of priority bottomland forests would be inundated by this project.

c. Currently the SRA is pursuing an alternative project, Waters Bluff, which is located on the Big Sandy Creek/Sabine River confluence. If Waters Bluff is built, Big Sandy Lake will not be built. The Big Sandy project is not being pursued at this time.

d. The Waters Bluff development process has been held up in litigation between the SRA and the USFWS over the donation of a portion of land within the reservoir

site as a conservation easement. Although a federal judge ruled against the SRA, as of this writing, it has not yet been decided whether the decision will be appealed. No development of the Big Sandy project is expected until the lawsuit is resolved and/or it is determined that pursuit of the Waters Bluff project is no longer feasible. Following that, it is estimated that the project would require about 15-20 years to develop such that it could not function as a water supply to the study area in time to meet its near term demands.

In view of the inactivity, the potential environmental conflicts, and schedule constraints described above, Big Sandy Lake has been considered an unreliable alternative and has been eliminated from further consideration.

Prairie Creek Lake - This reservoir was planned to be located on Prairie Creek in Gregg and Smith counties. There are no known efforts to develop Prairie Creek Lake at this time. The City of Longview, a previous sponsor, had applied for a state permit for Prairie Creek Lake and Little Cypress Reservoir at the same time. As a result of the TWC decision to grant only a single permit, the City decided to abandon plans for Prairie Creek and continue to pursue the Little Cypress project. Prairie Creek Lake is a relatively small project, intended to serve local demands only. The project was estimated to produce a yield of 40,000 acre-feet/year with approximately 30,000 acre-feet/year of this amount being supplied as a result of a direct diversion of water from the Sabine River. It was not envisioned as a regional water supply reservoir. Due to the inactivity, the lack of a state permit, and the intended purpose to supply only local demands, the Prairie Creek Lake project was considered an unreliable alternative and eliminated from further consideration.

Carthage Reservoir - The Carthage Reservoir project has been proposed to be located on the Sabine River south and east of Longview. Information from the Sabine River Authority suggests that this project is currently inactive and it is unlikely that this project will ever be built. Similar to the Carl L. Estes site, the Carthage Reservoir would cover large oil and gas reserves. Additionally, the reservoir site is located such that construction of the lake would inundate about 17 percent of an 88,576 acre USFWS Priority 1 bottomland hardwoods site known as the Lower Sabine River Bottom. Within this site, it is anticipated that about 9486 acres of bottomland hardwoods could be lost. It is also expected that construction of this lake would directly or indirectly impact the Woodland Cathedral nature sanctuary owned by International Paper Company. In view of the potential economic and environmental conflicts, this project has been considered unreliable and has been eliminated from further consideration.

Bon Wier Reservoir - The Bon Wier Reservoir project has been studied by the COE and has been envisioned as providing additional water supply, recreation, and possibly hydroelectric power generation in the lower Sabine River Basin. However, it is not classified as an authorized federal project. The project site is on the Sabine River, immediately downstream of Toledo Bend Reservoir. It has been estimated that the Bon Wier Reservoir would have a conservation storage pool volume of 339,800 acre-feet and a dependable yield of about 441,500 acre-feet/year. This project has been expected to ultimately serve as a water supply to the lower Sabine Basin or

perhaps the greater Houston area. This project is not being actively pursued at this time due to the relatively large amount of uncommitted water currently available in Toledo Bend Reservoir. In view of the lack of project development activity and the availability of uncommitted water from the nearby Toledo Bend Reservoir, the Bon Wier Reservoir has been eliminated from further consideration.

Big Cow Creek Reservoir - Local interests in the lower Sabine River Basin have worked together toward the development of a central water supply to serve area needs. The Big Cow Creek project, located on Big Cow Creek approximately four miles northwest of the City of Newton, would create a 34,200 acre-foot capacity reservoir with a dependable yield of 34,000 acre-feet/year. Big Cow Creek has been referred to as a long range project in studies for the Sabine River Basin. This project is not currently being actively pursued. Its development is dependent on local interests and will serve primarily local demands. The uncertain development schedule and the intent of the project to serve only local needs outside of the five-county region in question, along with the availability of uncommitted water from nearby Toledo Bend Reservoir, caused the Big Cow Creek Reservoir to be eliminated from further consideration.

Waters Bluff/Belzora Landing - The Waters Bluff Reservoir site is located on the Sabine River in Smith and Upshur Counties. This project has been proposed by the Sabine River Authority to serve as a regional water supply with incidental production of hydroelectric power. It is estimated that the reservoir will have a storage volume of 525,163 acre-feet and a dependable yield of 344,000 acre-feet/year. An alternative first phase to this project has also been identified as the Belzora Landing Reservoir. This project would impound water in the upstream portion of the Waters Bluff Reservoir site to the same conservation pool elevation. Storage volume and dependable yield for this initial phase project are 115,189 acre-feet and 115,000 acre-feet/year, respectively. The Waters Bluff project with its optional first phase are currently considered unreliable alternatives for water supply to the five county study area for the following reasons:

a. The USFWS has accepted a permanent conservation easement on 3802 acres of the Little Sandy Hunting and Fishing Club, most of which would be inundated by the proposed Belzora Landing project. Since an easement of this type could prevent the construction of both projects, the SRA filed a lawsuit against the USFWS. A federal judge recently decided against the SRA in this suit. At the time of this writing, no final decision has been made by the SRA with regard to appealing the judicial decision.

b. Even if the easement issue is resolved, representatives have said that federal legislation will be required to develop the project. Although this legislation is being actively pursued, the amount of time required to gain the necessary level of support is uncertain. The SRA has estimated that the project is at least 15 to 20 years away from being developed.

c. The area of land which was donated to the USFWS was a portion of a 13,798 acre USFWS Priority 1 site. The proposed Waters Bluff Reservoir would inundate the entire Priority 1 site creating a loss of about 12,142 acres of bottomland hardwoods.

In view of the legal, legislative, environmental and time constraints on the development of the Waters Bluff/Belzora Landing Reservoir project, it has been considered unreliable and has been eliminated from further consideration.

b. Trinity River Basin

Hurricane Bayou Reservoir - The proposed Hurricane Bayou Reservoir site is located in Houston County, south of Houston County Lake. The yield for this project has been estimated at about 17,925 acre-feet/year. The proposed Hurricane Bayou Reservoir site has not been identified as being in conflict with any identified priority preservation areas. However, the Trinity River Authority is not presently pursuing the development of this project. The TRA has identified the project as a future resource to be developed at such time as it is needed to meet local demands, and is not expected to provide water for export to other basins (TRA, 1989). Because of the uncertain schedule for development, present inactivity, and relatively small yield intended for local uses only, this water supply is considered to be an unreliable source. Therefore, the Hurricane Bayou Reservoir was eliminated from further consideration.

Tennessee Colony Reservoir - The proposed Tennessee Colony Reservoir site is on the Trinity River primarily in Freestone and Anderson Counties. As identified by the COE, this project would have a conservation pool of 1,115,000 acre-feet and a yield of 285,680 acre-feet/year. This project is in conflict with a designated Priority 2 site of 9,446 acres. Currently the project is inactive. In addition to being an environmentally sensitive area, there are extensive lignite reserves present on the site. If the lignite mining were to begin in 1990, the lignite reserves would not be exhausted until 2030 (COE, 1989). Mining is not taking place presently. Once the lignite reserves are mined and there is a demonstrated need of water, the project may be reactivated. Due to environmental and lignite conflicts, the Tennessee Colony Reservoir is considered an unreliable alternative and has been eliminated from further consideration.

c. Neches River Basin

Sam Rayburn Reservoir - As discussed previously in the section on Existing Surface Water Alternatives, Sam Rayburn Reservoir is an existing reservoir that currently has about 370,000 acre-feet/year available for diversion from B.A. Steinhagen Lake. An alternative to this approach is to pursue the reallocation of flood control storage in Sam Rayburn Reservoir to municipal water supply storage. This approach allows for a more economical diversion point location upstream of the Sam Rayburn Dam. Although this approach will be evaluated more fully in the section on Evaluation of Existing and Proposed Surface Water Alternatives, it must be understood that the reallocation process possesses some of the same potential development

conflicts as any other reservoir development project. Some of the major steps to be expected in this reallocation process include:

a. Approval from the Secretary of the Army and/or Congress for a reallocation of more than 4412 acre-feet of storage.

b. Depending on the results of the COE initial reconnaissance study conducted to identify potential adverse impacts, a preliminary investigation of the impact of the increase in water surface elevation, a Feasibility Study may be required. Costs for the Feasibility Study are split in half between the COE and the applicant. Depending on the results of the Feasibility Study, an EIS may be required.

c. Acquisition of a state permit to store and divert water from Sam Rayburn Reservoir.

d. Coordination with LNVA as the original sponsor of the project.

e. Payment of the cost of storage in the lake to the Federal government, as estimated by the COE, of about ten cents per 1000 gallons.

f. Based on Lufkin's contract with LNVA, a cost of one cent per 1000 gallons could also be required.

For the purpose of performing an economic evaluation of this alternative, it is assumed that the reallocation of flood storage to a municipal (or industrial) water supply is feasible and can be accomplished within the time constraints previously described for the five county study area. This alternative will be considered further in the following section.

Rockland Reservoir - The Rockland Reservoir dam site would be located approximately three miles west of Rockland on the Neches River. This lake is one of four projects authorized by Congress in the River and Harbor Act of March 1945 for the Neches River Basin (COE, 1989). The project was designed by the COE to serve as a flood control, hydroelectric power generation and water supply reservoir with a total storage capacity of 3,287,300 acre-feet. The proposed lake would cover approximately one-half of a USFWS Priority 1 site and an entire Priority 2 site (USFWS, 1984). The Priority 2 site, known as the Neches River South site, consists mostly of property in the Angelina National Forest which is owned by the U.S. Forest Service. Overall, the Rockland Lake would inundate a total of 68,324 acres of bottomland forests. The most recent publication from the COE classified Rockland Lake as a "deauthorized" project. Because of the deauthorized status of the project by the COE and the environmental impact potential, this project is considered unreliable and has been eliminated from further consideration.

Ponta Reservoir - The Ponta Reservoir dam site would be located on the Angelina River approximately due west of the City of Nacogdoches. The local sponsors for the reservoir are the

former Neches River Conservation District, now the Angelina and Neches River Authority, and the Angelina and Nacogdoches Counties WCID #1. The reservoir, as proposed would have a storage capacity of approximately 810,000 acre-feet and a yield of 300,000 acre-feet per year. This yield is much larger than the projected local needs and local sponsors have chosen not to pursue the development of the reservoir at this time. In addition to not being actively pursued by any local sponsor, the project site would cover an entire 6,784 acre USFWS designated Priority 1 site. Due to the inactive status of the project development, a yield much greater than local needs, and the potential environmental impact, the Ponta Reservoir was eliminated from further consideration.

Weches Reservoir - The Weches Reservoir dam site would be located on the Neches River southwest of the City of Alto. The local sponsor for the reservoir is the former Neches River Conservation District, now the Angelina and Neches River Authority. The reservoir, as proposed, would have a storage capacity of approximately 720,000 acre-feet and a yield of 249,000 acre-feet per year. This yield is much larger than the projected needs of the area and the local sponsor has chosen not to pursue the development of the reservoir at this time. In addition to not being actively pursued by any local sponsor, the project site would inundate a USFWS designated Priority 1 site of approximately 25,304 acres. It is estimated that approximately 17,966 acres of bottomland forest would be lost. Due to the inactive status of the project development, a yield much greater than local needs, and the potential environmental impact, the Weches Reservoir was eliminated from further consideration.

d. Cypress River Basin

Little Cypress Reservoir - This reservoir site is located on Little Cypress Creek, north of Longview. The Little Cypress Utility District has obtained a Texas Water Commission permit for the Little Cypress Reservoir, and has started the Federal 404 permitting process. However, discussions with the regional Corps of Engineers office have indicated that the Corps of Engineers does not consider the Little Cypress Utility District's 404 permit application valid because there has been no activity for more than a year. The Corps of Engineers has indicated they will require the Little Cypress Utility District to re-apply for a 404 permit. Therefore the Little Cypress Reservoir project and the Lake Eastex project are at the same stage of development. Assuming the project can be developed, approximately 40,000 acre-feet per annum could be available from the Little Cypress Reservoir. The Little Cypress Utility District is currently negotiating with the City of Shreveport, Louisiana on a water service agreement for this 40,000 acre-feet/year supply. However, a representative of the Little Cypress Utility District indicated that if a water user from Texas requested water prior to an executed water service contract with Shreveport, the Texas user would take priority. This alternative will be considered further in the following section.

5. Evaluation of Existing and Proposed Surface Water Alternatives

The results of the preliminary investigation of surface water alternatives indicate that, from the Sabine, Little Cypress, Neches, and Trinity River Basins, only the following alternatives justify a more detailed evaluation.

Existing Reservoirs

Toledo Bend Reservoir
Sam Rayburn Reservoir (via B.A. Steinhagen Lake)
Lake Palestine

Proposed Reservoirs

Lake Eastex
Little Cypress Reservoir
Sam Rayburn Reservoir (via reallocation of flood storage to water supply storage).

The reservoirs listed above represent source alternatives. Various combinations of these source alternatives provide the basis for the evaluation of project alternatives which follow. The project alternatives described in the following paragraphs were developed based on the quantity of water available and the cost required to deliver water from each of the listed sources.

The project alternatives for the five county study area, which have been evaluated are listed below.

Alternative 1 - Sam Rayburn Reservoir (via B.A. Steinhagen Lake)

Alternative 2 - Toledo Bend Reservoir

Alternative 3 - Toledo Bend Reservoir with Lake Palestine

Alternative 4 - Toledo Bend Reservoir with Lake Palestine and Little Cypress Reservoir

Alternative 5 - Toledo Bend Reservoir with Little Cypress Reservoir

Alternative 6 - Sam Rayburn Reservoir (via storage reallocation)

Alternative 7 - Sam Rayburn Reservoir (via storage reallocation) with Lake Palestine and Little Cypress Reservoir

Alternative 8 - Sam Rayburn Reservoir (via storage reallocation) with Lake Palestine

Alternative 9 - Sam Rayburn Reservoir (via storage reallocation) with Little Cypress Reservoir

Alternative 10 - Lake Eastex with Sam Rayburn Reservoir (via storage reallocation)

Alternative 10a - Lake Eastex with Sam Rayburn Reservoir (via storage reallocation), including Angelina County Regional Water Study

The Lake Eastex project has been identified as a viable regional water supply for the five county study area. It has received a large measure of support from local communities, and has been actively pursued by the Angelina and Neches River Authority for 12 years. Therefore, each of the project alternatives evaluated below are compared to an alternative which includes the Lake Eastex project. In order to provide an equal basis for comparison, all alternatives are evaluated on cost to deliver raw water to two delivery points central to the study area. One delivery point is located west of New Summerfield near Mud Creek at U.S. 79 in Cherokee County and the other delivery point is near the Angelina River at U.S. 59 in Angelina County. These points were chosen because they represent central locations within the region where raw water could easily be diverted for treatment and distribution. The demands for the study area have been allocated to the delivery points as follows:

Northern delivery point - includes maximum net surface water demands from Cherokee, Rusk, and Smith Counties and half of the regional demand for new industries (10,000 acre-feet/year) for a total of 44,214 acre-feet/year.

Southern delivery point - includes maximum net surface water demands from Angelina and Nacogdoches Counties and half of the regional demand for new industries for a total of 65,888 acre-feet/year.

Cost estimates for each of the alternatives which were evaluated include capital costs for the transmission system, annual operation and maintenance costs and annual raw water costs. Costs for treatment and treated water distribution are not included. The capital costs were amortized based on a 30 year term, assuming an interest rate of eight percent. The amortized cost presented in each of the cost summary tables includes an allowance for the costs associated with financing (bond issue costs, legal fees, capitalization of interest, etc.).

Also presented with each alternative is a summary of potential sources of environmental impact which were identified for each alternative for which a cost estimate was prepared. The potential sources of environmental impacts have been included in order to provide an indication of relative environmental impacts which may be anticipated as a result of each of these project alternatives.

a. Alternative 1 - Sam Rayburn Reservoir (via B. A. Steinhagen Lake)

The Lower Neches Valley Authority has indicated that about 370,000 acre-feet/year is currently available from Sam Rayburn Reservoir. However, for reasons discussed in the Existing Surface Water Alternatives section, the water must currently be diverted from B. A. Steinhagen Lake. An alternative which diverts an amount equal to the maximum net surface water demand for the five-county study area in the year 2040 (110,102 acre-feet/year) was developed.

This alternative requires a raw water intake and pumping structure on Steinhagen Lake, five additional booster pump stations, and a transmission line which carries water to the two central delivery points within the study area. The transmission line begins toward the east, then proceeds north and west along the west side of Sam Rayburn Reservoir to Lufkin (Exhibit III.6). At Lufkin, the flow splits with about 65,888 acre-feet/year going to the southern delivery point and about 44,214 acre-feet/year going to the northern delivery point. Potential environmental impacts include the raw water intake and pumping structure, five booster pump stations and 134 miles of transmission lines ranging in size from 48 to 78 inches in diameter. A cost summary for this alternative is presented in Table III.10.

Table III.10

COST SUMMARY FOR ALTERNATIVE 1
(via B.A. Steinhagen Lake)

Capital Costs	
118.0 mgd Intake/Pump Station	$ 10,391,000
Booster Pumps 2 - 118.0 mgd 3 - 47.3 mgd	$ 7,060,000
Transmission Line 67 miles - 78 inch pipe 10 miles - 60 inch pipe 57 miles - 48 inch pipe	$167,402,000
subtotal	$184,853,000
Engineering and Contingency (25%)	$ 46,213,250
TOTAL	$231,066,250
Annual Costs	
Raw Water ($0.06/1000 gal)	$ 2,153,000
O&M (5% of Capital Cost)	$ 11,553,313
Amortized Capital Cost (includes financing costs)	$ 26,469,101
TOTAL	$ 40,175,414
Cost per 1000 gallons	$1.1198

b. Alternative 2 - Toledo Bend Reservoir

The Sabine River Authority has indicated that about 375,000 acre-feet/year is currently available from the Toledo Bend Reservoir. This amount exceeds the net surface water demand for the five county study area. Therefore, an alternative which diverts water from Toledo Bend was developed.

This alternative requires a raw water intake and pumping structure, three additional booster pump stations, and a transmission line which carries raw water to the two delivery points within the study area. The transmission line begins in the northern half of the lake, follows

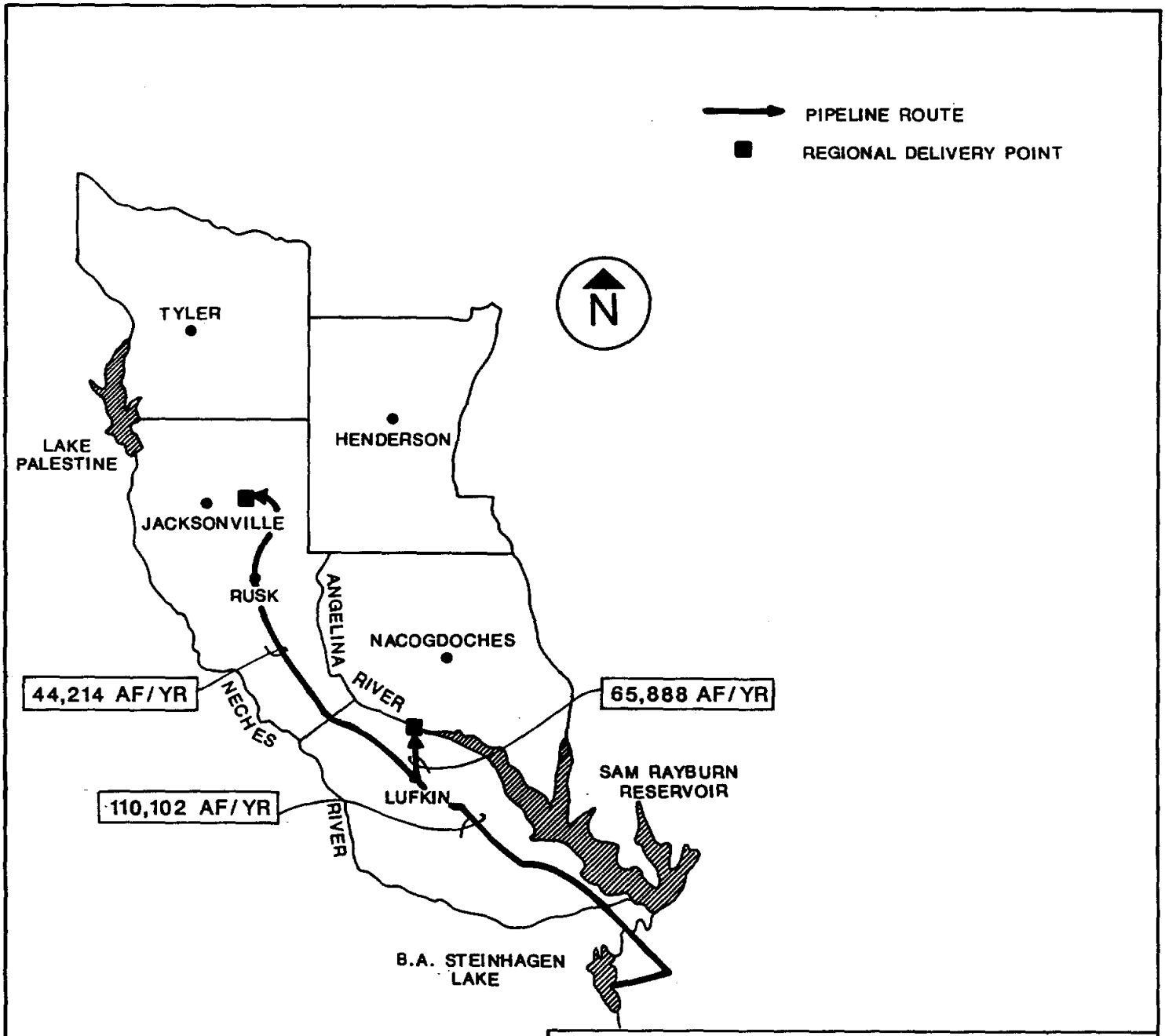


EXHIBIT III.6

WATER SUPPLY ALTERNATIVE 1

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

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existing highway alignments to Nacogdoches, and then splits to deliver about 65,888 acre-feet/year to the southern delivery point and about 44,214 acre-feet/year to the northern delivery point (Exhibit III.7). Potential sources of environmental impact include the raw water intake and pumping structure, three booster pump stations and 114 miles of transmission lines ranging in size from 48 to 78 inches in diameter. A cost summary for this alternative is presented in Table III.11.

