REGIONAL WATER PLANNING STUDY

Cost Update for Palmetto Bend Stage 2
and
Yield Enhancement Alternative for Lake Texana
and
Palmetto Bend Stage 2

for

The Lavaca-Navidad River Authority

The Alamo Conservation and Reuse District
and
The City of Corpus Christi

by

HDR Engineering, Inc.
Austin, Texas

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Acknowledgements

The comments and input received from the Advisory Committee members listed below, and their representatives, are appreciated.

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1.) Update previous estimates of the costs and yields of Palmetto Bend Stage 2:

2.) Estimate costs to obtain and convey Garwood Irrigation water, and yield of specified quantities of such water rights in Lake Texana and Palmetto Bend Stage 2;

3.) Present a legal opinion for transferring a part of Garwood Irrigation Company's water rights to the Lavaca-Navidad River Authority, Corpus Christi, and Alamo Conservation and Reuse District for municipal and industrial purposes, including required regulatory agency approvals and permits;

4.) Estimate increased yields of Lake Texana and Palmetto Bend Stage 2 for a range of import quantities from Garwood Irrigation Company and other potential Colorado River sources;

5.) Estimate capital and operation and maintenance costs for diversion and conveyance facilities for the range of diversion quantities of objective four, including modifications to Garwood facilities to deliver water to Lake Texana and Palmetto Bend Stage 2;

6.) Identify potentially significant environmental impacts and provide reconnaissance level estimates of mitigation costs of Palmetto Bend Stage 2, and diversions of Garwood irrigation water to Lake Texana and Palmetto Bend Stage 2;

7.) Estimate effects, if any, of diversion of Garwood irrigation water upon Garwood's operations and rates to customers, other water rights, and the cost of water from Lake Texana and Palmetto Bend Stage 2;

8.) Estimate yield increases to Lake Texana and Palmetto Bend Stage 2 that would be available for use outside the Lavaca-Navidad and adjoining coastal basins; and

9.) Develop water conservation and drought contingency plans for the Lavaca-Navidad River Basin study area.

Cost and Yield of Palmetto Bend Stage 2

The U.S. Bureau of Reclamation (BuRec) studied Palmetto Bend Stages 1 and 2 in 1965. Palmetto Bend Stage 1 was selected for construction, completed in 1980, and named Lake Texana shortly thereafter. The 1965 BuRec studies of Palmetto Bend Stage 2 were updated, with results as follows. Firm yield of Stage 2 in 2000 is estimated at 48,171 acre-feet per year, and in 2040 is estimated at 43,355 acre-feet per year. Firm yield of Stage 2 combined with Lake Texana is 131,785 acre-feet per year in 2000, and is 125,792 acre-feet per year in 2040. These yields are higher than the previous BuRec estimates, and are also higher than yields which were used as a basis for obtaining the water rights permits for the reservoirs; i.e., L-NRA's water rights permits include a total of 105,000 acre-feet per year for the two reservoirs, 75,000 acre-feet for Stage 1, and 30,000 acre-feet for Stage 2.

Estimates of construction, land acquisition, mitigation, permitting, relocations, engineering, legal, and other costs to build Stage 2 as a stand-alone project in 1990 prices are $75.25 million. If the project is financed at eight percent for 25 years, the annual cost would be $7.85 million, with a cost per acre-foot for water of $163 in year 2000 at the year

2000 yield of 48,171 acre-feet per year. Cost per thousand gallons of firm yield (raw water) would be 50 cents. By constructing Stage 2 in combination with, or linked to, Stage 1 (Lake Texana), the yield could be increased by 2,218 acre-feet annually to 50,389 acre-feet. However, the total construction costs would be increased from $75.25 million to $112.65 million, annual debt, operation, and maintenance costs would be increased from $7.85 million to $11.35 million, and cost per acre-foot of water would be increased from $163 to $225. Cost per thousand gallons would rise from 50 cents to 69 cents.

Evaluation of Acquiring Water Rights from the Garwood Irrigation Company and Other Colorado Basin Sources

Garwood Irrigation Company has a channel dam and pump station located on the Colorado River, near the southern boundary of Colorado County. A system of canals delivers water for irrigation throughout Garwood's service area, most of which is located in southwestern Colorado County. The Garwood system delivers water into the watersheds of Mustang and Sandy Creeks, both of which flow into Lake Texana. In this portion of the study, estimates were made of the costs and potential yields in Lake Texana and Palmetto Bend Stage 2 of diverting different quantities of Garwood irrigation water and estimates of unappropriated Colorado River flows into tributaries of the Navidad River which flow into Lake Texana. The evaluations were made for each of two different Colorado River diversion points and associated routes as follows: (1) use of Garwood diversion facilities and conveyance canals, augmented with additional pumping capacity, and (2) the development of new diversion works and conveyance canals at a location near but downstream of Garwood's facilities. In both cases, water would be transferred through canals until it could be discharged into streams (Pinoak Creek and Sandy Creek) having enough channel capacity to carry the flows to Lake Texana.