Table III.11

COST SUMMARY FOR ALTERNATIVE 2
Toledo Bend Reservoir

Capital Costs	
118.0 mgd Intake/Pump Station	$ 10,033,000
Booster Pumps 1 - 118.8 mgd 2 - 47.3 mgd	$ 5,102,000
Transmission Line 53 miles - 78 inch pipe 10 miles - 60 inch pipe 51 miles - 48 inch pipe	$139,366,000
subtotal	$154,501,000
Engineering and Contingency (25%)	$ 38,625,250
TOTAL	$193,126,250
Annual Costs	
Raw Water ($0.075/1000 gal)	$ 2,691,000
O&M (5% of Capital Cost)	$ 9,656,313
Amortized Capital Cost (includes financing costs)	$ 22,122,998
TOTAL	$ 34,470,311
Cost per 1000 gallons	$0.9608

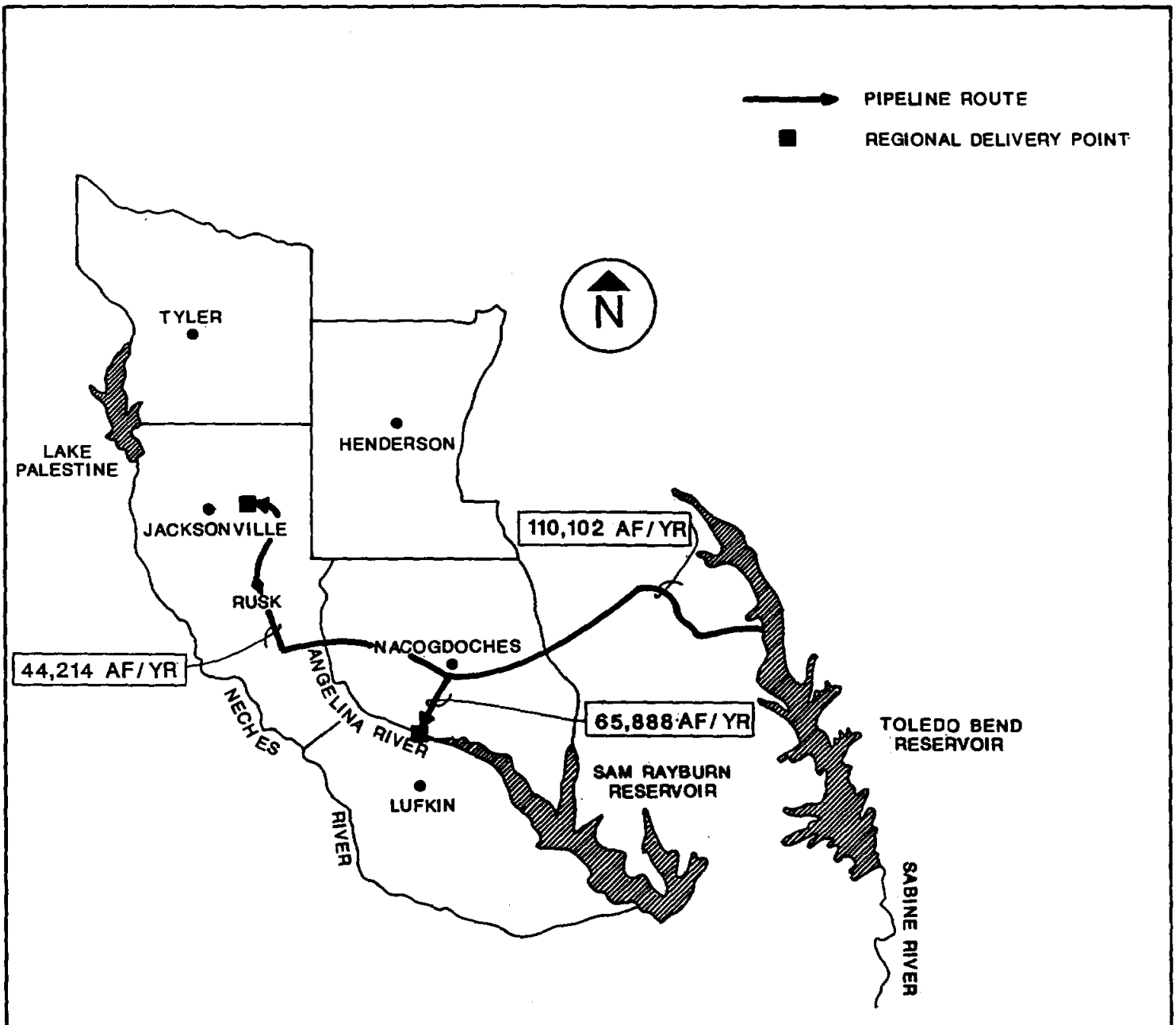

EXHIBIT III.7

WATER SUPPLY ALTERNATIVE 2

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c. Alternative 3 - Toledo Bend Reservoir with Lake Palestine

Although Lake Palestine has a raw water cost comparable to the raw water from Toledo Bend and has a more favorable location from which to supply the five-county study area, it has a relatively small amount of uncommitted water (about 5000 acre-feet/year). In order to meet the surface water demands for the study area, any surface water alternative which involves Lake Palestine must include an additional source.

The evaluation of alternatives 1 and 2 above indicates that Toledo Bend would be a more economical supplement than Sam Rayburn Reservoir (via B. A. Steinhagen). Therefore, an alternative was developed which maximizes water use from Lake Palestine and meets all remaining demands with water supplied from Toledo Bend. This alternative requires the following components:

a. Raw water intake and pumping stations for both lakes.
b. Three booster pump stations for the line from Toledo Bend Reservoir and one booster pump station for the line from Lake Palestine.
c. Transmission line from Toledo Bend to the southern and northern delivery points.
d. Transmission line from Lake Palestine to the northern delivery point only.

The transmission line from Toledo Bend is routed as described for Alternative 2 (Exhibit III.8). However, the split of flow at Nacogdoches is 65,888 acre-feet/year to the southern delivery point and 39,214 acre-feet/year to the northern delivery point. The transmission line from Lake Palestine is designed to convey 5000 acre-feet/year to the northern delivery point. Potential sources of environmental impact include two raw water intake and pumping structures, four booster pump stations and 137 miles of transmission lines ranging in size from 18 to 72 inches in diameter. A cost summary for this alternative is presented in Table III.12.

Table III.12

COST SUMMARY FOR ALTERNATIVE 3
Toledo Bend Reservoir with Lake Palestine

Capital Costs		
Lake Palestine		
5.4 mgd Intake/Pump Station		$ 1,454,000
Booster Pump 1 - 5.4 mgd		$ 143,000
Transmission Line 23 miles - 18 inch		$ 4,493,000
Toledo Bend Reservoir		
112.6 mgd Intake/Pump Station		$ 10,565,000
Booster Pumps 1 - 112.6 mgd 2 - 42 mgd		$ 4,856,000
Transmission Line 53 miles - 72 inch pipe 10 miles - 60 inch pipe 51 miles - 48 inch pipe		$130,970,000
	subtotal	$152,481,000
Engineering and Contingency (25%)		$ 38,120,250
	TOTAL	$190,601,250
Annual Costs		
Raw Water - Lake Palestine ($0.0767/1000 gal)		$ 125,000
Toledo Bend Reservoir ($0.075/1000 gal)		$ 2,568,000
O&M (5% of Capital Cost)		$ 9,530,063
Amortized Capital Cost (includes financing costs)		$ 21,833,754
	TOTAL	$ 34,056,817
Cost per 1000 gallons		$0.9493

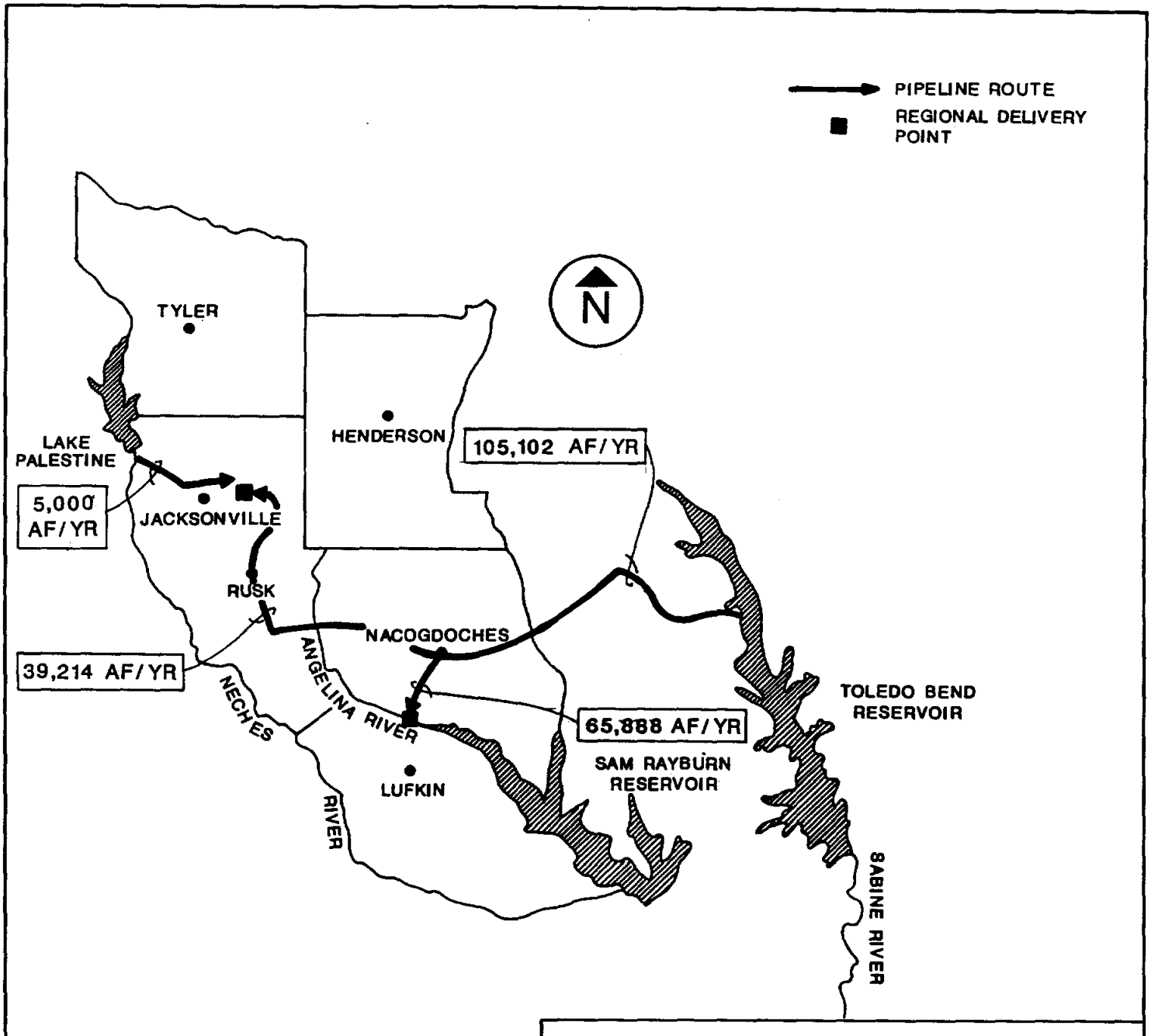

EXHIBIT III.8

WATER SUPPLY ALTERNATIVE 3

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d. Alternative 4 - Toledo Bend Reservoir with Lake Palestine and Little Cypress Reservoir

The proposed Little Cypress Reservoir is similar to Lake Palestine in that it is not expected to have enough uncommitted water to meet the anticipated study area demands. The Little Cypress Utility District has indicated that up to 40,000 acre-feet/year from the proposed reservoir is currently uncommitted. The Little Cypress Reservoir, like Lake Palestine, has a more favorable location from which to supply the five county study area than Toledo Bend or Sam Rayburn Reservoir (via B. A. Steinhagen Lake). Therefore, an alternative has been developed which utilizes water from Lake Palestine and the Little Cypress Reservoir to meet demands at the northern delivery point. Demands at the southern delivery point will be met with water supplied from Toledo Bend.

This three reservoir alternative includes the following major components.

a. Raw water intake and pumping stations at each of the three lakes.

b. A transmission line from the Little Cypress Reservoir designed to convey 39,214 acre-feet/year south and west to a point on Mud Creek about 10 miles north of the northern delivery point (Exhibit III.9). An additional raw water intake to draw water from Mud Creek will be used to pump water to the northern delivery point.

c. A transmission line from Lake Palestine designed to convey 5,000 acre-feet/year south and east to the northern delivery point.

d. A transmission line from the Toledo Bend Reservoir designed to convey about 65,888 acre-feet/year to the southern delivery point.

e. One additional booster pump station each for the transmission lines from Toledo Bend Reservoir and Lake Palestine.

Potential sources of environmental impact include four raw water intake and pumping structures, two booster pump stations and 144 miles of transmission lines ranging in size from 18 to 60 inches in diameter. The cost summary for this alternative is presented in Table III.13.

Table III.13

COST SUMMARY FOR ALTERNATIVE 4
Toledo Bend Reservoir with Lake Palestine and Little Cypress Reservoir

Capital Costs		
Lake Palestine		
5.4 mgd Intake/Pump Station		$ 1,454,000
Booster Pump 1 - 5.4 mgd		$ 143,000
Transmission Line 23 miles - 18 inch pipe		$ 4,493,000
Toledo Bend Reservoir		
70.6 mgd Intake/Pump Station		$ 7,069,000
Booster Pumps 1 - 70.6 mgd		$ 1,767,000
Transmission Line 63 miles - 60 inch pipe		$ 68,191,000
Little Cypress Reservoir		
42.0 mgd Intake/Pump Station		$ 6,202,000
42.0 mgd Intake/Pump Station		$ 2,136,000
Transmission Line 58 miles - 48 inch pipe		$ 45,936,000
	subtotal	$137,391,000
Engineering & Contingency (25%)		$ 34,347,750
	TOTAL	$171,738,750
Annual Costs		
Raw Water - Lake Palestine ($0.0767/1000 gal)		$ 125,000
Little Cypress Reservoir ($0.217/1000 gal)		$ 2,773,000
Toledo Bend Reservoir ($0.075/1000 gal)		$ 1,610,000
O&M (5% of Capital Cost)		$ 8,586,938
Amortized Capital Cost (includes financing costs)		$ 19,673,017
	TOTAL	$ 32,768,955
Cost per 1000 gallons		$0.9134

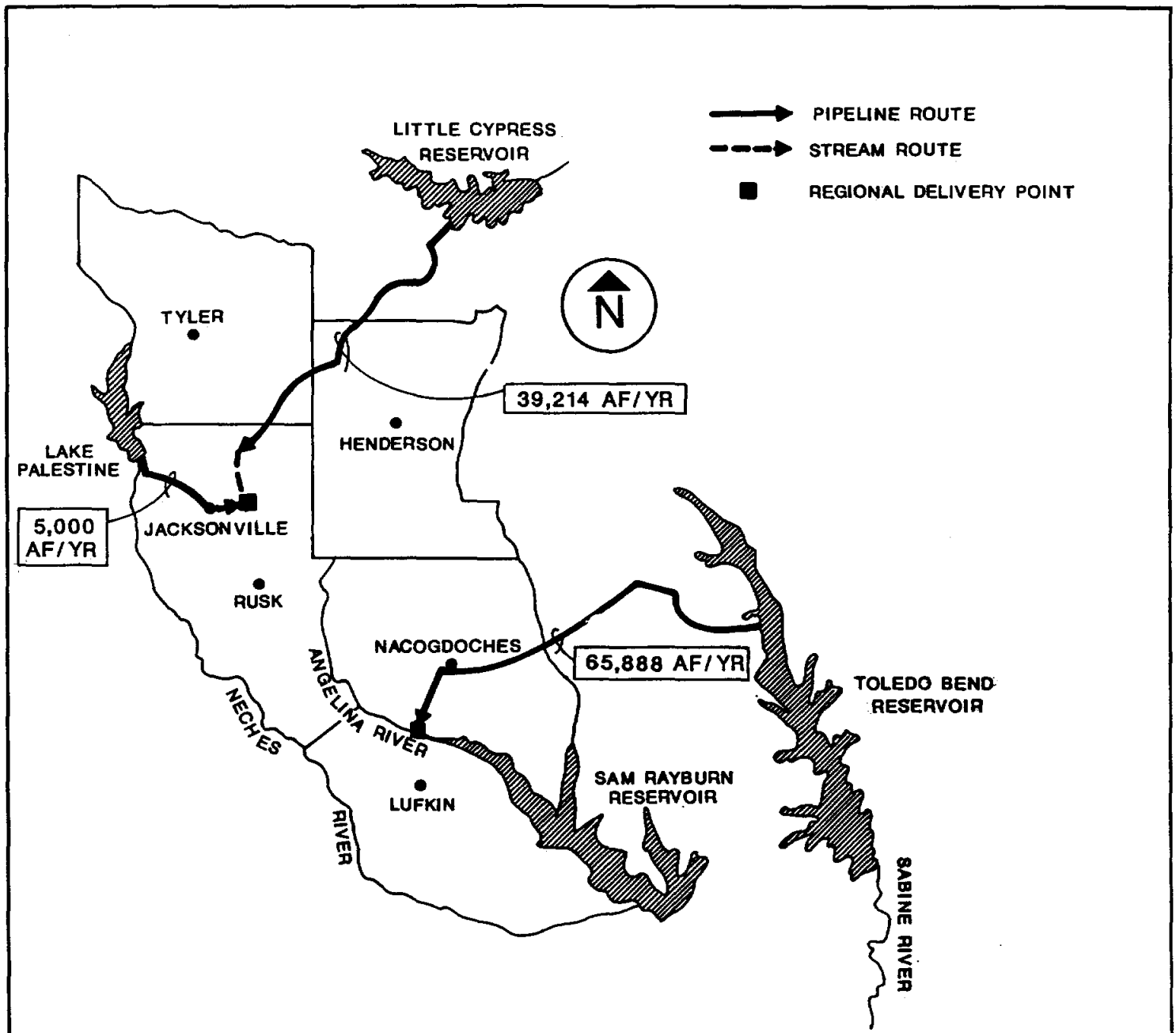

EXHIBIT III.9

WATER SUPPLY ALTERNATIVE 4

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e. Alternative 5 - Toledo Bend Reservoir with Little Cypress Reservoir

Another possible alternative using water supply reservoirs discussed to this point is Lake Toledo Bend with the Little Cypress Reservoir. However, the evaluation of Alternatives 2, 3, and 4 indicate the following:

a. The unit price of raw water in Lake Palestine is lower than raw water in the Little Cypress Reservoir.

b. Lake Palestine is closer to the northern delivery point than the Little Cypress Reservoir. Therefore, transmission costs from Lake Palestine are lower than transmission costs from Little Cypress.

These conclusions indicate that Alternative 4 would prove to be more economical than a plan which uses Lake Toledo Bend with Little Cypress only. No cost estimates were developed for this alternative.

f. Alternative 6 - Sam Rayburn Reservoir (via storage reallocation)

The previous discussion in the section on Proposed Surface Water Alternatives indicated that a potential source of surface water in Sam Rayburn Reservoir could be developed through a reallocation of flood control storage within the body of the lake. Based on this potential, a plan was developed which assumes that an amount equal to the 2040 surface water demand for the five-county study area could be diverted directly from Sam Rayburn Reservoir. The plan is similar in configuration and components to the Sam Rayburn (via B. A. Steinhagen Lake) alternative. The main difference between the two alternatives is the point of diversion being the upper end of Sam Rayburn Reservoir instead of at B. A. Steinhagen Lake (Exhibit III.10). With Sam Rayburn Reservoir being much closer to the southern delivery point, a significant reduction in cost from that shown for Alternative 1 is obtained.

Potential sources of environmental impact include one raw water intake and pumping structure, four booster pump stations, 88 miles of transmission line ranging in size from 48 to 78 inches in diameter, increase in conservation storage elevation in Sam Rayburn Reservoir and the decrease in instream flows between Sam Rayburn Dam and Steinhagen Lake.

As described on pages III-43 - III-44, there are some costs for this alternative which are unique to the development of a source of water by the reallocation process. Initial (capital) costs include participation in the Corps of Engineers Feasibility Study for reallocation of storage and the acquisition of a state permit to impound and divert water. Annual costs include the purchase of storage volume from the Corps of Engineers and the purchase of water from the LNVA. These costs have been estimated and are included in the cost summary for this alternative (Table III.14).

Table III.14

COST SUMMARY FOR ALTERNATIVE 6
Sam Rayburn Reservoir (via storage reallocation)

Capital Costs		
Reallocation Costs		$ 200,000
118.0 mgd Intake/Pump Station		$ 7,883,000
Booster Pumps 1 - 118.0 mgd 3 - 47.3 mgd		$ 4,399,000
Transmission Line 21 miles - 78 inch 10 miles - 60 inch 57 miles - 48 inch		$ 90,911,000
	subtotal	$103,393,000
Engineering and Contingency (25%)		$ 25,848,250
	TOTAL	$129,241,250
Annual Costs		
Raw Water - (COE $0.10/1000 gal)		$ 3,587,000
(LNVA $0.01/1000 gal)		$ 359,000
O&M (5% of Capital Cost)		$ 6,462,063
Amortized Capital Cost (includes financing costs)		$ 14,804,844
	TOTAL	$ 25,212,907
Cost per 1000 gallons		$0.7028

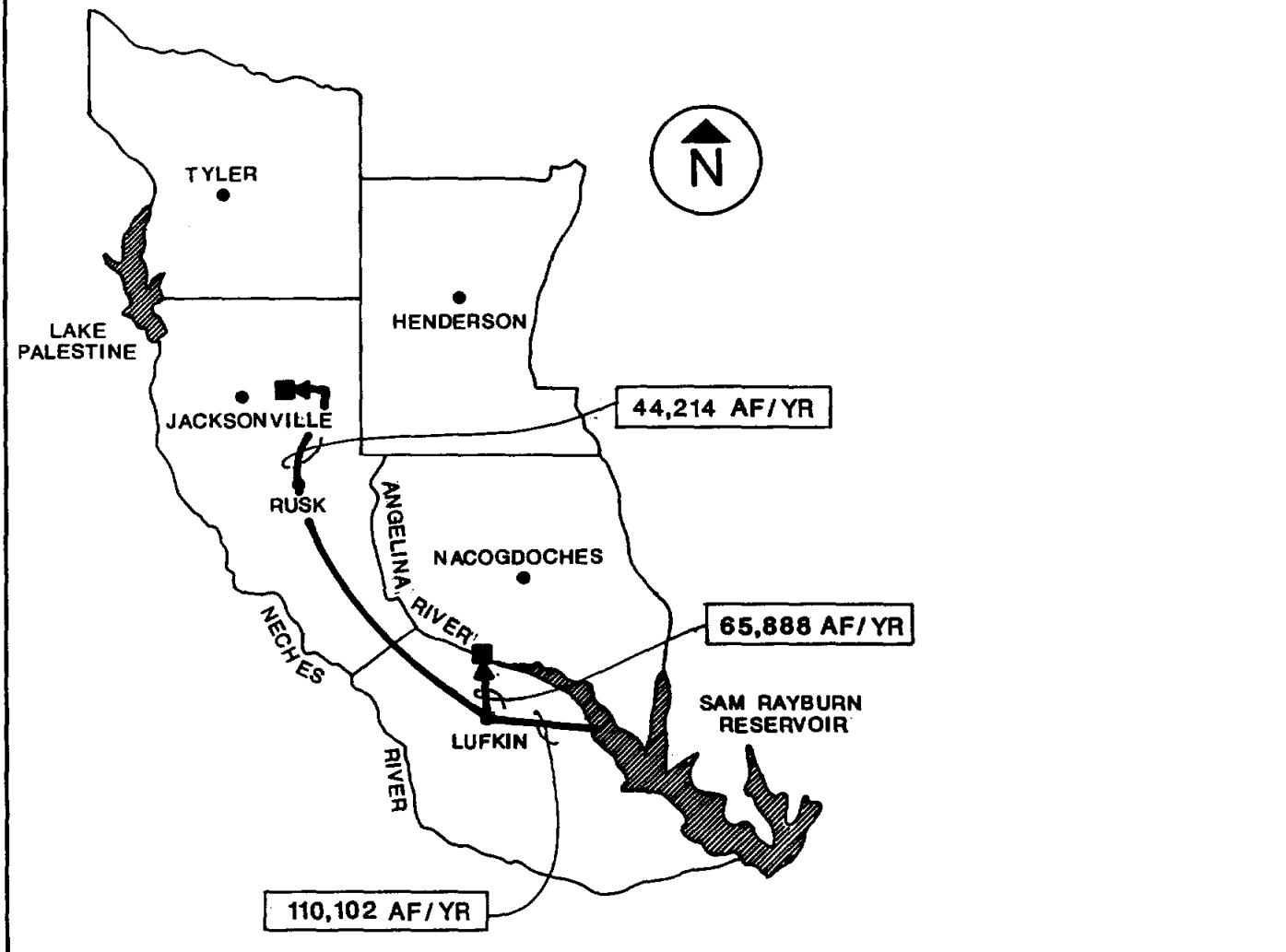

EXHIBIT III.10

WATER SUPPLY ALTERNATIVE 6

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

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g. Alternative 7 - Sam Rayburn Reservoir (via storage reallocation) with Lake Palestine and Little Cypress Reservoir

Similar to the Toledo Bend Reservoir alternative described previously (Alternatives 2 and 4), a cost benefit can be realized by taking advantage of the availability of water from reservoirs located closer to the northern delivery point. This approach eliminates the need to pump water from Lufkin to the northern delivery point (Exhibit III.11). This alternative was developed to evaluate the cost for supplying water to the northern delivery point from Lake Palestine (5000 acre-feet/year) and the Little Cypress Reservoir (39,214 acre-feet/year) and supplying water to the southern delivery point from Sam Rayburn Reservoir (65,888 acre-feet/year). The system components for the transmission of raw water from the Little Cypress Reservoir and Lake Palestine are the same as those in Alternative 4. The system components for the transmission of raw water from Sam Rayburn Reservoir include a raw water intake and pump station along with a 60-inch pipeline and a single booster pump station. Potential sources of environmental impact include four raw water intake and pumping structures, two booster pump stations, 112 miles of transmission lines ranging in size from 18 to 60 inches in diameter, increase in conservation storage elevation in Sam Rayburn Reservoir and the decrease in instream flows between Sam Rayburn Dam and Steinhagen Lake. A cost summary for this alternative is presented in Table III.15.

h. Alternative 8 - Sam Rayburn Reservoir (via storage reallocation) with Lake Palestine

This alternative is similar to Alternative 7 above except that the supply from the Little Cypress Reservoir is not utilized. Instead, the northern delivery point demand in excess of that which can be supplied from Lake Palestine is met from Sam Rayburn Reservoir. It has been shown (Alternatives 6 & 7) that water can be supplied to the northern delivery point more economically from the Little Cypress Reservoir than from Sam Rayburn Reservoir due to the higher pumping and pipeline cost. Therefore, Alternative 7 represents a more economical solution. No cost estimates were prepared for this alternative.

i. Alternative 9 - Sam Rayburn Reservoir (via storage reallocation) with Little Cypress Reservoir

An alternative which considers water supplied from the Little Cypress Reservoir and Sam Rayburn Reservoir was considered briefly. However, it has been shown that water supplied to the northern delivery point from Lake Palestine is more economical than water supplied from the Little Cypress Reservoir (Alternative 5). Therefore, Alternative 7 represents a more economical solution. No cost estimates were prepared for this alternative.

Table III.15

COST SUMMARY FOR ALTERNATIVE 7
Sam Rayburn Reservoir (via storage reallocation)
With Lake Palestine and Little Cypress Reservoir

Capital Costs		
Lake Palestine		
5.4 mgd Intake/Pump Station		$ 1,454,000
Booster Pump 1 - 5.4 mgd		$ 143,000
Transmission Line 23 miles - 18 inch		$ 4,493,000
Sam Rayburn Reservoir		
Reallocation Costs		$ 200,000
70.6 mgd Intake/Pump Station		$ 5,354,000
Booster Pumps 1 - 70.6 mgd		$ 803,000
Transmission Line 31 miles - 60 inch pipe		$ 33,554,000
Little Cypress Reservoir		
42.0 mgd Intake/Pump Station 42.0 mgd Intake/Pump Station		$ 6,202,000 $ 2,136,000
Transmission Line 58 miles - 48 inch pipe		$ 45,936,000
	subtotal	$100,275,000
Engineering & Contingency (25%)		$ 25,068,760
	TOTAL	$125,343,750
Annual Costs		
Raw Water - Lake Palestine ($0.0767/1000 gal)		$ 125,000
Little Cypress Reservoir ($0.217/1000 gal)		$ 2,773,000
Sam Rayburn Reservoir (COE $0.10/1000 gal)		$ 2,147,000
(LNVA $0.01/1000 gal)		$ 215,000
O&M (5% of Capital Cost)		$ 6,267,188
Amortized Capital Cost (includes financing costs)		$ 14,358,377
	TOTAL	$ 25,885,565
Cost per 1000 gallons		$0.7216

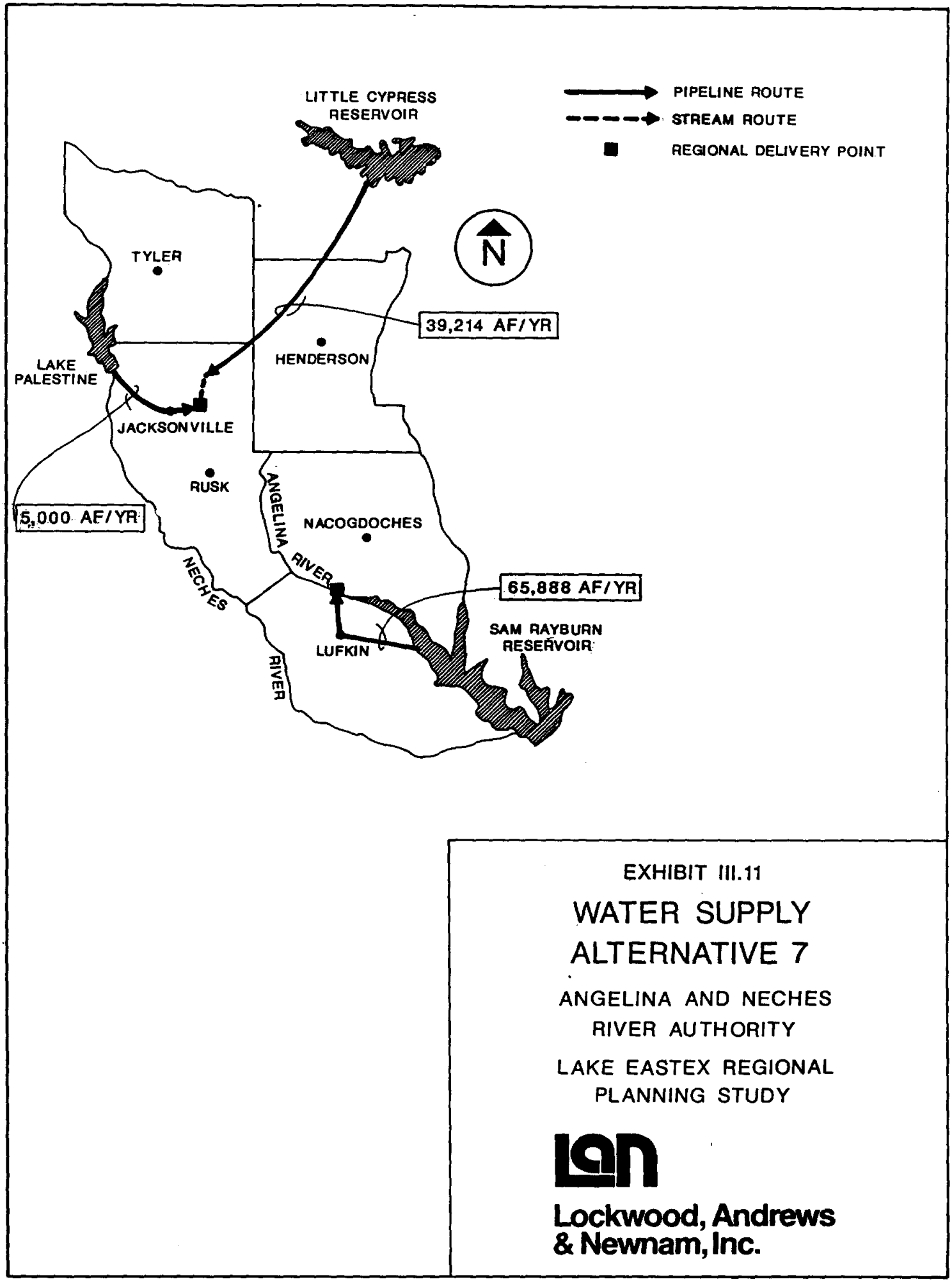

EXHIBIT III.11

WATER SUPPLY ALTERNATIVE 7

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

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j. Alternative 10 - Lake Eastex with Sam Rayburn Reservoir (via storage reallocation)

Given that the dependable yield of Lake Eastex (85,507 acre-feet/year) is less than the maximum net surface water demand for the study area in 2040 (110,102 acre-feet/year), a supplemental source must be considered for any alternative which includes Lake Eastex. Based on the evaluation of alternatives completed to this point, Sam Rayburn Reservoir represents the most economical supplement.

This alternative has been configured such that the northern delivery point demands (44,214 acre-feet/year) would be met entirely from Lake Eastex. The southern delivery point demands (65,888 acre-feet/year) will be met with water from Lake Eastex (via Mud Creek and the Angelina River) and Sam Rayburn Reservoir (Exhibit III.12). This alternative requires two raw water intake and pump stations for Lake Eastex water, one for each delivery point. The transmission of water from Sam Rayburn Reservoir requires a third raw water intake and pump station, a single booster pump station, and a 36-inch transmission pipeline from Sam Rayburn Reservoir to the southern delivery point. Utilization of Lake Eastex water at the southern delivery point allows for a reduced cost in transporting water by pipeline from Sam Rayburn Reservoir to the southern delivery point. Since 41,293 acre-feet/year can be supplied to the southern delivery point from Lake Eastex only 24,595 acre-feet/year will need to be delivered through pipeline facilities to the delivery point. Potential sources of environmental impact include three raw water intake and pumping structures, one booster pump station, 33 miles of transmission line ranging in size from 36 to 48 inches in diameter, increase in conservation storage elevation in Sam Rayburn Reservoir, a decrease in instream flows between Sam Rayburn Dam and Steinhagen Lake and inundation of 10,000 acres of Mud Creek floodplain. The cost summary for this alternative is presented in Table III.16.

Table III.16

COST SUMMARY FOR ALTERNATIVE 10
Lake Eastex With Sam Rayburn (via storage reallocation)

Capital Costs		
Lake Eastex		
47.3 mgd Intake/Pump Station		$ 3,434,000
44.2 mgd Intake/Pump Station		$ 1,105,000
Transmission Line 2.0 miles - 48 inch pipe 0.19 miles - 48 inch pipe		$ 1,734,000
Sam Rayburn Reservoir		
Reallocation Costs		$ 200,000
26.4 mgd Intake/Pump Station		$ 3,272,000
Booster Pump 1 - 26.4 mgd		$ 537,000
Transmission Line 31 miles - 36 inch pipe		$17,186,000
	subtotal	$27,468,000
Engineering and Contingency (25%)		$ 6,867,000
	TOTAL	$34,335,000
Annual Costs		
Raw Water - Lake Eastex ($0.45/1000 gal)		$12,537,000
Sam Rayburn Reservoir (COE $0.10/1000 gal)		$ 802,000
(LNVA $0.01/1000 gal)		$ 80,000
O&M (5% of Capital Cost)		$ 1,716,750
Amortized Capital Cost (includes financing costs)		$ 3,933,143
	TOTAL	$19,096,893
Cost per 1000 gallons		$0.5286

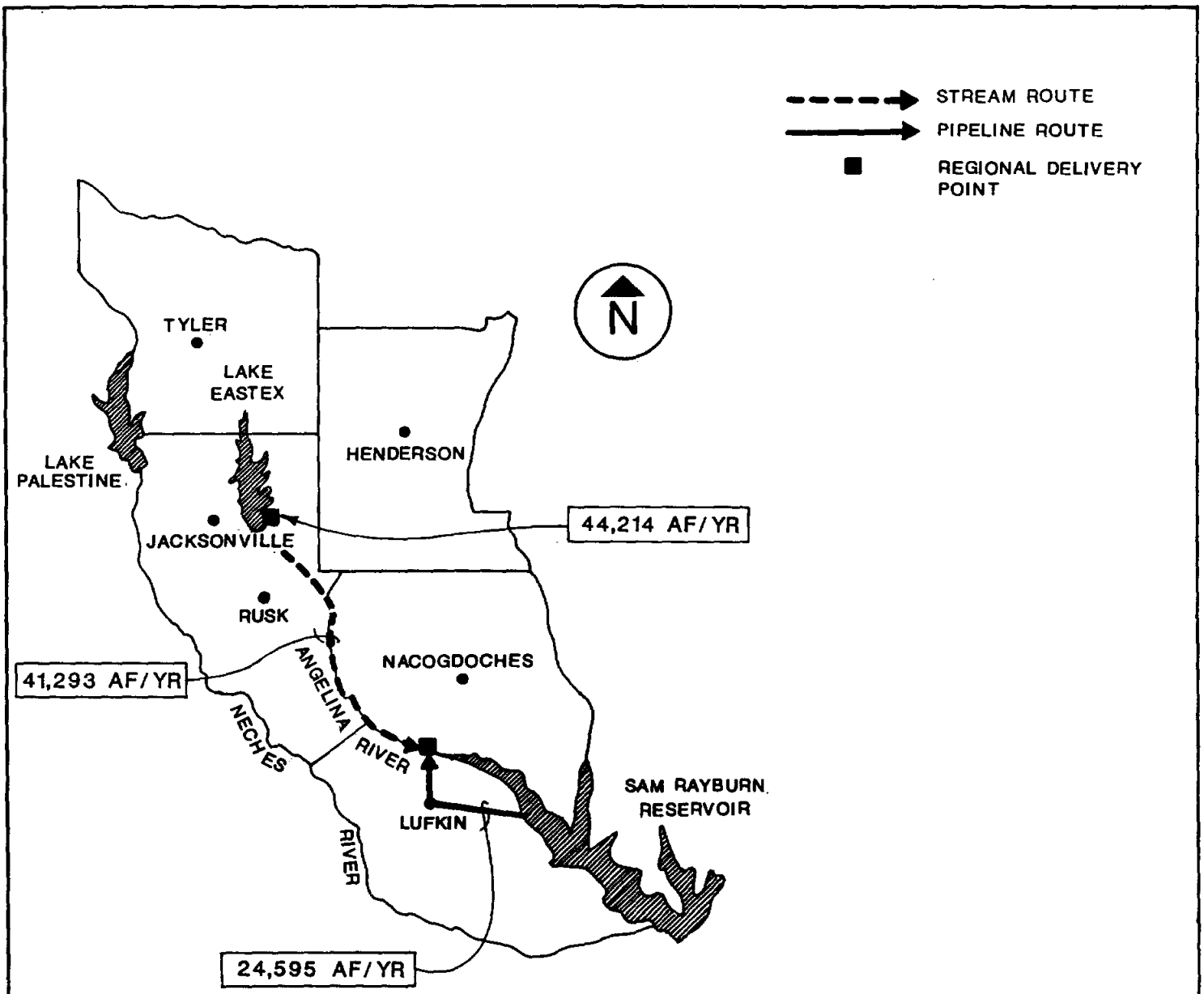

EXHIBIT III.12

WATER SUPPLY ALTERNATIVE 10

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

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k. The Angelina County Regional Water Study

A regional water supply study has recently been completed for Angelina County which has identified a regional delivery system to serve users in that county. The reader is referred to the Angelina County Regional Water Study, June 1990, prepared by Everett Griffith, Jr. & Associates Inc. for details. The initial recommendation of that study is to utilize groundwater resources until the year 2010. Ultimately however, surface water would be required to supplement the area groundwater supply. It is anticipated that by the year 2010, a water supply plan which utilizes groundwater and surface water will be developed. Lake Eastex and Sam Rayburn Reservoir are the surface water sources most likely to be utilized.

The ultimate plan for the Angelina County regional delivery system proposes that the groundwater be supplemented with surface water diverted from Sam Rayburn Reservoir east of the City of Huntington. This surface water would then be pumped to an improved version of the looped distribution system owned by the City of Lufkin, with branches from that loop conveying water to various users located beyond the loop periphery.

The previous analysis of alternatives indicates that Alternative 10 is the most economical surface water supply alternative for the five county study area. With the information available from the Angelina County study, it was possible to consider the impact to the evaluation of Alternative 10 assuming the City of Lufkin functions as a point of distribution to users in Angelina County rather than the previously assumed southern delivery point location. By developing an alternative which supplies the demand for Angelina County to the regional system in Lufkin, an evaluation more consistent with current plans is achieved. Alternative 10a, described below, is the refinement of Alternative 10 which includes the basic concepts of the Angelina County regional plan.

l. Alternative 10a - Lake Eastex with Sam Rayburn Reservoir (via storage reallocation), including the Angelina County Regional System

This alternative is configured similar to Alternative 10. The revision to Alternative 10 is the delivery of the Angelina County demand (20,127 acre-feet/year) to the City of Lufkin instead of the southern delivery point (Exhibit III.13). The key components of this configuration are summarized below.

a. The northern delivery point demands (44,214 acre-feet/year) will be met entirely from Lake Eastex.
b. The Angelina County demand (20,127 acre-feet/year) will be met from Sam Rayburn Reservoir. This amount will be delivered to the City of Lufkin, which serves as the distribution point for the Angelina County regional plan.
c. The remaining portion of the southern delivery point demand (46,543 acre-feet/year) will be met from Lake Eastex (via Mud Creek and the Angelina River) and Sam Rayburn Reservoir.

Potential sources of environmental impact are similar to those listed for alternative 10. Differences consist of the range of pipeline sizes (down to 18 inches) and the addition of any impacts which may be associated with the Angelina County regional system. The cost summary for this alternative is presented in Table III.17.

Table III.17

COST SUMMARY FOR ALTERNATIVE 10a
Lake Eastex With Sam Rayburn Reservoir (via storage reallocation), including the Angelina County Regional Water Study

Capital Costs		
Lake Eastex		
47.3 mgd Intake/Pump Station		$ 3,434,000
44.2 mgd Intake/Pump Station		$ 1,105,000
Transmission Line 2.0 miles - 48 inch pipe 0.19 miles - 48 inch pipe		$ 1,734,000
Sam Rayburn Reservoir		
Reallocation Costs		$ 200,000
26.4 mgd Intake/Pump Station		$ 3,272,000
Booster Pump 1 - 26.4 mgd		$ 537,000
Transmission Line 21 miles - 36 inch pipe 10 miles - 18 inch pipe		$13,596,000
	subtotal	$23,878,000
Engineering and Contingency (25%)		$ 5,969,500
	TOTAL	$29,847,500
Annual Costs		
Raw Water - Lake Eastex ($0.45/1000 gal)		$12,537,000
Sam Rayburn Reservoir (COE $0.10/1000 gal)		$ 802,000
(LNVA $0.01/1000 gal)		$ 80,000
O&M (5% of Capital Cost)		$ 1,492,375
Amortized Capital Cost (includes financing costs)		$ 3,419,091
	TOTAL	$18,358,466
Cost per 1000 gallons		$0.5082

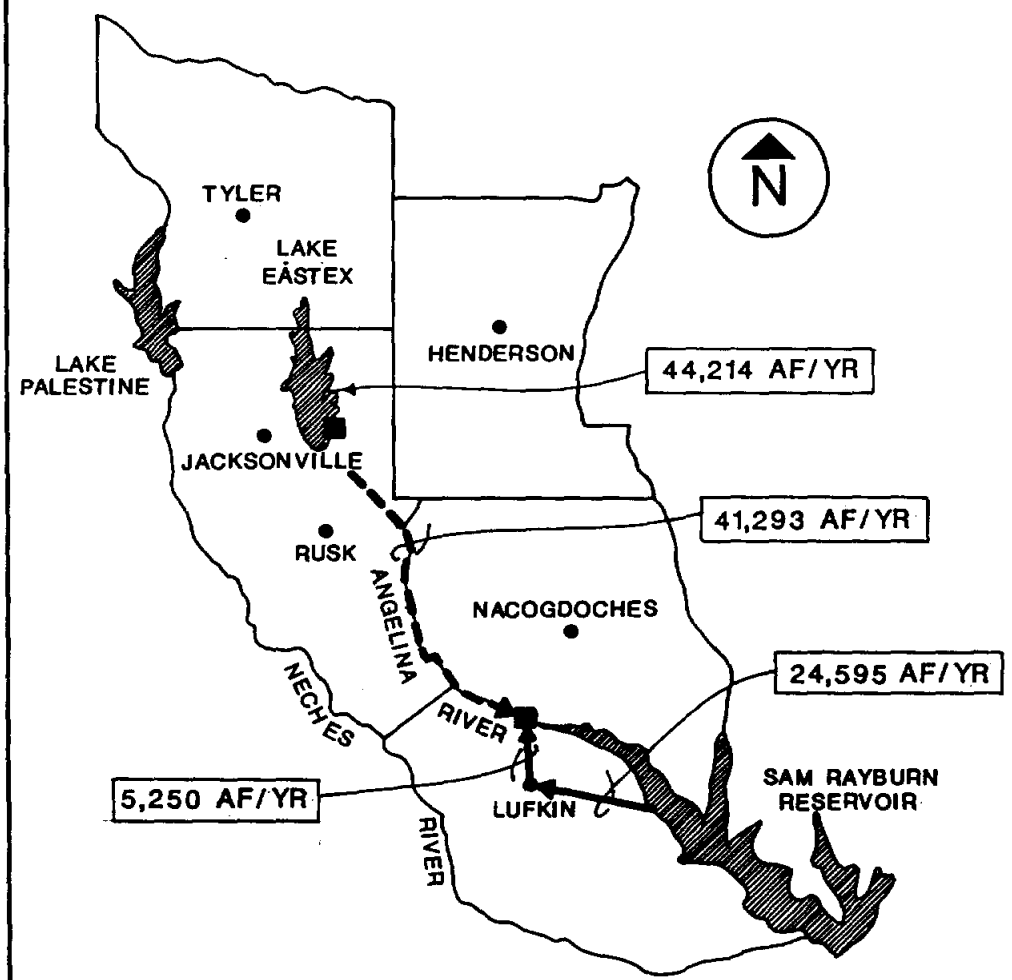

EXHIBIT III.13

WATER SUPPLY ALTERNATIVE 10a

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

Lockwood, Andrews & Newnam, Inc.

C. SELECTION OF THE PREFERRED ALTERNATIVE

A summary of the results of the economic evaluation of surface water alternatives is presented in Table III.18.

The results of the evaluation of surface water alternatives indicate that an approach which utilizes Lake Eastex, supplemented by Sam Rayburn Reservoir, is the lowest cost alternative for the five-county study area. Specifically, Alternative 10a, which includes the concepts of the Angelina County Regional Water Study provides the most economical regional solution and was determined to be about two thirds of the cost of the lowest cost alternative which does not include Lake Eastex. It should be noted that if regional demands develop to a level less than 85,507 ac.ft./yr., Lake Eastex provides the most economical source of supply for the region as a whole. The unit cost of water from Lake Eastex (about $0.44/1000 gal.) is less than all those shown in Table III.18. It is recommended that the development of Lake Eastex continue to be actively pursued and that this project serve as an initial phase to meeting the short and long term water demands in the five-county study area.

Table III.18

SURFACE ALTERNATIVES EVALUATION SUMMARY

Alternative No.	Description	Cost per 1000 gallons for raw water ($)	Potential Source of Environmental Impacts
1	Sam Rayburn Reservoir (via B.A. Steinhagen Lake)	1.1198	118.0 mgd intake/pump station 5 booster pump stations 134 miles of transmission pipelines, 48 inch to 78 inch diameter
2	Toledo Bend Reservoir	0.9608	118.0 mgd intake/pump station 3 booster pump stations 114 miles of transmission pipelines, 48 inch to 78 inch diameter
3	Toledo Bend Reservoir with Lake Palestine	0.9493	5.4 mgd intake/pump station 112.6 mgd intake/pump station 4 booster pump stations 137 miles of transmission pipelines, 18 inch to 72 inch diameter
4	Toledo Bend Reservoir with Lake Palestine and Little Cypress Reservoir	0.9134	5.4 mgd intake/pump station 70.6 mgd intake/pump station 2-42.0 mgd intake/pump stations 2 booster pump stations 144 miles of transmission pipelines, 18 inch to 60 inch diameter
6	Sam Rayburn Reservoir (via storage reallocation)	0.7028	118.0 mgd intake/pump station 4 booster pump stations 88 miles of transmission pipeline, 48 inch to 78 inch diameter Slight increase in normal pool elevation for Sam Rayburn Reservoir Slight decrease in flows between Sam Rayburn Dam and Steinhagen Lake
7	Sam Rayburn Reservoir (via storage reallocation) with Lake Palestine and Little Cypress Reservoir	0.7216	5.4 mgd intake/pump station 70.6 mgd intake/pump station 2-42.0 mgd intake/pump stations 2 booster pump stations 112 miles of transmission pipelines, 18 inch to 60 inch diameter Slight increase in normal pool elevation for Sam Rayburn Reservoir Slight decrease in flows between Sam Rayburn Dam and Steinhagen Lake
10	Lake Eastex with Sam Rayburn Reservoir (via storage reallocation)	0.5286	47.3 mgd intake/pump station 44.2 mgd intake/pump station 26.4 mgd intake/pump station 1 booster pump station 33 miles of transmission pipeline, 36 inch and 48 inch diameters Slight increase in normal pool elevation for Sam Rayburn Reservoir Slight decrease in flows between Sam Rayburn Dam and Steinhagen Lake Inundation of about 10,000 acres of Mud Creek floodplain
10a	Lake Eastex with Sam Rayburn Reservoir (via storage reallocation), including the Angelina County Regional Water Study	0.5082	Same as above except transmission pipelines vary from 18 to 48 inches in diameter instead of 36 to 48 inches in diameter

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IV. LAKE EASTEX ALTERNATIVE

IV. LAKE EASTEX ALTERNATIVE

A. RESERVOIR DESCRIPTION

1. Purpose

The primary purpose of Lake Eastex is water supply. Previous sections of this report have discussed the anticipated water demands for a five county service area surrounding the lake. These sections have also concluded that some locations within this service area are expected to experience water shortages within the next decade. An evaluation of several surface water development alternatives has shown that the solutions which best satisfies the needs of the defined five county service area are those that include Lake Eastex as the major source.

Lake Eastex is expected to provide significant additional recreational benefits to the five-county area as well. Lake Eastex is not, by design, a flood control reservoir, nor is it envisioned to have any hydroelectric capabilities.

2. Location

Lake Eastex will be located in the Mud Creek floodplain primarily in Cherokee County, with the northern limits of the lake extending into Smith County. The location of the dam is about 16 river miles upstream of the confluence of Mud Creek with the Angelina River, and about 2.5 miles south of U.S. Highway 79 (Exhibit IV.1).

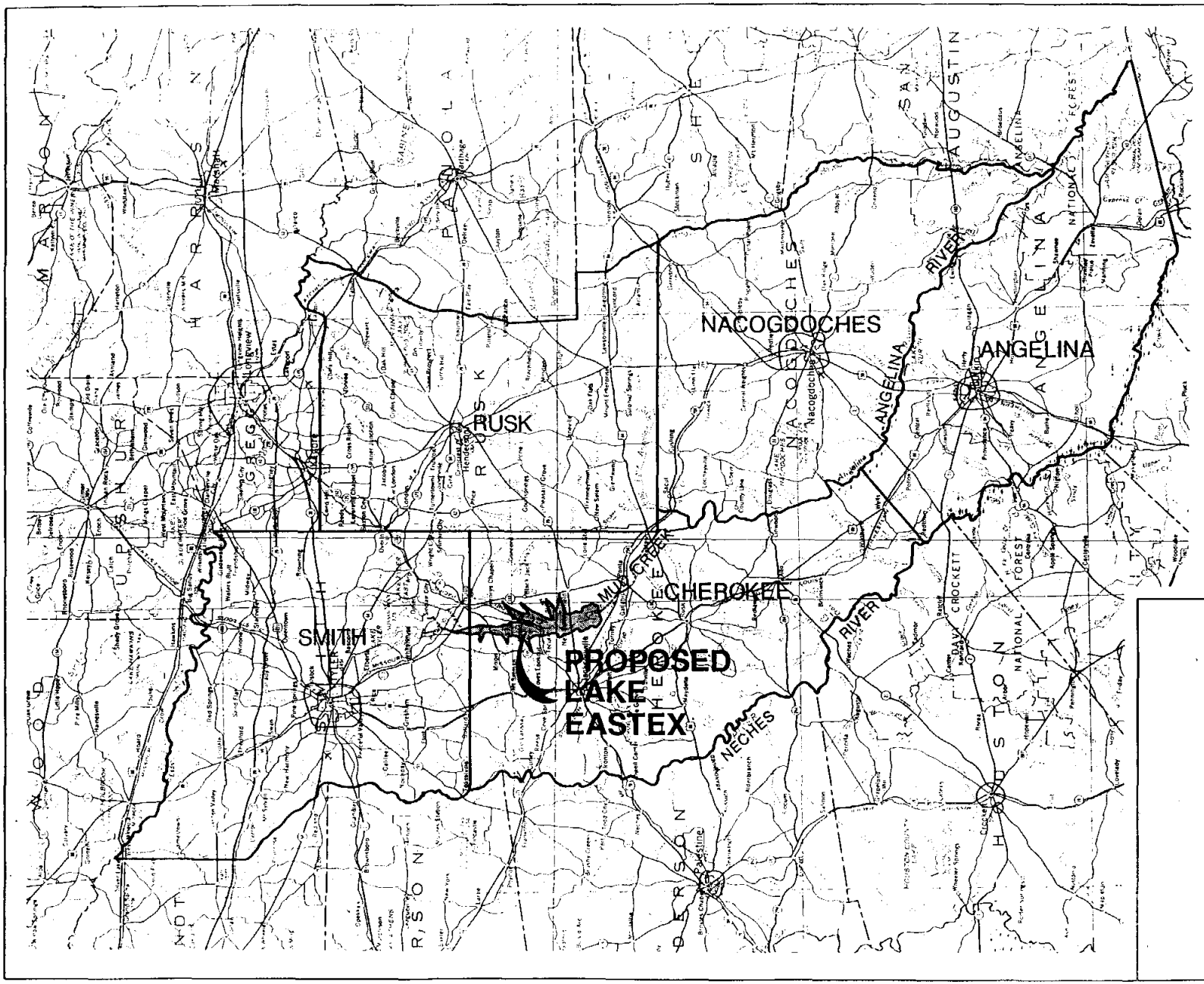
3. Physical Data

The following table presents some of the key physical information for Lake Eastex.

Table IV.1
LAKE EASTEX PHYSICAL DATA

Contributing drainage area	391 sq. mi. (1)
Length	14 mi.±
Width	1.5 mi±
Surface area at normal pool	10,000 ac.±
Normal pool elevation	315.0 ft msl
PMF pool elevation	330.4 ft (2)
Dependable yield	85,507 ac-ft (3)
Storage volume at normal pool	187,839 ac-ft

Notes
(1) 107 sq. mi. of the total is controlled by Lake Tyler and Lake Tyler East
(2) PMF=Probable Maximum Flood, at this location, about 41 inches rainfall in 72 hours
(3) Includes a 100-year sedimentation allowance



LEGEND

COUNTY BOUNDARIES FOR STUDY AREA

0 5 10 20

GRAPHIC SCALE IN MILES

EXHIBIT IV.1

LOCATION MAP

LAKE EASTEX

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

Lockwood, Andrews & Newnam, Inc.

4. Lake Eastex Dam and Outlet Structures

The preliminary design for the Lake Eastex dam calls for an earth fill design with an impervious clay core and cut-off trench designed to prevent seepage. Erosion protection for the dam face will be provided by a soil cement layer. Stabilizing berms for about 1500 feet of the length of dam are expected. A pictorial description of the dam is presented on Exhibits IV.2 through IV.6. Key dimensions are presented in Table IV.2.

Table IV.2
LAKE EASTEX DAM DIMENSIONS

Height above natural ground	65 ft.
Maximum Elevation	336 ft.
Length	6600 ft.
Service Spillway	
Length	300 ft.
Elevation	315 ft.
Emergency Spillway	
Length	1500 ft.
Elevation	320 ft.
Outlet Works	2-48" pipes

The service spillway is an uncontrolled weir sized to pass the 50-year storm event. Larger storm events will pass through both service and emergency spillways.

The outlet works, shown in Exhibit IV.7, consists of two 48-inch diameter conduits through the embankment with a stilling basin on the discharge end. The flowline elevation for the inlet structure is 267.5 feet. The inlet structure contains a total of three gates with centerline elevations of 270, 295, and 310, respectively, for selected releases.

Estimated costs for the construction of the Lake Eastex dam are presented in Table IV.3.

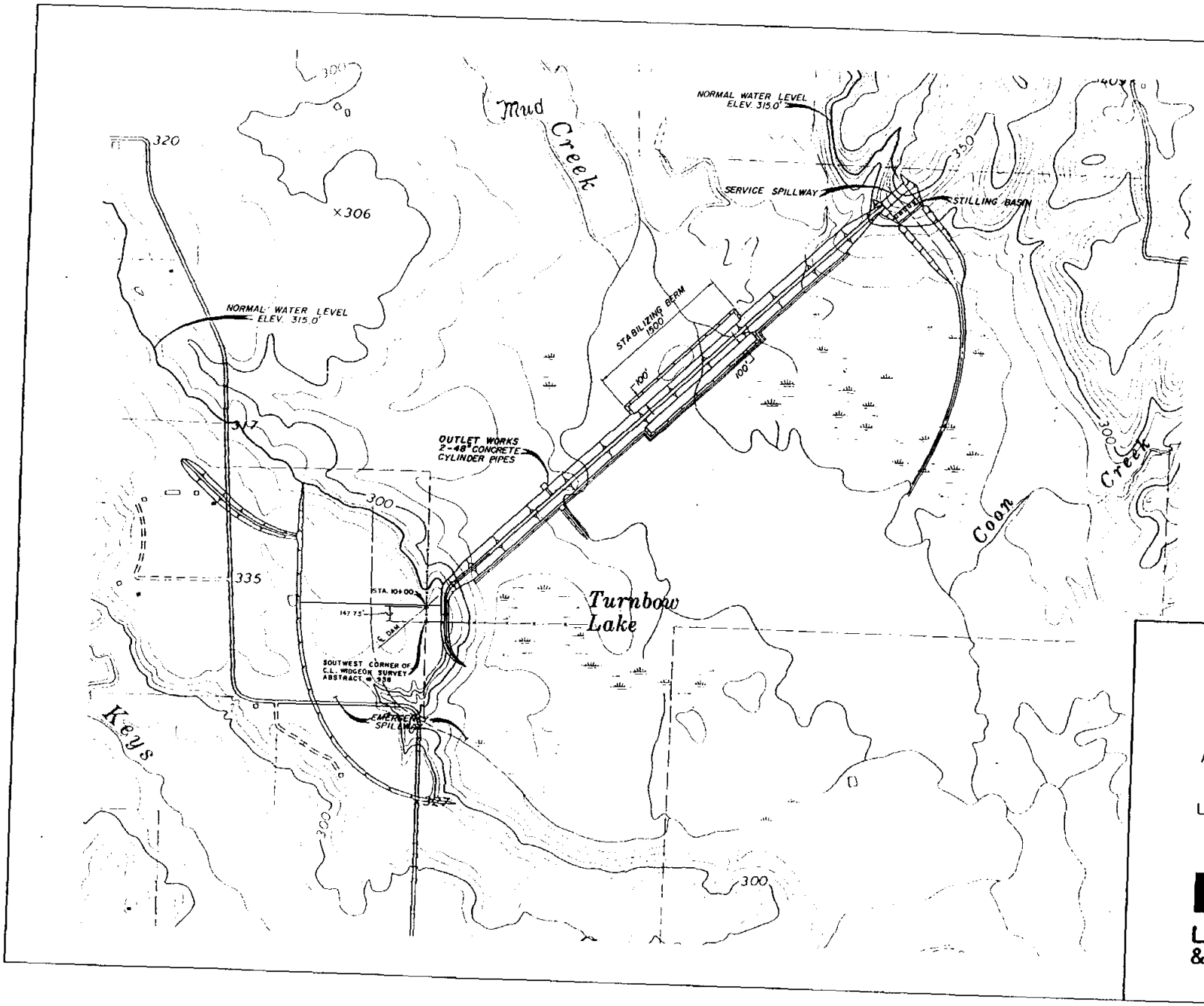


EXHIBIT IV.2

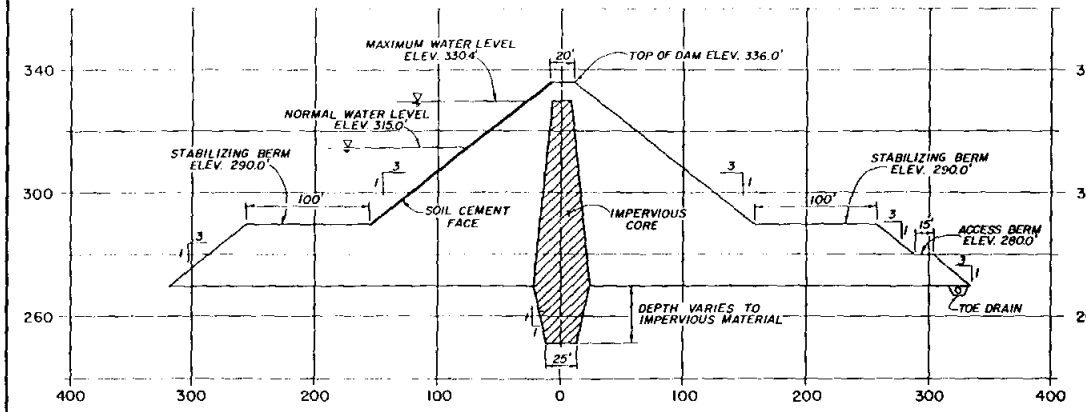
LAYOUT OF DAM

LAKE EASTEX DAM

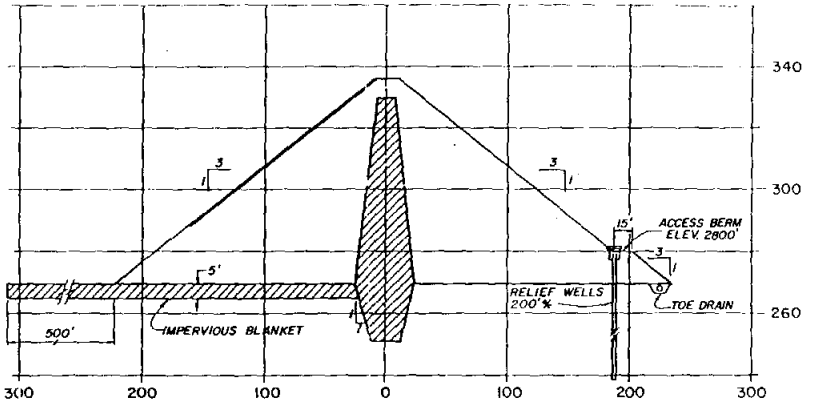
ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

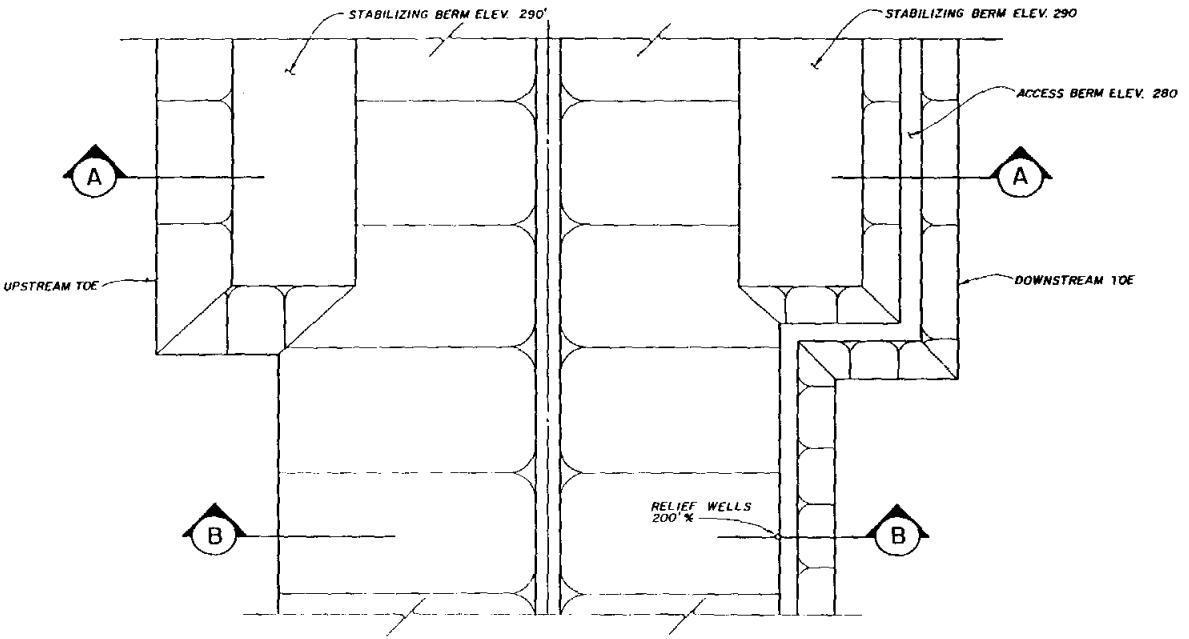
Lockwood, Andrews & Newnam, Inc.



A DAM SECTION



B DAM SECTION



PLAN VIEW PORTION SHOWING BERM ORIENTATION

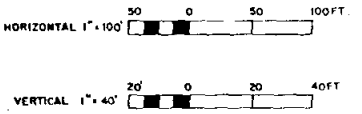


EXHIBIT IV.3

CROSS SECTION AND PLAN PORTION

LAKE EASTEX DAM

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

Lockwood, Andrews & Newnam, Inc.

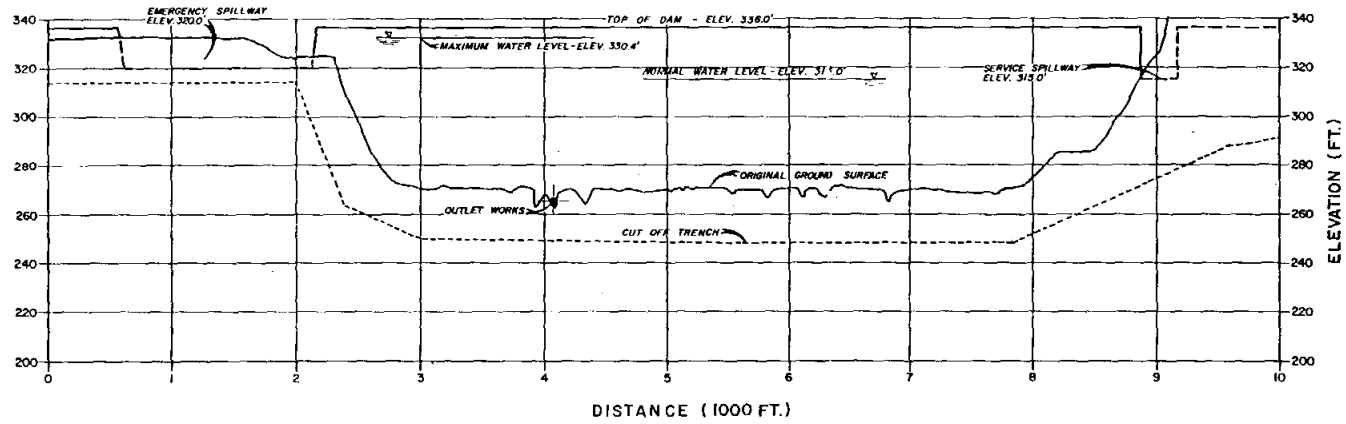


EXHIBIT IV.4

CENTERLINE PROFILE

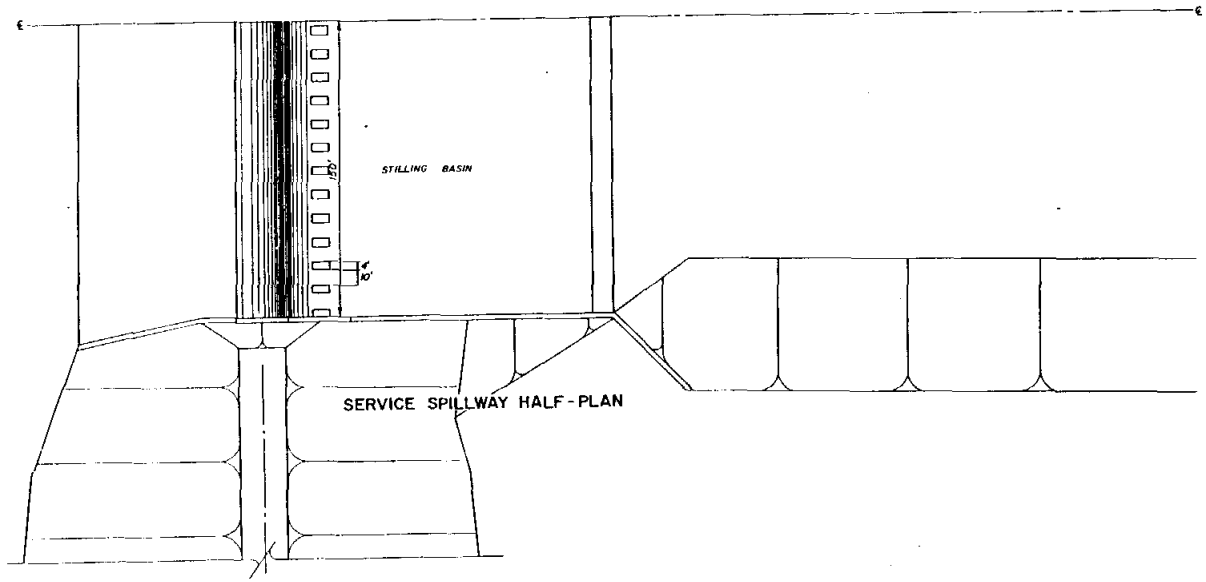
LAKE EASTEX DAM

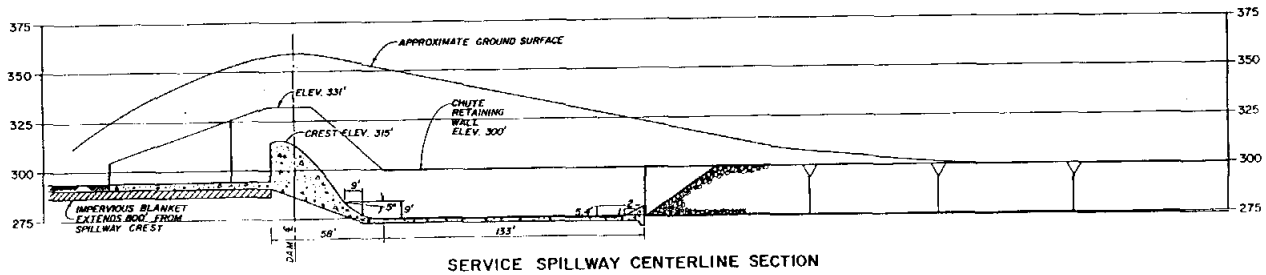
ANGELINA AND NECHES
RIVER AUTHORITY

LAKE EASTEX REGIONAL
PLANNING STUDY

Lockwood, Andrews
& Newnam, Inc.

25 0 25 50FT





SERVICE SPILLWAY CENTERLINE SECTION

EXHIBIT IV.5

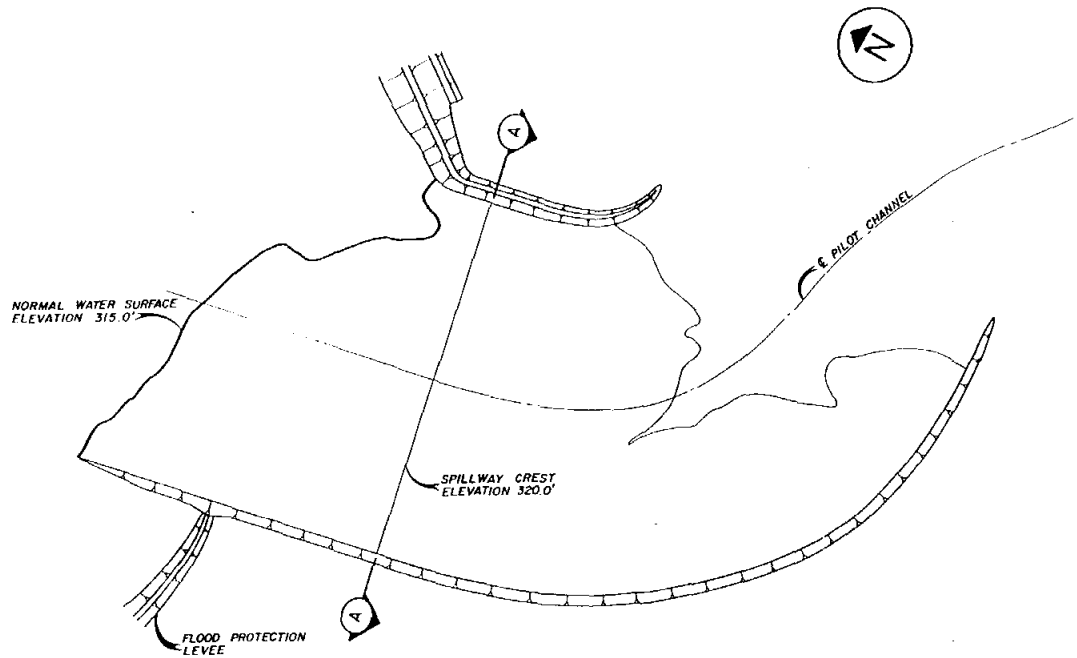
SERVICE SPILLWAY

LAKE EASTEX DAM

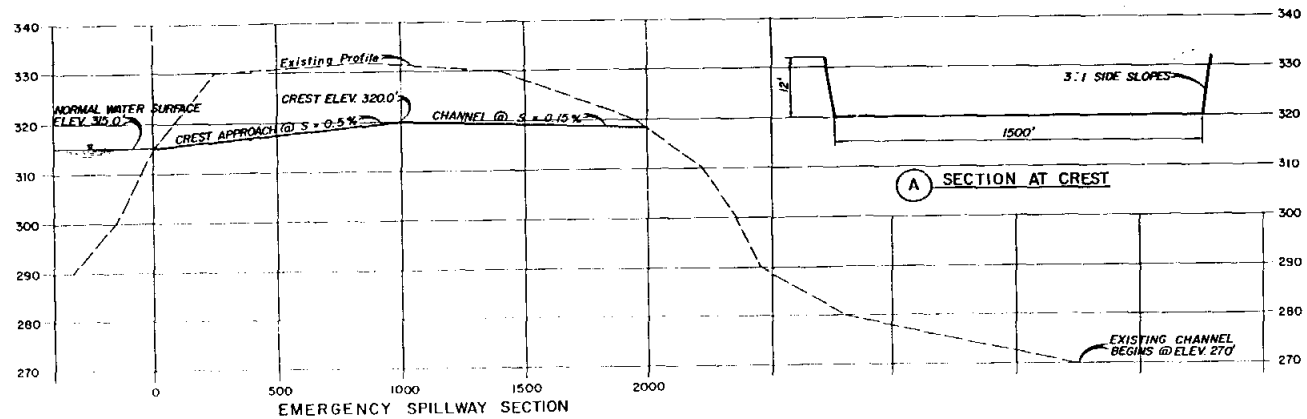
ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

Lockwood, Andrews & Newnam, Inc.



EMERGENCY SPILLWAY PLAN



EMERGENCY SPILLWAY SECTION

HORIZONTAL 200 0 200 400FT

VERTICAL 10 0 10 20FT

EXHIBIT IV.6

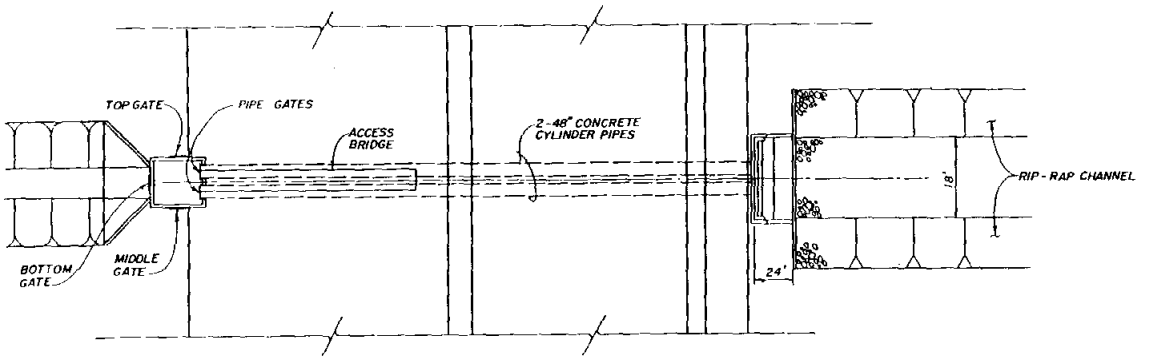
EMERGENCY SPILLWAY

LAKE EASTEX DAM

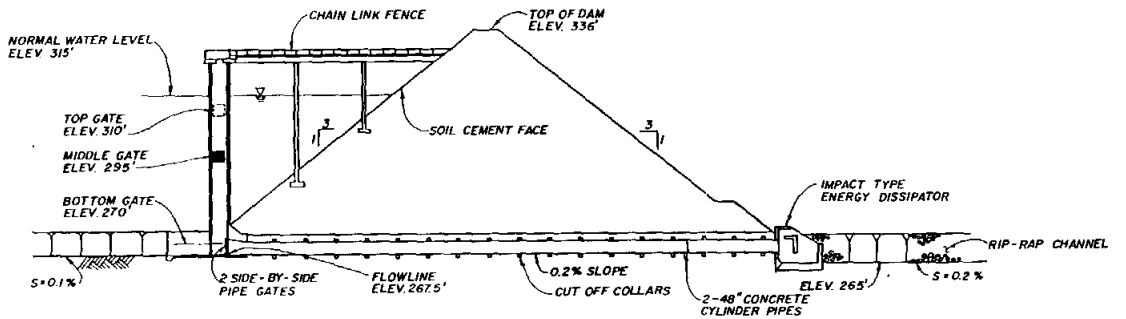
ANGELINA AND NECHES
RIVER AUTHORITY

LAKE EASTEX REGIONAL
PLANNING STUDY

Lockwood, Andrews
& Newnam, Inc.



PLAN OF OUTLET WORKS



OUTLET WORKS SECTION

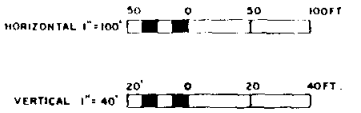


EXHIBIT IV.7

OUTLET WORKS

LAKE EASTEX DAM

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

Lockwood, Andrews & Newnam, Inc.

Table IV.3
DAM CONSTRUCTION COST ESTIMATE

Component	Cost
Embankment	$10,707,000
Spillway	4,222,000
Outlet Works	400,000
Outfall Channel	813,000
Site Work	650,000
Subtotal	$16,792,000
Engineering and Contingency (25%)	4,198,000
TOTAL	$20,990,000

5. Lake Eastex Operation

A reservoir operation model was developed in order to determine the dependable yield of the proposed reservoir. The model included the following major components:

a. Historical inflows between 1940 and 1979 adjusted to reflect changes that have occurred within the basin

b. The maximum allowable diversion from Lake Tyler and Lake Tyler East

c. Historical evaporation rates

d. Area - capacity relationship developed from topographic maps with 10-foot contour intervals (Exhibit IV.8)

e. An estimate of the sedimentation volume expected to occur within the normal pool during a project life of 100 years

The model results indicate that the dependable yield for the Lake Eastex Reservoir based on a conservation pool elevation of 315 and a storage volume of 187,839 acre-feet is 85,507 acre-feet/year.

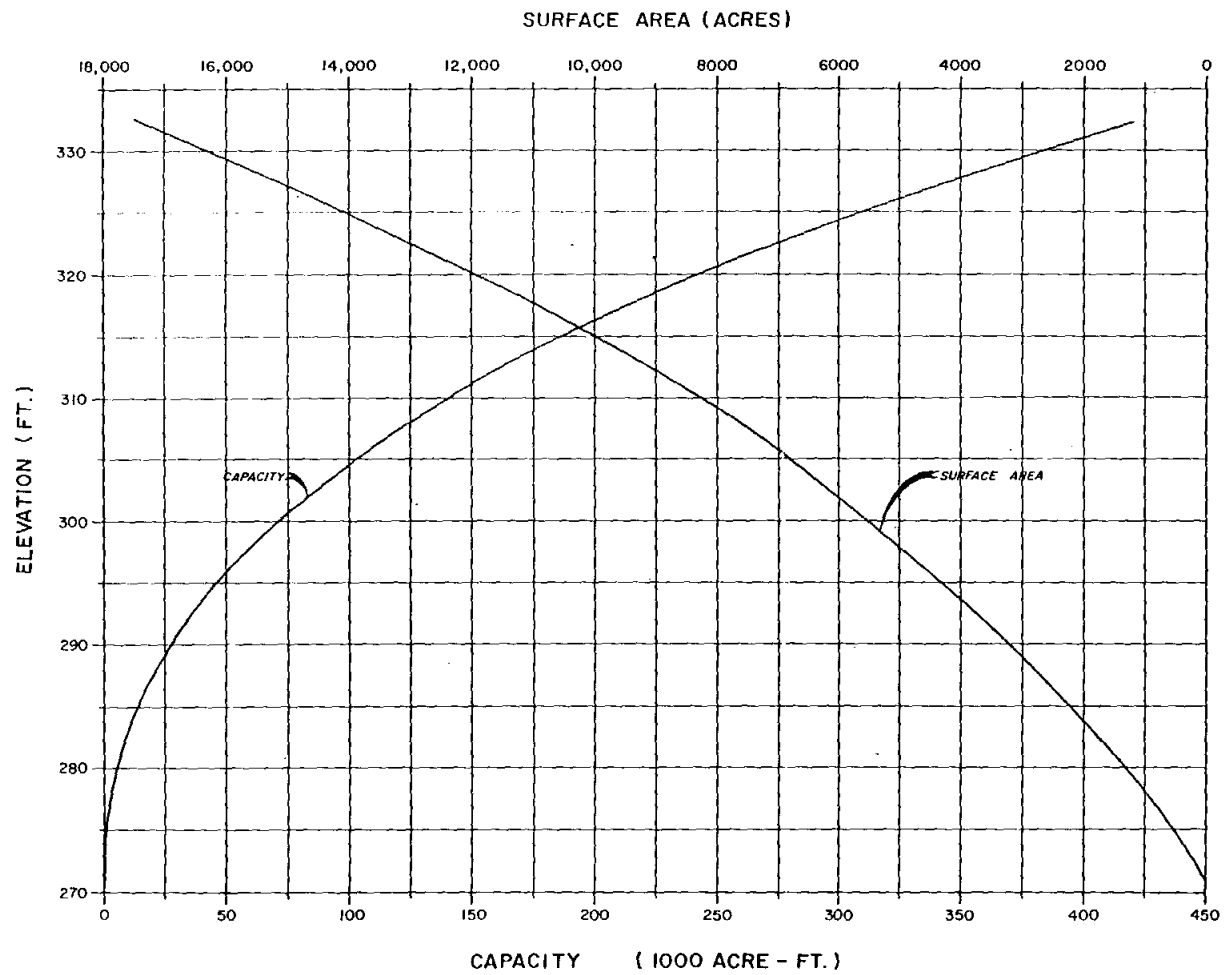


EXHIBIT IV.8

AREA - CAPACITY CURVES

LAKE EASTEX

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

Lockwood, Andrews & Newnam, Inc.

B. RESERVOIR CONFLICTS

1. Introduction

In any construction project of this magnitude, there will be conflicts with existing roadways and utilities which will require modification, as well as large quantities of land to be acquired. In the preliminary phase of this project, several major conflicts were identified from U.S.G.S. maps and State Department of Highways and Public Transportation (SDHPT) county road maps. An item was considered in conflict if the reservoir will interfere with its normal operation. Additional potential conflicts have since been identified through field investigations and through meetings with other owners of utilities already identified as being in conflict. These conflicts include state highways, county roads, power lines, telephone cables, oil and gas wells and related pipelines. Exhibits IV.9 and IV.10 show the present location of each conflict.

All owners of facilities having potential conflicts with the reservoir were contacted and asked to provide information regarding the most cost effective method to rectify the conflict. Each estimate was then reviewed for reasonableness of approach to insure the proposed modification and associated costs were necessary and appropriate. The costs presented in this section are provided for planning purposes and are not intended to be final estimates. The cost estimates for resolution of the following described conflicts are shown in Table IV.4.

2. State and Federal Highways

The State and Federal highway crossings were evaluated using the SDHPT criteria as follows:

a. Bridges should have a low chord elevation three feet above the highest of the following:

- The 50-year reservoir pool elevation.
- The 50-year tributary backwater elevation.

b. The bridge should be of adequate length to pass the 50-year frequency storm discharge.

c. The embankment elevation, measured at the low point of the shoulder, should be set at a minimum of three feet above the controlling water surface elevation cited above.

d. Riprap is required for slope protection against wave action.

There are seven highways which traverse the PMF line, either within the reservoir main body or its tributaries, for a total of ten crossings. Three of these crossings are outside the

50-year reservoir pool elevation and were evaluated for height and capacity requirements. It does not appear that any will be significantly impacted by the 50-year frequency storm backwater from the lake pool. Three crossings were within the 50-year reservoir pool elevation. After evaluating these highways using the above criteria, it was found they have sufficient capacity and elevation to pass the 50-year storm discharge. The only modifications required to these highways will be riprap on the embankment within the 50-year reservoir pool.

Four crossings will require major modifications to meet the SDHPT criteria: U.S. Highway 79, F.M. 2064, F.M. 2750, and State Highway 135. The most critical of these is U.S. Highway 79 at Mud Creek which crosses the reservoir approximately 2.5 miles upstream of the dam. The most economical structure is a bridge approximately 5000 feet long with a low chord elevation 15 feet above normal pool elevation. An allowance was made for boat traffic for larger boats, sailboats, and smaller boats during higher lake levels by assuming a total of 21 feet of clearance through the middle spans of the bridge.

Another highway requiring major modifications is F.M. 2064 at Mud Creek. It is proposed to be rerouted along the high peninsula on the east side of the reservoir along with the Missouri-Pacific Railroad. The relocation is necessary to reduce the length of elevated crossing. The optimal structural length is approximately 780 feet with a low chord elevation 15 feet above normal pool elevation to allow for boat traffic.

To reduce project costs, the option to abandon F.M. 2064 is being pursued. Presently, there are two major routes connecting the City of Jacksonville to the City of Troup, State Highway 135 and F.M. 2064. Considering this redundancy and the cost impact of modifying both routes to keep them in service, it is felt that adequate regional mobility can be maintained through the abandonment of one of these. The cost to relocate F.M. 2064 is approximately 2.4 times more than the cost to modify State Highway 135. The abandonment of F.M. 2064 could result in a project cost savings of approximately $9 million. Coordination efforts with the SDHPT indicate that a strong demonstration of local support for the abandonment of FM 2064 by Cherokee County (possibly in the form of a resolution) would substantially improve the probability of obtaining SDHPT approval.

The other highways requiring significant modification are State Highway 135 and F.M. 2750. These crossings will be raised eight and twelve feet, respectively, using embankments. Bridge openings will also be enlarged to enable passage of the 50-year frequency storm runoff.

3. County Roads

Cherokee County maintains several roads that will be inundated by the normal pool of the reservoir. A few of these will be relocated or raised as needed to maintain access for landowners and to provide flood travel routes for the area. Roads which will be relocated are Precinct 1 CR, CR 4227, and CR 4224. Portions of some roads are proposed to be abandoned in place, as follows: CR 4301, CR 4222, CR 4223, and CR 4905.

In Smith County, CR 2138, crosses a narrow finger of the reservoir at its extreme northern end. The bridge is currently under design for a federal bridge rehabilitation project. The proposed elevation will be adequate to pass the 25-year frequency discharge as required by Smith County; therefore, no modification will be necessary. No other Smith County roads are in conflict.

4. Railroad

The Union-Pacific Railroad crosses the reservoir in two locations. The Jacksonville-Troup leg roughly parallels F.M. 2064. It will be relocated along the high peninsula on the east side of the reservoir along with F.M. 2064 and will generally follow the same alignment. The new alignment will require approximately three miles of new track. Preliminary estimates indicate that it may be economically desirable to locate the railroad and the highway on the same embankment. If F.M. 2064 is abandoned, the railroad will not be affected. It will be realigned as explained previously. The Whitehouse - Troup leg crosses the PMF flood elevation of the reservoir at the far north end. It is outside the 50-year pool elevation; therefore, no modifications will be necessary.

5. Electric Power Lines

There are several power distribution lines and several high-voltage transmission lines that will be split by the proposed reservoir. Southwestern Electric Service Company has four lines that will need modification. Two six-inch conduits will be placed on the state highway bridges, one along U.S. 79 and one along F.M. 2064. If F.M. 2064 is abandoned the conduit could be placed on the railroad bridge if railroad officials approve. One distribution line will be relocated along the southwest part of the lake with unneeded portions being removed. Their existing high-voltage transmission line will be raised on steel poles placed upon concrete footings to provide flood protection.

Texas Power and Light has three high-voltage transmission lines which cross the body of the proposed lake. All three lines will be raised on steel towers placed upon concrete footings.

Cherokee County Electric Cooperative Association will need to relocate several distribution lines and retire lines that are no longer necessary. Two lines which will cross the proposed lake will be buried.

6. Oil and Gas Pipelines and Wells

There are a significant number of oil and gas wells in the northern vicinity of the reservoir that will require coordination with several companies. TXO Production Corporation owns two active wells located on the perimeter of the PMF line. The reservoir should not interfere with their normal operation. Exxon Company, U.S.A. owns one active well that will be submerged by the proposed reservoir and one active well on the perimeter of the PMF floodplain. The estimated remaining life of the well that will be submerged is eight years. Since

the proposed reservoir is scheduled to be completed and filled in 10 years, the reservoir will have no affect on the well since it will be out of service by that time. The proposed reservoir will also have no affect on the normal operation of the Exxon well located along the perimeter of the PMF floodplain.

There are thirteen active pipelines which presently cross the proposed Lake Eastex site. Two transmission lines owned by TXO Production Corporation pass only through the PMF floodplain and no modifications will be necessary. A single pipeline operated by Texlan Oil Company crosses the northern tip of the proposed reservoir. This line is a three inch low pressure line buried six feet below grade, and Texlan has indicated they will not require any modifications. If, at a later date, Texlan feels modifications to this line are necessary, they plan to insert a two inch line into the existing three inch line to assure structural integrity.

Delhi Gas Pipeline Company and United Gas Pipe Line Company each own three pipelines which cross the normal pool elevation of the proposed Lake Eastex. Delhi proposes to modify their 4-, 6- and 8-inch lines by placing concrete saddle weights on the lines to offset buoyancy when submerged. United Gas proposes to relocate a portion of its 6-inch line and replace their two 8-inch lines with heavier pipe. They will also loop their 8-inch transmission line to ensure service at all times.

Exxon Company, U.S.A., Exxon Pipeline Company and ARCO Pipe Line Company each own a pipeline which cross the proposed reservoir site. These lines are 3, 8 and 12 inches in diameter, respectively. The companies propose to replace each pipeline in a casing at a greater burial depth.

Valero Transmission has recently constructed a 30-inch natural gas pipeline from New Bethel to Carthage which crosses the proposed reservoir site. Modification required due to the inundation of the line may consist of anchoring the pipeline approximately every 70 feet to resist buoyant forces. The proposed anchoring, if required, will take place just prior to inundation by the lake.

7. Telephone Cables

There are five underground cables that traverse the body of the reservoir. The MCI cable, which presently shares the Union-Pacific Railroad (Jacksonville - Troup leg) right-of-way, will be relocated along with the railroad. It will also be weighted to prevent buoyancy. The other crossings are owned by United Telephone System. One could be abandoned in place, and the remaining three could be modified, but stay in their present location. Modifications may include burying the cable deeper than at present in "submarine cables."

8. Conflict Cost Estimates

Table IV.4 summarizes costs associated with each of the conflict categories as described above. These costs include engineering, labor, material, and any additional required right-of-way.

Table IV.4
CONFLICT RESOLUTION COST ESTIMATE

Component	Cost
State and Federal Highways	$26,595,000
County Roads	$ 1,478,000
Railroad	$ 4,905,000
Electric Power Lines	$ 4,532,000
Oil and Gas Pipelines and Wells	$ 2,103,000
Telephone Cables	$ 550,000
R/W Acquisition	$ 111,000
Subtotal	$40,274,000
Engineering and Contingency (25%)	$10,069,000
TOTAL	$50,343,000

9. Land Acquisition

The proposed Lake Eastex reservoir will affect approximately 15,000 acres of land in Cherokee and Smith Counties. There are a total of 416 tracts that will be affected with an average tract size of approximately 66 acres. Not all of these tracts will be bought by the ANRA in their entirety. The following criteria is suggested to guide the decision as to what land will be acquired:

a. Purchase of full fee title up to three feet above normal pool elevation, which is 3' + 315.0' = 318.0'. Title will be transferred to the ANRA.

b. Purchase of a flowage easement between elevation 318.0' and the 500-year flood elevation of 322.6'. Title will remain in original owner's name, but an easement will be recorded with the county. Development by the owner within this easement will be restricted.

c. For tracts which are only partially affected and if access to the remaining portion has been cut off by the reservoir, ANRA can pick the least expensive of the following two options:
   - provide access to remaining portion of tract.
   - purchase remaining portion of tract.

A Land Acquisition Plan has been developed and will be presented to the ANRA under a separate cover. The purpose of this plan is to establish a general procedure for the Angelina and Neches River Authority and its agents to follow for the purchase of property and flowage

easements. The plan explains of a series of interrelated tasks such as: management by an experienced land acquisition agent working on behalf of the Angelina and Neches River Authority, a title search to identify Deed of Record owners, a boundary identification and parcel map preparation by a surveyor, an appraisal for each property by an independent appraiser, negotiations for transfer of title and purchase of flowage easement, and condemnation procedures, if necessary. These land acquisition tasks and the estimated associated costs are given in Table IV.5.

Table IV.5

LAND ACQUISITION COSTS

Task	Cost
ANRA Program Management	$ 219,000
Title Search and Title Insurance	$ 424,000
Surveyor's Tasks	$ 743,000
Appraisal	$ 500,000
Negotiations	$ 312,000
Condemnation Costs	$ 377,000
Land Cost	$11,207,00
Subtotal	$13,782,000
Contingency (20%)	$ 2,756,000
TOTAL	$16,538,000

Preliminary time schedule estimates allow three and one-half years to acquire the tracts affected by the proposed reservoir. However, because of the interdependent nature of these land acquisition tasks, it should be noted that a delay in one segment of the process may delay subsequent tasks.

C. SYSTEM CONFIGURATION

1. Introduction

This section will describe the water system facilities and preliminary configuration designed to deliver treated water to the participants of this study. Participant demands which were used to develop the water systems will be presented. Along with the description of the water delivery system developed for Angelina County, it will be explained how the Angelina County Regional Water Study and its recommendations were incorporated into this planning

effort. Finally, estimates of the capital costs for the proposed delivery systems in 1990 dollars will be presented. A more detailed financial plan will be presented in a following section (Section V) which will take into account bond financing, interest rates, and inflation.

2. Development of Participant Demands

As stated in Section III.A, the high population, high per capita series water use projections developed by the Texas Water Development Board (TWDB) were used as the base for the projections developed in this study. Demand projections for each participant were estimated based on current water use information obtained from each participant or the TWDB projections for the water use category most comparable to each individual participant (i.e., for a rural water supply corporation the corresponding county rural projection curve was chosen). For cities with populations greater than 1000, the TWDB projections could be used directly. Although, in a case where a city served as the water supplier to a water supply corporation, the city's water use projection was adjusted to account for the additional demand. This approach assumes that the rural water supply corporations, after acquiring surface water rights, will pursue the utilization of the more economical regional delivery system, rather than a more costly individual system. Demands for each participant are presented in Table IV.6.

The water distribution systems which will be described later in this section were sized to deliver 100 percent of the participants' demands as presented above. This approach was taken in order to provide the participants with an economic comparison between the current cost of water from groundwater and/or surface water sources and the cost to convert totally to a Lake Eastex surface water supply. Exceptions to this are the participants located in Angelina County. The recently developed regional plan (EGA, 1990) for this county calls for initial total reliance on groundwater, with conversion to conjunctive use by 2010. The total demand of 46.73 million gallons per day in the year 2040, shown in Table IV.6, corresponds to about 52,340 acre-feet per year which is 61% of the annual firm yield from Lake Eastex.

3. Description of Delivery Systems

The goal for the development of the delivery systems was to minimize costs given the geographic constraints of the project participants. There are two main geographic clusters of participants; seventeen participants are located in Smith, Rusk and north Cherokee Counties and six participants are located in Nacogdoches, Angelina and south Cherokee Counties. Several grouping configurations were considered. A description of the evaluation of various configurations is presented in subsequent paragraphs. The resultant regional system to be served by Lake Eastex consists of four subsystems which can be summarized as follows:

Table IV.6

PROJECTED DEMANDS FOR PROJECT PARTICIPANTS
AVERAGE DAY PROJECTED DEMANDS IN MGD

Entity	2000	2010	2020	2030	2040
Angelina WSC[3]	0	0	0.04	0.12	0.17
City of Arp	0.23	0.26	0.30	0.35	0.37
Blackjack WSC	0.10	0.10	0.11	0.12	0.12
Cherokee County[2]	0	0	0	0	0
Leo F. Childs	0.08	0.08	0.08	0.08	0.08
Craft-Turney WSC	0.50	0.54	0.59	0.62	0.64
City of Henderson	2.78	3.03	3.32	3.63	3.87
Jackson WSC	0.28	0.32	0.37	0.43	0.45
City of Jacksonville	4.26	4.70	4.95	5.24	5.38
City of Lufkin[3]	0	0	0.97	2.58	3.79
City of Nacogdoches	9.86	11.36	12.87	14.29	15.05
City of New London	0.42	0.45	0.53	0.62	0.66
New Summerfield WSC	0.13	0.14	0.16	0.17	0.17
City of Overton	0.50	0.54	0.60	0.66	0.70
Redland WSC[3]	0	0	0.03	0.08	0.12
Reklaw WSC	0.05	0.06	0.06	0.06	0.07
City of Rusk	0.79	0.87	0.92	0.97	1.00
Star Mountain WSC	0.22	0.25	0.29	0.34	0.36
Temple-Inland, Inc.	9.19	9.19	9.19	9.19	9.19
City of Troup	0.41	0.46	0.50	0.55	0.59
Walnut Grove WSC	0.79	0.91	1.05	1.22	1.30
Woodlawn WSC[3]	0	0	0.03	0.09	0.13
Wright City WSC	0.45	0.51	0.59	0.69	0.73
Subtotal	31.04	33.77	37.55	42.10	44.94
Other Angelina Co. Regional System Demands	0	0	0.43	1.13	1.79
Total Demand on Lake Eastex	31.04	33.77	37.98	43.23	46.73

(1) As stated in section IV.C.2., the delivery systems for the participants have been sized to convey all of the year 2040 demands. This approach was taken in order to provide a consistent basis for economic comparison between current sources and a Lake Eastex supply. Exceptions have been noted.

(2) Cherokee County, as an entity, is not a water user and will not be diverting water out of Lake Eastex; therefore no demand is shown.

(3) This participant is also a participant or is recommended to be a participant in the Angelina County Regional System. Demand which is shown is the portion of the total demand which has been assumed as being supplied from Lake Eastex. Total 2040 demands which were used for sizing the Southern distribution system are as follows: Angelina WSC = 0.55 mgd, Lufkin = 11.81 mgd, Redland WSC = 0.37, and Woodlawn WSC = 0.40 mgd.

a. The northern distribution system consists of sixteen participants for which a new delivery system is proposed. These participants include the City of Arp, Blackjack WSC, Mr. Leo Childs, Craft-Turney WSC, City of Henderson, Jackson WSC, City of Jacksonville, City of New London, New Summerfield WSC, City of Overton, Reklaw WSC, City of Rusk, Star Mountain WSC, City of Troup, Walnut Grove WSC, and Wright City WSC.

b. The southern distribution system consists of four participants in Angelina County that have been considered, in this design, as participants in the Angelina County Regional System. These participants are Angelina WSC, City of Lufkin, Redland WSC, and Woodlawn WSC. Because there exists a plan for a proposed regional system in Angelina County, a new distribution system was not designed. Instead, an expansion which coordinates with the current plans for an Angelina County Regional System is proposed. The current regional plan in Angelina County proposes to use groundwater through the year 2010, but will need to be supplemented by surface water thereafter. For purposes of this study a system was designed which modifies the proposed regional system, planned to be in place in 2010, to receive additional water from Lake Eastex.

c. There are two participants, the City of Nacogdoches and Temple - Inland Forest Products, Inc. which are geographically separated from the previously described clusters of participants. Each of these participants will have individual facilities to supply their needs.

d. Cherokee County, as an entity, is not a water user. Therefore, no delivery system was designed. That portion of water which is reserved by Cherokee County will remain in the lake to be diverted at a later time if water rights are sold to a water user. The unit cost attributable to Cherokee County (presented later) will represent the cost for raw water only.

4. Analysis and Design Criteria

A pipe network was modeled for each of the distribution systems described above using the University of Kentucky "Computer Analysis of Flow in Pipe Networks" model. The model accounted for changes in elevation, high points between participants, and head loss due to friction in pipe segments. The model was used to determine general pump horsepower and pipeline diameter requirements in the system for cost estimating purposes. The systems presented are conceptual for planning purposes and are not intended to represent a final design. A more detailed design evaluation will be needed at the preliminary engineering and design stage.

The parameters that were used for modeling purposes are as follows:

a. Transmission lines are sized for peak day, average hour flow rates with a maximum target velocity of six feet per second.

b. The maximum allowable working pressure was held at 150 psi, except in one case in which it was judged that a short segment of high strength pipe would be less expensive than an additional pump station.

c. The target delivery pressure to the participant is thirteen pounds per square inch to enable the filling of a ground storage tank.

d. Pumping facilities are sized to handle peak day flow rates.

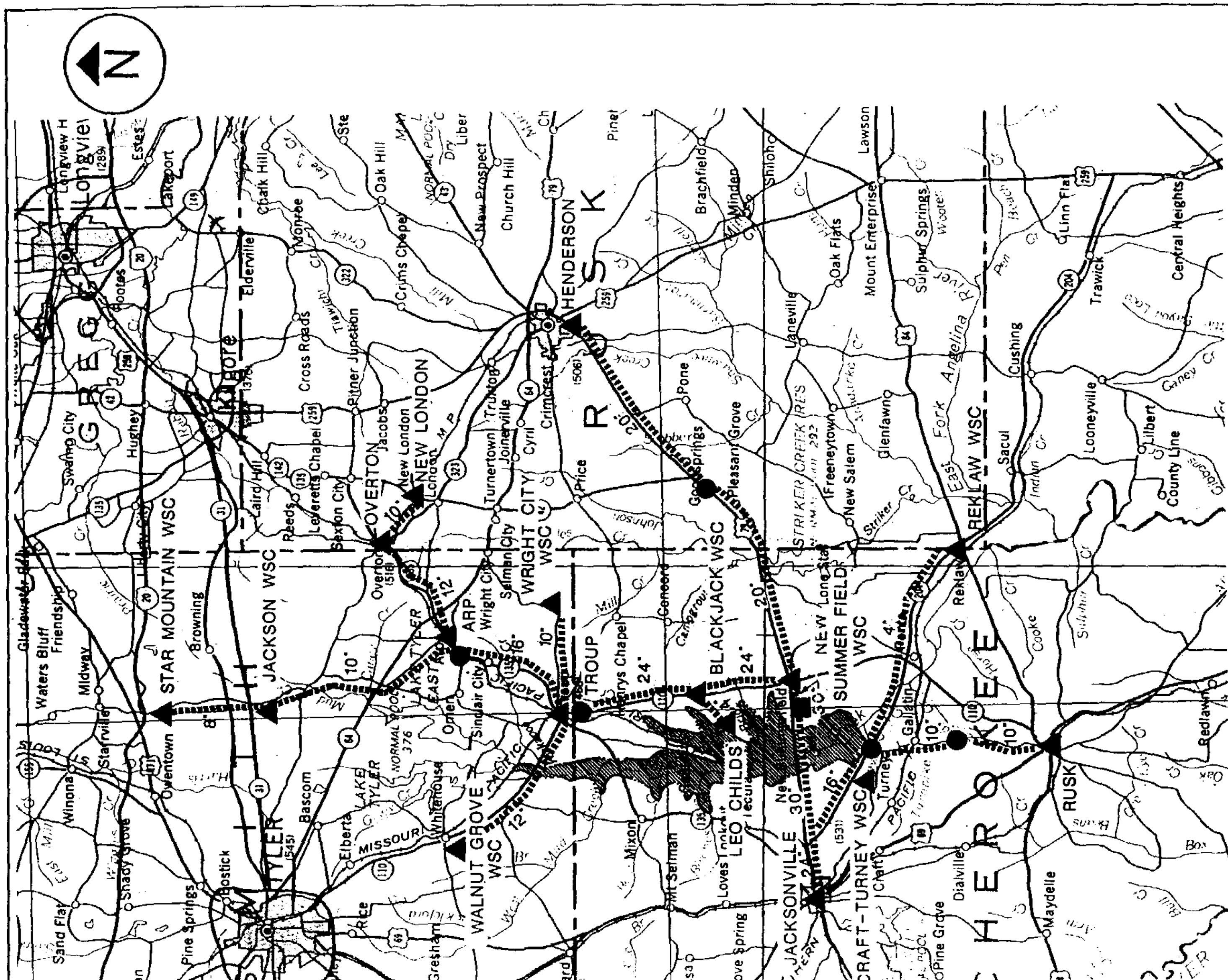
e. Treatment facilities are sized for average day flow rates with a peaking factor adequate to meet peak day demands.

5. Northern Delivery System

The northern distribution system supplies the sixteen participants listed previously. A survey of these participants indicated that they have historically experienced an peak day, average hour flowrate of 1.85 times the average day flowrate. This historical peaking factor was used to size the water distribution facilities. Several alternatives which considered number and placement of water treatment facilities along with associated piping systems and booster pump stations were investigated. The most economical alternative resulted in a single treatment plant located along Highway 79 on the east side of the lake approximately one mile west of New Summerfield. This facility location, along with the proposed piping system and booster pump stations is shown on Exhibit IV.11.

Phased construction of each of the major delivery system components was investigated and it was found to be advantageous to phase only the pumping facilities. The initial phase will consist of the ultimate capacity water treatment plant and transmission lines. Pumping facilities will have an initial capacity sufficient to meet 2020 demands. The initial facilities are proposed to be on line when the reservoir is sufficiently full to begin producing water, estimated to be about 1999. The second phase construction will take place in the year 2020 and will consist of expansion of the pumping facilities to meet 2040 water demands.

The total capital cost for the initial phase facilities is approximately $50,099,000. Improvements which are required for the second phase include additional pumping capacity. The capital cost associated with these improvements is $841,000. Table IV.7 shows a cost summary for the treatment and delivery system components.



LEGEND

▲ PARTICIPANT

■ PROPOSED WATER TREATMENT PLANT

● PROPOSED BOOSTER PUMP STATION

PROPOSED PIPE ROUTE

0 20 40 60 MILES

GRAPHIC SCALE

EXHIBIT IV.11

SYSTEM CONFIGURATION

NORTHERN DISTRIBUTION SYSTEM

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

Lockwood, Andrews & Newnam, Inc.

Table IV.7

CAPITAL COST FOR NORTHERN DISTRIBUTION SYSTEM

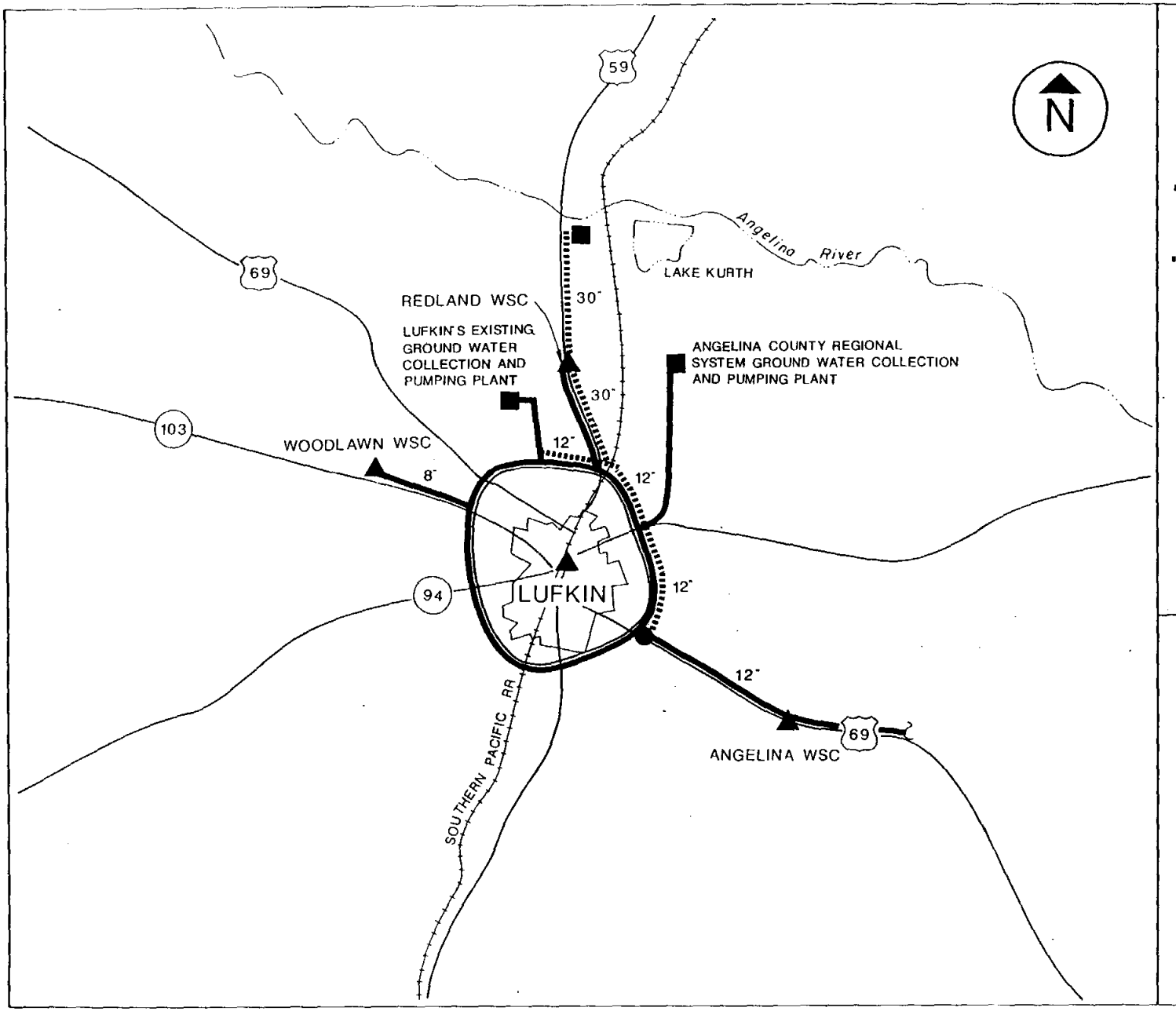
Component	Initial Phase	Second Phase
Intake and Pumping Facilities	$ 5,324,000	$673,000
Water Treatment Plant	$12,115,000	
Transmission Lines	$22,640,000	
Subtotal	$40,079,000	$673,000
Engineering & Contingency (25%)	$10,020,000	$168,000
TOTAL	$50,099,000	$841,000

6. Southern Delivery System

The southern distribution system supplies four participants, all located in Angelina County. They are Angelina WSC, City of Lufkin, Redland WSC, and Woodlawn WSC. A survey of these participants showed a peak day, average hour flowrate of 1.80 times their average day flowrate. This peak factor was used to size the water distribution facilities.

In the development of the delivery system to supply water from Lake Eastex to the participants in Angelina County, it was noted that two of the participants, Redland WSC and the City of Lufkin, are participants in the Angelina County regional plan. Although the Angelina WSC and the Woodlawn WSC are not currently participants in the regional plan for Angelina County, the delivery system for each of these four participants, was configured and phased consistent with that plan. This approach included slight modifications to the Angelina County regional system, as currently proposed, to allow for service to the two additional entities (Exhibit IV.12). These modifications include an eight-inch line, instead of the originally proposed six-inch line, from the proposed primary loop around Lufkin to serve the Woodlawn WSC and a short eight-inch line from the Angelina WSC to tie-in with the twelve-inch line along Highway 69. The primary reasons for this approach are presented below:

a. Two of the four participants are currently participants in the Angelina County regional plan. One of these, the City of Lufkin, represents by far, the greatest demand of the four participants in this study.



LEGEND

- PARTICIPANT
- WATER TREATMENT PLANT
- BOOSTER PUMP STATION
- PORTION OF ANGELINA COUNTY REGIONAL SYSTEM WITH 2010 CAPACITY
- PROPOSED PIPE ROUTE FOR ADDITIONAL CAPACITY FOR 2040 DEMANDS

0 45 90 135 MILES

GRAPHIC SCALE

EXHIBIT IV.12

SYSTEM CONFIGURATION

SOUTHERN DISTRIBUTION SYSTEM

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

Lockwood, Andrews & Newnam, Inc.

b. By contract, this study has been directed to coordinate closely with the Angelina County Regional Water Study and present results consistent with its concepts.

c. The evaluation of surface water alternatives (Section III.B) indicated that utilization of the concepts of the Angelina County regional plan could provide economic benefits to the study area, and particularly Angelina County.

d. An economic comparison between plans to deliver Lake Eastex water to the Angelina WSC and the Woodlawn WSC indicated that participation in the regional plan would be less expensive than obtaining Lake Eastex water through an independent system serving these two entities alone.

The economic comparison, described in paragraph d. above, involved the development of a delivery system which would divert Lake Eastex water from the Angelina River near U.S. Highway 59, treat the water in a proposed new facility, and deliver the water through a transmission pipeline to each of these participants. The unit costs, which result from this delivery system configuration are shown in Table IV.8. Unit costs for an independent delivery system greatly exceed the cost of participation in the Angelina County regional system which ranges from $1.35 to $2.63 per 1000 gallons (for current Angelina County participants), depending on location and contract amount.

Table IV.8

UNIT COST SUMMARY FOR ANGELINA WSC AND WOODLAWN WSC INDEPENDENT SYSTEM ($/1000 Gal.)

Participant	Raw Water Cost	Delivery System Cost	Total Cost
Angelina WSC	0.45	3.10	3.55
Woodlawn WSC	0.45	2.92	3.37

For a detailed description of the regional system the reader is referred to the Angelina County Regional Water Study, June 1990, prepared by Everett Griffith, Jr. & Associates Inc. The regional system described in this report proposes the use of groundwater until approximately 2010. The improvements described below represent only those items necessary to expand the proposed 2010 regional system to a 2040 demand capacity and transmission facilities to deliver surface water from Lake Eastex, via the Angelina River, to the Regional System. Exhibit IV.12 shows the primary components of the Angelina County regional system along with the additional improvements needed to expand the 2010 system to 2040 capacity. The improvements include a six million gallon per day water treatment plant located in the vicinity of Highway 59 and the Angelina River, a raw water intake structure and pumping facilities at the river, and approximately 14 miles of additional pipeline. These system components would be part of a

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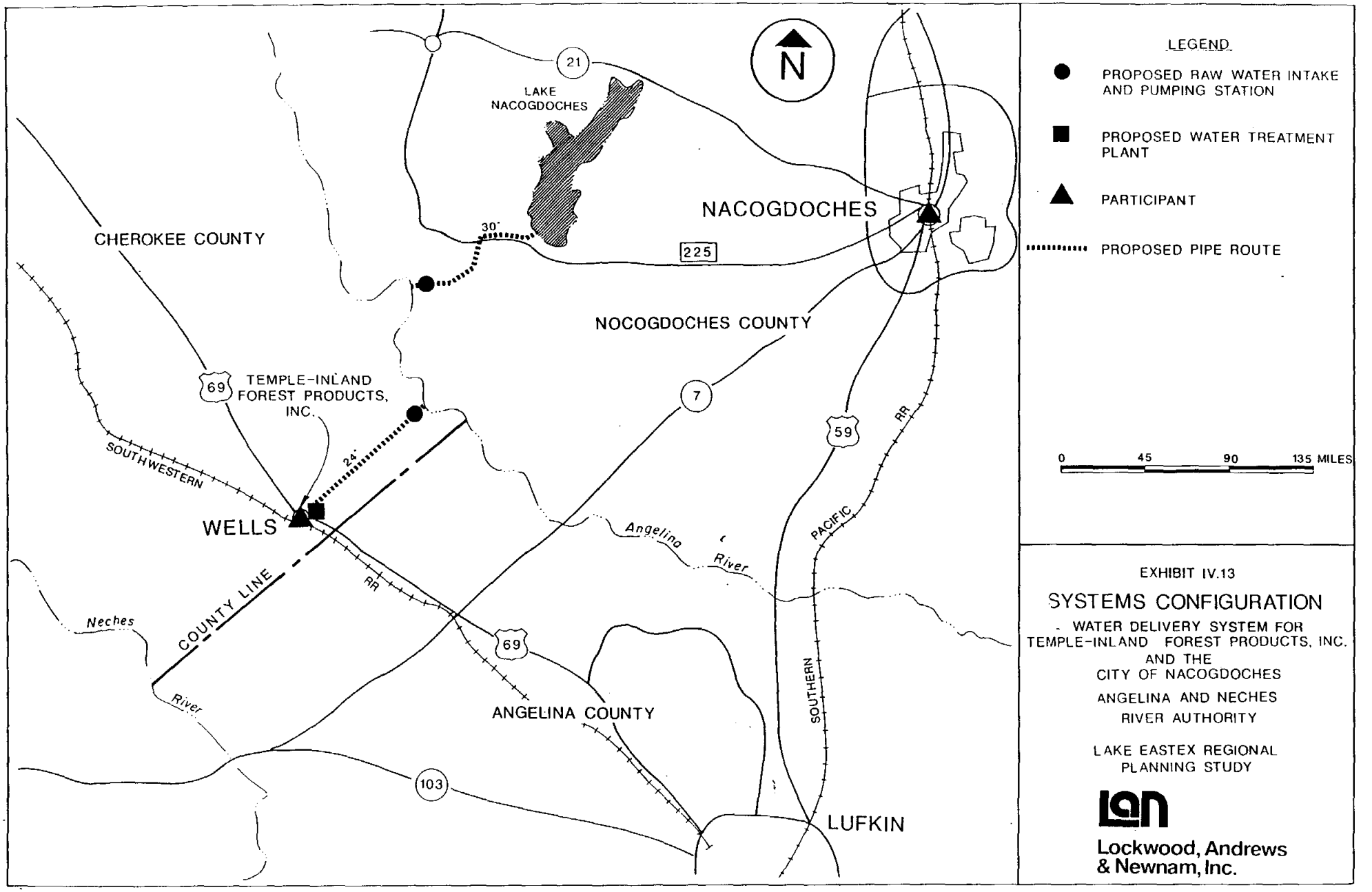

EXHIBIT IV.13

SYSTEMS CONFIGURATION

WATER DELIVERY SYSTEM FOR TEMPLE-INLAND FOREST PRODUCTS, INC. AND THE CITY OF NACOGDOCHES

ANGELINA AND NECHES RIVER AUTHORITY

LAKE EASTEX REGIONAL PLANNING STUDY

Lockwood, Andrews & Newnam, Inc.

Table IV.10

CAPITAL COST FOR WATER DELIVERY SYSTEM TO TEMPLE-INLAND

Component	Cost
Intake Structure/Pumping Facilities	$ 1,312,000
Water Treatment Plant (9.2 mgd)	$ 7,873,000
Transmission Lines	$ 1,320,000
Subtotal	$10,505,000
Engineering & Contingency (25%)	$ 2,626,000
TOTAL	$13,131,000

8. City of Nacogdoches Delivery System

Of all the participants in this study, only the City of Nacogdoches requested delivery of raw water. Like the Temple-Inland delivery system, the Angelina River was used as the major conveyance facility. Improved facilities will take water from the Angelina River approximately 39 river miles downstream of the Lake Eastex dam and deliver raw water to Lake Nacogdoches. The City of Nacogdoches presently has facilities to treat water from Lake Nacogdoches and deliver it to the City. Facilities for this system, as shown in Exhibit IV.13, will include an intake and pumping structure plus approximately 21,000 feet of 30-inch transmission pipeline. A cost estimate for these facilities is given in Table IV.11.

LIST OF REFERENCES

Cherokee County Appraisal District
1989 Cherokee County Land Appraisals, Rusk.

Everett Griffith, Jr. & Associates, Inc.
1990 Angelina County Regional Water Study, Lufkin.

Lockwood, Andrews & Newnam, Inc.
1984 Engineering Report on Eastex Reservoir, Angelina and Neches River Authority, Lufkin.

Texas Water Development Board
1989 Water Use Projections, High Series (Preliminary), Austin.

Woods, D. J. Ph.D.
1985 Computer Analysis of Flow in Pipe Networks Including Extended Period Simulation, University of Kentucky.

V. PROJECT FINANCING

V. PROJECT FINANCING

A. INTRODUCTION

This section of the regional water supply planning study report presents a financial model for the development of Lake Eastex. Presented are the total project cost components, the determination of an annual cost for the lake and related delivery system facilities, and the determination of unit costs for water to each of the project participants.

B. PROJECT COSTS

The costs associated with the development of the Lake Eastex project are divided into two categories in order to identify and present the cost of raw water in the lake and the cost associated with the treatment and delivery systems. Additionally, in recognition of the uncertainty of future events which could impact the cost of the project, several cost alternatives have been provided. These alternatives have been developed around two major variables in the previously identified project cost components. First, the abandonment of FM 2064 across the reservoir has been, and is being, pursued as a cost reduction measure. Replacement costs for this one facility alone are approximately $9.1 million dollars, including construction, engineering and contingencies. Because this is viewed as a reasonable alternative and since a final decision has not been reached, estimates are included with and without these costs. Secondly, the cost estimates were developed allowing for some variability in the environmental mitigation costs. This approach was taken due to the preliminary nature of much of the environmental investigations and in recognition that the final requirements will be determined during the federal permitting process. Therefore, two estimates for environmental mitigation costs are presented. One estimate is based on mitigation requirements which might reasonably be expected using other recent and similar projects as a guideline. This represents the most reasonably anticipated cost impact due to environmental mitigation. A second alternative is also presented which assumes less significant environmental impact and therefore less stringent mitigation requirements. This estimate should be considered as an absolute best case in terms of cost impact due to environmental mitigation. The cost alternatives which have been utilized in the plan of financing are summarized below.

Alternative I - includes reasonably anticipated environmental mitigation requirements and assumes that FM 2064 must remain in service and be relocated.

Alternative II - includes reasonably anticipated environmental mitigation requirements and assumes that FM 2064 can be abandoned in place.

Alternative III - assumes "best case" environmental mitigation requirements and assumes that FM 2064 must remain in service and be relocated.

Alternative IV - assumes "best case" environmental mitigation requirements and assumes that FM 2064 can be abandoned in place.

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Cost estimates presented in previous sections of the report have included the more reasonably anticipated mitigation allowance and have been based on the assumption that FM 2064 will need to be relocated. The additional cost alternatives have been provided here to help define practical limits to the range of estimated costs. The primary cost components and the estimated cost for each alternative utilized in the plan of financing are presented in Table V.1.

Table V.1

LAKE EASTEX PROJECT COST SUMMARY

Construction of the Reservoir				
Component	Alternative I	Alternative II	Alternative III	Alternative IV
Dam	$20,990,000	$20,990,000	$20,990,000	$20,990,000
Conflict Resolution	50,343,000	41,224,000	50,343,000	41,224,000
Land Acquisition	16,538,000	16,538,000	16,538,000	16,538,000
Mitigation Allowance	15,322,000	15,322,000	6,605,000	6,605,000
Total	$103,193,000	$94,074,000	$94,476,000	$85,357,000

Construction of the Delivery Systems		
System	Initial Phase	Second Phase
Northern	$50,099,000	$ 841,000
Southern	See Note (1)	8,115,000
Temple-Inland	13,131,000	
Nacogdoches	4,733,000	
Total	$67,963,000	$8,956,000

(1) The costs given for the Southern System are for the facilities required to deliver treated water from Lake Eastex to an existing (in year 2010) Angelina County regional water system. Therefore, they have been shown as a second phase cost.

C. PLAN OF FINANCING

1. Introduction

This section presents the plans for financing the reservoir and the transmission and treatment facilities. The financing alternatives are based on capital cost estimates as shown in Table V.1, above, and additional financing assumptions as described below.

The financing alternatives are divided into two sections. The first section presents the financing alternatives for the reservoir, and the second section presents the plan of financing for the transmission and treatment facilities. Each section contains a description of the financing methodology, a summary of alternatives, and a summary of assumptions.

2. Reservoir Financing

It is assumed that the design, acquisition, financing and construction of the reservoir are to be funded from the proceeds of contract revenue bonds issued by the Angelina & Neches River Authority (ANRA) on behalf of various participants as described in this study, and resources from the Texas Water Development Board (TWDB). The Bonds are to be supported by contract revenues based on each participants water demand as further described in Section IV.C.

The following reservoir financing alternatives have been designed to minimize annual debt service requirements by scheduling each bond issue to coincide with capital requirements as they become due. Assuming issuance of the bonds, the first installment is scheduled for sale on January 1, 1995, with an additional installment each six months thereafter, and the last bonds being issued on January 1, 1999. Additionally, each bond issue has been structured to take advantage of interest earnings in the Construction Fund, Capitalized Interest Fund, and Reserve Fund.

Since it is assumed that the bonds are to be supported by contract revenues based on raw water costs from the reservoir, an estimated cost per 1,000 gallons has been presented for each financing alternative. This analysis assumes that 60 percent of the reservoir-yield is initially purchased by the participants and the remaining 40 percent by the State of Texas. For an estimate of the annual debt service requirement for each participant, see Section V.D.

Table V.2

SUMMARY OF ALTERNATIVES FINANCING

	Alternative I	Alternative II	Alternative III	Alternative IV
Mitigation Allowance	Anticipated	Anticipated	Best Case	Best Case
Farm to Market Road 2064	Not Abandoned	Abandoned	Not Abandoned	Abandoned
Total Capital Costs	$103,193,000	$94,074,000	$94,476,000	$85,357,000
$ to be Funded by Participants	60%	60%	60%	60%
$ to be Funded by the State of Texas	40%	40%	40%	40%
Capital Costs to be Funded by Participants	$61,937,000	$56,466,000	$56,686,000	$51,214,000
Total Principal Amount of Bonds Issued	$89,585,000	$81,880,000	$81,555,000	$73,845,000
Average Annual Debt Service Requirements	$8,075,000	$7,380,000	$7,345,000	$6,655,000
Annual Reserve Fund Revenues	$607,000	$555,000	$552,000	$501,000
Net Annual Debt Service to be Paid by Participants	$7,468,000	$6,825,000	$6,793,000	$6,154,000
Annual Reservoir Yield @ 60% (1,000 gallon units)	16,717,503	16,717,503	16,717,503	16,717,503
Raw Water Cost per 1,000 Gallon Unit	$0.45	$0.41	$0.41	$0.37

3. Summary of Assumptions for Reservoir Financing

Capital Costs

The plan of financing assumes that 60 percent of the capital cost associated with the design, acquisition, and construction of the reservoir will be funded from the proceeds of contract revenue bonds issued by the ANRA on behalf of the participants, and the remaining 40 percent will be funded by the State of Texas.

Capacity

It is assumed that the ANRA will have rights to 60 percent of the raw water capacity of the reservoir which it will contract to sell to the participants, and the State of Texas will have rights to the remaining 40 percent of the raw water capacity.

Dates for Bond Issues

The bonds have been scheduled to coincide with capital requirements as they become due. The first bonds are scheduled to be issued on January 1, 1995 for initial design work. The

The remaining bond issues are to be sold in six-month increments, with the last bond issue on January 1, 1999 for final construction purposes.

Contract Water Revenues

It is assumed that water will be available for delivery by the first quarter of 2000 and contract water revenues will become available beginning April 1, 2000. The first debt service requirements to be made with such revenues is on January 1, 2001.

Principal and Interest Dates

Principal	January 1
Interest	January 1 & July 1

Structure and Term

All of the bond issues have been structured to have a level annual debt service requirement based on a 30-year bond amortization.

Interest Rate

For purposes of this analysis an interest rate of 8.0% on the bonds has been assumed. Actual interest rates will be dependent upon, among other things, the creditworthiness of the participants, the ability to receive a bond rating, the ability to qualify for municipal bond insurance, and economic conditions at the time of sale.

Estimated Costs of Issuance

The cost of issuance, exclusive of bond insurance, if any, has been estimated to be four percent of the principal amount of each bond issue. This expense includes fees for the financial advisor, bond counsel, underwriter's discount, along with printing costs and any other costs associated with issuance of the bonds.

Bond Insurance/Bond Rating

No assumptions have been made concerning the probability that the bonds will receive a particular municipal bond rating or qualify for municipal bond insurance.

Capitalized Interest Fund

Upon sale of each installment of the bonds, a portion of the bond proceeds will be deposited into a Capitalized Interest Fund. The purpose of such fund is to make debt service requirements on the bonds during the construction period, or until such a time as the reservoir is able to generate revenues sufficient to make debt service requirements. The financing

alternatives assume that interest will be capitalized until July 1, 2000, after which time debt service requirements will be paid from contract revenues from the participants.

It is assumed the Capitalized Interest Fund will earn interest at an annual rate of 7.50%, which earnings will remain in the Capitalized Interest Fund to pay interest during construction.

Construction Fund

Upon sale of each installment of the bonds, a portion of the bonds proceeds will be deposited into a Construction Fund. The purpose of such fund is to pay the cost associated with the design, acquisition, and construction of the reservoir. It is assumed that expenditures of the Construction Fund will be made in uniform monthly payments, with the final payment made on June 1, 1999.

It is assumed the Construction Fund will earn interest at an annual rate of 7.00%, which earnings will remain in the Construction Fund to pay construction expenditures. Due to the need for the Construction Fund to maintain a greater degree of liquidity, it is assumed that it will generate slightly less in interest earnings than the Capitalized Interest Fund and the Reserve Fund.

Reserve Fund

Upon sale of each installment of the bonds, a portion of the bond proceeds will be deposited into a Reserve Fund. The purpose of such fund is to provide security for payment of principal and interest on the bonds in the event that anticipated contract revenues are not sufficient to make debt service requirements as they become due. Each bond issue will have a reserve fund in an amount equal to one year's average annual debt service requirements.

It is assumed the Reserve Fund will earn interest at an annual rate of 7.50%, which earnings will be deposited into the Capitalized Interest Fund to pay interest during construction. After the construction of the reservoir is complete, interest earnings from the Reserve Fund will be deposited into a debt service fund to pay debt service requirements of the bonds.

4. Delivery System Facilities Financing

The design, acquisition, financing and construction of the transmission and treatment facilities is to be funded from the proceeds of contract revenue bonds issued by the ANRA on behalf of the participants. The bonds are to be supported by contract revenues based on each participants water demand as further described in Section IV.C.

Like the reservoir financing alternatives, the transmission and treatment financing alternatives have been designed to minimize annual debt service requirements by scheduling each bond issue to coincide with construction capital requirements as they become due, and to

The following financing alternatives have been divided into two sections. The first section shown in Tables V.3 and V.4, presents the financing alternatives for the participants of the Northern System, including the City of Nacogdoches and Temple-Inland, Phases I & II, as further described in Section IV.C. The second section, shown in Table V.5, presents the alternative financing for the Southern System, also described in Section IV.C. For an annual debt service cost for each participant see Section V.D.

Table V.3

SUMMARY OF ALTERNATIVES FINANCING
North, Nacogdoches and Temple-Inland Systems

Total Capital Costs	$67,963,000
% to be Funded by Participants	100%
Capital Costs to be Funded by Participants	$67,963,000
Total Principal Amount of Bonds Issued	$90,120,000
Average Annual Debt Service Requirements	$ 8,055,000
Annual Reserve Fund Revenues	$ 605,000
Net Annual Debt Service to be Paid by Participants	$ 7,450,000

Table V.4

SUMMARY OF ALTERNATIVES FINANCING
North System Phase II

Total Capital Costs	$ 841,000
% to be Funded by Participants	100%
Capital Costs to be Funded by Participants	$ 841,000
Total Principal Amount of Bonds Issued	$1,135,000
Average Annual Debt Service Requirements	$ 140,000
Annual Reserve Fund Revenues	$ 11,000
Net Annual Debt Service to be Paid by Participants	$ 129,000

Table V.5

SUMMARY OF ALTERNATIVES FINANCING
South System

Total Capital Costs	$ 8,115,000
% to be Funded by Participants	100%
Capital Costs to be Funded by Participants	$ 8,115,000
Total Principal Amount of Bonds Issued	$10,980,000
Average Annual Debt Service Requirements	$ 1,145,000
Annual Reserve Fund Revenues	$ 87,000
Net Annual Debt Service to be Paid by Participants	$ 1,058,000

5. Summary of Assumptions for Delivery System Facilities Financing

Capital Costs

The plan of financing assumes that 100 percent of the capital cost associated with the design, acquisition, and construction of the transmission and treatment facilities will be funded from the proceeds of contract revenue bonds issued by the ANRA on behalf of the participants.

Dates for Bond Issues

The bonds have been scheduled to coincide with capital requirements as they become due. The first bonds for Phase I of the Northern System are scheduled to be issued on April 1, 1997 for initial design work, and each six months thereafter, with the final bonds being issued on April 1, 1999 for final construction purposes. Phase II bonds of the Northern System are to be sold in one issue dated on April 1, 2019.

The first bonds of the Southern System are to be sold on April 1, 2008, and each six months thereafter, with the final bonds being sold on April 1, 2010.

Contract Water Revenues

It is assumed that contract revenues will begin to pay debt service on the Northern System's Phase I bonds on January 1, 2001. The Northern System's Phase II debt service requirements will begin to be paid with contract revenues on January 1, 2021.

Contract revenues will begin to pay debt service requirements on the Southern System's bonds on January 1, 2011.

Principal and Interest Dates*

Principal	January 1
Interest	January 1 & July 1

Structure and Term

All of the bond issues have been structured to have a level annual debt service requirement. Additionally, it is assumed that the bonds issued for the Northern, Nacogdoches and Temple-Inland Systems Phases I and II will be amortized over a 30-year and 15-year basis, respectively. The Southern System's bonds will also have level annual debt service requirements based on a 30-year bond amortization.

Interest Rate*

For purposes of this analysis an interest rate of 8.00% on the bonds has been assumed. Actual interest rates will be dependent upon, among other things, the creditworthiness of the participants, the ability to receive a bond rating, the ability to qualify for municipal bond insurance, and economic conditions at the time of sale.

Estimated Costs of Issuance*

The cost of issuance, exclusive of bond insurance, if any, has been estimated to be four percent of the principal amount of each bond issue. This expense includes fees for the financial advisor, bond counsel, underwriter's discount, along with printing costs and any other costs associated with issuance of the bonds.

Bond Insurance/Bond Rating*

No assumptions have been made concerning the probability that the bonds will receive a particular municipal bond rating or qualify for municipal bond insurance.

Capitalized Interest Fund*

Upon sale of each installment of the bonds, a portion of the bond proceeds will be deposited into a Capitalized Interest Fund. The purpose of such fund is to make debt service requirements on the bonds during the construction period, or until such a time as revenues are sufficient to make debt service requirements.

*Includes bonds for all delivery systems.

It is assumed that bonds issued for the Northern, Nacogdoches and Temple-Inland Systems Phases I and II have capitalized interest until July 1, 2000 and January 1, 2021, respectively. Bonds issued for the Southern System will have capitalized interest until July 1, 2011.

It is assumed the Capitalized Interest Fund will earn interest at an annual rate of 7.50%, which earnings will remain in the fund to pay interest during construction.

Construction Fund*

Upon sale of each installment of the bonds, a portion of the bonds proceeds will be deposited into a Construction Fund. The purpose of such fund is to pay the cost associated with the design, acquisition, and construction of the transmission and treatment facilities. It is assumed that expenditures from the construction fund will be made in uniform monthly payments.

The Northern, Nacogdoches and Temple-Inland Systems Phases I and II final payments from the Construction Fund will be made on September 1, 1999 and July 1, 2020, respectively. The final payment from the Construction Fund for the Southern System is assumed to be September 1, 2010.

It is assumed the Construction Fund will earn interest at an annual rate of 7.00%, which earnings will remain in the fund to pay construction expenditures. Due to the need for the Construction Fund to maintain a greater degree of liquidity, it is assumed that it will generate slightly less in interest earnings than the Capitalized Interest Fund and the Reserve Fund.

Reserve Fund*

Upon sale of each installment of the bonds, a portion of the bond proceeds will be deposited into a Reserve Fund. The purpose of such fund is to provide security for payment of principal and interest on the bonds in the event that anticipated contract revenues are not sufficient to make debt service requirements as they become due. Each bond issue will have a reserve fund in an amount equal to one year's average annual debt service requirements.

It is assumed the Reserve Fund will earn interest at an annual rate of 7.50%, which earnings will be deposited into the Capitalized Interest Fund to pay interest during construction. After the construction of the transmission and treatment facilities is complete, interest earnings from the Reserve Fund will be deposited into a debt service fund to pay debt service requirements of the bonds.

*Includes bonds for all delivery systems.

D. PARTICIPANT COSTS

1. Introduction

Based on the assumptions and criteria presented in the sections immediately preceding, the unit cost of delivered water and the initial phase annual cost was determined for each participant. As noted in Section V.C, costs and annual debt service were determined separately for the reservoir and delivery system components. The total unit cost of delivered water as presented below includes the reservoir, delivery system, operation and maintenance, and annual debt service.

2. Unit Cost of Raw Water

Under the various alternatives presented in the previous sections, the unit cost of raw water in the lake was calculated. The unit cost recommended for planning purposes is $0.45 per 1000 gallons. This cost is the same for all participants. However, the most cost effective points of delivery for the City of Nacogdoches, Temple-Inland Forest Products, Inc., and the Southern participants are at various locations downstream of the dam, utilizing Mud Creek and the Angelina River as a conveyance. In taking this approach for conveyance, it is necessary to account for transmission losses which will naturally occur in the stream. Such losses were determined based on an accepted methodology, as described in Groundwater Hydrology by Herman Bower, 1978, which accounts for soil type and condition, level of the water table, and level of flow. Based on this method, the loss was calculated to be approximately seven percent of the total flowrate between the Lake Eastex Dam and the US 59 bridge north of Lufkin. It was then assumed that the loss varied linearly along this route. Practically, these losses are accounted for by an increase in demand. This increase in demand results in an effective raw water cost for the true consumptive demand which is slightly higher than $0.45/1000 gallons. Depending on the withdrawal location for the various participants, the effective raw water costs (and the resulting total unit costs) could be from one to three cents higher than those stated above. If FM 2064 is abandoned in place, the unit cost of raw water can be reduced for all participants by about four cents.

3. Unit Cost for Delivery Systems Capital Cost

The approach for the determination of delivery system capital costs also varied somewhat by location within the region. For the Northern System, a uniform unit cost was determined for all participants in this system. This cost was calculated as the sum of all component costs for all participants divided by the total amount of water and includes raw water, delivery system, operation and maintenance, and annual debt service. As a result, each participant in this subsystem pays the same unit cost regardless of location or quantity of purchase.

Because of their remote location, relative to the other project participants, delivery systems for the City of Nacogdoches and Temple-Inland Forest Products, Inc. were developed to serve each of these participants individually. Consequently, the unit cost attributable to these two participants is based only on the cost of the specific system from which they are served.

Unit costs for participants in Angelina County (southern delivery system) were allocated based on a pro-rata share of demand for each facility component (pumping, treatment, and pipelines). This approach was taken for the southern system in order to be more consistent with the cost allocation plan developed in the Angelina County Regional Water Study, which is currently being implemented.

The phased construction of the delivery systems will cause the unit cost for participants in the northern and southern systems to vary with time. The City of Nacogdoches and Temple-Inland Forest Products, Inc. systems are not anticipated to be phased. Therefore, unit costs for these systems will remain constant. The phased systems are expected to require overlapping debt service schedules, which for some limited amount of time, will require an overlap for the unit costs attributable to the construction of each phase. This variation of unit costs for the various Lake Eastex delivery systems is presented in Table V.6.

Table V.6
UNIT COST FOR DELIVERY SYSTEMS CAPITAL COSTS ($/1000 GAL.)

Northern Participants	Unit Cost 2000 to 2019		Unit Cost 2020 to 2029		Unit Cost 2030 to 2034		Unit Cost After 2034	
Contingency	20%	0%	20%	0%	20%	0%	20%	0%
City of Arp	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
Blackjack WSC	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
Cherokee County	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Leo F. Childs	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
Craft-Turney WSC	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
City of Henderson	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
Jackson WSC	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
City of Jacksonville	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
City of New London	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
New Summerfield WSC	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
City of Overton	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
Reklaw WSC	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
City of Rusk	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
Star Mountain WSC	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
City of Troup	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
Walnut Grove WSC	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
Wright City WSC	0.91	0.77	0.93	0.78	0.02	0.01	0.00	0.00
City of Nacogdoches	0.09	0.08	0.09	0.08	0.00	0.00	0.00	0.00
Temple-Inland Forest Products, Inc.	0.43	0.36	0.43	0.36	0.00	0.00	0.00	0.00

Southern Participants	Unit Cost 2000 to 2009		Unit Cost 2010 to 2029		Unit Cost 2030 to 2040		Unit Cost After 2040	
Angelina WSC	0.00		0.49	0.42	0.49	0.42	0.00	0.00
City of Lufkin	0.00		0.48	0.41	0.48	0.41	0.00	0.00
Redland WSC	0.00		0.48	0.41	0.48	0.41	0.00	0.00
Woodlawn WSC	0.00		0.47	0.39	0.47	0.39	0.00	0.00

4. Unit Costs for Operation and Maintenance

Based on previous experience with similar projects, operation and maintenance costs for the delivery systems have been estimated at five percent of the capital cost for each phase. The distribution of these costs to the participants was done similar to the distribution of the delivery system capital costs on which they are based. Therefore, for some participants the operation and maintenance component of the total unit cost for delivered water also varies with time due to phasing and has been presented in Table V.7.

Table V.7
UNIT COST OF O&M FOR DELIVERY SYSTEMS ($/1000 GAL.)

Northern Participants	Unit Cost 2000 to 2019		Unit Cost 2020 to 2029		Unit Cost 2030 to 2034		Unit Cost After 2034	
Contingency	20%	0%	20%	0%	20%	0%	20%	0%
City of Arp	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
Blackjack WSC	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
Cherokee County	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leo F. Childs	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
Craft-Turney WSC	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
City of Henderson	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
Jackson WSC	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
City of Jacksonville	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
City of New London	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
New Summerfield WSC	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
City of Overton	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
Reklaw WSC	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
City of Rusk	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
Star Mountain WSC	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
City of Troup	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
Walnut Grove WSC	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
Wright City WSC	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34
City of Nacogdoches	0.04	0.03	0.04	0.03	0.04	0.03	0.04	0.03
Temple-Inland Forest Products, Inc.	0.19	0.15	0.19	0.15	0.19	0.15	0.19	0.15

Southern Participants	Unit Cost 2000 to 2009		Unit Cost 2010 to 2029		Unit Cost 2030 to 2040		Unit Cost After 2040	
Angelina WSC	0.00		0.30	0.25	0.30	0.25	0.30	0.25
City of Lufkin	0.00		0.25	0.21	0.25	0.21	0.25	0.21
Redland WSC	0.00		0.25	0.21	0.25	0.21	0.25	0.21
Woodlawn WSC	0.00		0.24	0.20	0.24	0.20	0.24	0.20

5. Total Unit Cost

As described previously, the total unit cost for the delivery of Lake Eastex water to each of the project participants is the sum of the cost components discussed above. Table V.8 presents the total unit cost for each participant and the variation of the costs due to phasing. Each of the values presented in this table could be reduced by about four cents if FM 2064 is abandoned.

Table V.8
TOTAL UNIT COST FOR DELIVERED WATER FROM LAKE EASTEX

Northern Participants	Unit Cost 2000 to 2019		Unit Cost 2020 to 2029		Unit Cost 2030 to 2034		Unit Cost After 2034	
Contingency	20%	0%	20%	0%	20%	0%	20%	0%
City of Arp	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
Blackjack WSC	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
Cherokee County	0.45	0.45	0.45	0.45	0.45	0.45	0.00	0.00
Leo F. Childs	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
Craft-Turney WSC	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
City of Henderson	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
Jackson WSC	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
City of Jacksonville	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
City of New London	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
New Summerfield WSC	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
City of Overton	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
Reklaw WSC	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
City of Rusk	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
Star Mountain WSC	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
City of Troup	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
Walnut Grove WSC	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
Wright City WSC	1.76	1.55	1.79	1.57	0.88	0.80	0.41	0.34
City of Nacogdoches[1]	0.58	0.56	0.58	0.56	0.49	0.48	0.04	0.03
Temple-Inland Forest Products, Inc.[1]	1.07	0.96	1.07	0.96	0.64	0.60	0.19	0.15

Southern Participants[1]	Unit Cost 2000 to 2009[2]	Unit Cost 2010 to 2029		Unit Cost 2030 to 2040		Unit Cost After 2040	
Angelina WSC	0.45	1.24	1.12	0.79	0.67	0.30	0.25
City of Lufkin	0.45	1.18	1.07	0.73	0.63	0.25	0.21
Redland WSC	0.45	1.18	1.07	0.73	0.63	0.25	0.21
Woodlawn WSC	0.45	1.16	1.04	0.71	0.62	0.24	0.20

(1) As previously discussed, effective total unit costs for usable water from Lake Eastex could be from one to three cents higher for these entities due to conveyance losses in the natural channel.

(2) Unit costs for this phase include the cost for Lake Eastex raw water only. No delivery system costs are included.

6. Initial Annual Cost

The unit costs presented in Table V.8 above, are based on the demand assumptions developed in Section IV.C. For reference purposes, the annual costs attributable to each participant has been calculated based on these same demand assumptions. Annual costs for Lake Eastex project participants through the year 2029 are presented in Tables V.9 and V.10.

Table V.9

ESTIMATED ANNUAL COST
NORTH, NACOGDOCHES AND TEMPLE-INLAND SYSTEMS

Participant	Annual Cost 2000 to 2019	Annual Cost 2020 to 2029
City of Arp	$ 237,688	$ 241,750
Blackjack WSC	77,088	78,402
Cherokee County[1]	821,250	821,250
Leo F. Childs	51,392	52,268
Craft-Turney WSC	411,136	418,144
City of Henderson	2,486,088	2,528,465
Jackson WSC	289,080	294,008
City of Jacksonville	3,456,112	3,515,023
City of New London	423,984	431,211
New Summerfield WSC	109,208	111,070
City of Overton	449,680	457,345
Reklaw WSC	44,968	45,735
City of Rusk	642,400	653,350
Star Mountain WSC	231,264	235,206
City of Troup	379,016	385,477
Walnut Grove WSC	835,120	849,355
Wright City WSC	468,952	476,946
City of Nacogdoches	3,186,085	3,186,085
Temple-Inland Forest Products, Inc.	3,589,155	3,589,155

(1) Cherokee County's annual cost includes only undelivered raw water.

Table V.10

ESTIMATED ANNUAL COST
SOUTHERN SYSTEMS

Participant	Annual Cost[(1)] 2000 to 2009	Annual Cost 2010 to 2029
Angelina WSC	$ 27,923	$ 76,942
City of Lufkin	622,508	1,632,353
Redland WSC	19,710	51,684
Woodlawn WSC	21,353	55,042

(1) Annual cost for undelivered raw water only. Delivery system and associated costs for delivered water begin in 2010.

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The following maps are not attached to this report. They are located in the official file and may be copied upon request.

Map No. 1 - Exhibit IV.9 Reservoir Conflicts Transportation-Part 1
Map No. 2 - Exhibit IV.9 Reservoir Conflicts Part 2

Map No. 3 -Exhibit IV.10 Reservoir Conflicts - Utilities-Part 1

Map No. 4 - Exhibit IV.10 Reservoir conflicts Utilities - Part 2

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