Cost and yield analyses were made for the following six annual levels of diversions at the Garwood diversion point: (1) 30,000 acre-feet; (2) 44,000 acre-feet; (3) 50,000 acre-feet; (4) 60,000 acre-feet; (5) 106,000 acre-feet; and (6) 168,000 acre-feet in order to obtain estimates of water supply potential for a range of potential project sizes. It is emphasized, however, that there are no agreements between Garwood Irrigation Company and L-NRA regarding any levels of sale of Garwood water to L-NRA. These analyses are for the purpose of providing information about yields and costs for the levels studied.

Analyses of Colorado River monthly flow data at Garwood indicate that 30,000 acre-feet of Garwood Irrigation Company water could be diverted during the five-month period of November through March without affecting Garwood's irrigation operations. Diversions of this quantity on this schedule could be made and conveyed through Garwood's canals to Pinoak Creek. Water discharged into Pinoak Creek would flow into Sandy Creek, which flows into Lake Texana. It was estimated that a 30,000 acre-foot diversion of water at Garwood during the November to March period would increase the yield of Lake Texana by 23,100 acre-feet annually. At a cost of $200 per acre-foot of water rights, the capital costs for facilities and water rights to divert 30,000 acre-feet of water per year are estimated at $10.45 million. At a debt service of eight percent for 25 years, debt retirement, operation, and maintenance costs are estimated at $1.62 million annually, which is a cost per acre-foot of firm yield (23,100) of $70, and a cost per thousand gallons of raw water of 22 cents.

A 44,000 acre-foot diversion at Garwood was estimated to require separate diversion and transmission facilities and would have an estimated capital investment cost of $35.958

million, an annual debt retirement, operation, and maintenance cost of $ 3.729 million, a yield in Lake Texana of 33,800 acre-feet, a cost of $110 per acre-foot of yield, and a cost per thousand gallons of raw water of 34 cents.

For diversions exceeding 44,000 acre-feet of water at Garwood, it was assumed that additional costs would occur because of the potential impacts on Garwood's operations. For diversions of 50,000 acre-feet or less, the yields can be obtained with a November through March pumping schedule, but for larger diversions, year-round pumping would be required.

TABLE OF YIELDS AND COSTS

Garwood Purchase in Acre-feet/Year	Yield in Lake Texana Acre-feet/Year	Capital Investment ($ Million)	Annual Debt Repayment Operation & Maintenance ($ Million)	Cost per acre-foot of Yield	Cost per 1,000 gallons
50,000	38,100	$41.129	$4.249	$112	34¢
60,000	45,200	$47.651	$4.916	$109	33¢
106,000	55,500	$73.928	$7.631	$137	42¢
168,000	70,100	$109.126	$11.271	$161	49¢

Yield and cost estimates were made for a range of maximum sized pumping and diversion facilities for the diversion of estimated unappropriated quantities of Colorado River water at Garwood. The facilities evaluated were for each of four pumping facilities having a maximum capacity of: (1) 250 cubic feet per second; (2) 500 cubic feet per second; (3) 1,000 cubic feet per second; and (4) 1,500 cubic feet per second. Using a pumping facility having a maximum pumping rate of 250 cubic feet per second (cfs), the increase in annual yield of Lake Texana or Lake Texana combined with Palmetto Bend Stage 2 is estimated at 9,700 acre-feet at a cost of $171 per acre-foot or 52 cents per thousand gallons of water. With diversion facilities having maximum diversion rates of 500 cfs and 1,000 cfs, yield in Lake Texana and Palmetto Bend Stage 2 would be increased 16,200 and 21,800 acre-feet, respectively, at a cost of $170 per acre-foot or 52 cents per thousand gallons for each of these facilities. For a facility with a maximum diversion rate of 1,500 cfs, yield in both lakes combined would be increased by 25,200 acre-feet annually, at a cost of $188 per acre-foot, or 58 cents per thousand gallons.

Comparisons were made of the costs and yields in Lake Texana and Palmetto Bend Stage 2 using a combination of unappropriated Colorado River water and Garwood water. By combining Garwood water and unappropriated water, the combination using 30,000 acre-feet of Garwood water results in costs slightly higher than for purchasing only Garwood water to produce the same yield. For combinations using 44,000 acre-feet or more of Garwood water, the costs are significantly more than using only Garwood water. Using Garwood's facilities to deliver the 30,000 acre-feet of water is the principal factor in reducing these costs.

Yields for Use Outside the Lavaca-Navidad River Authority Service Area

It is estimated that the 75,000 acre-foot permitted yield of Lake Texana will be needed for the Lavaca-Navidad Basin service area within the next 30 to 36 years. Under high case projections of future water needs of the L-NRA service area, the yield of Palmetto Bend Stage 2 would also be needed by 2030. However, under medium case projections, one-fourth (10,405 acre-feet) of Palmetto Bend Stage 2 yield would be surplus to L-NRA service area needs in 2040, and under low case projections, 80 percent (34,595 acre-feet) of Palmetto Bend Stage 2 yield would be surplus in 2040. These surpluses plus the yield enhancements to Lake Texana and Palmetto Bend Stage 2 from the use of Garwood and/or unappropriated Colorado Basin surpluses could be available to out-of-basin users. The estimated quantities range from 23,100 acre-feet per year for the high case L-NRA service area demand in combination with a 30,000 acre-foot diversion of Garwood water, to 57,695 acre-feet for the low case L-NRA service area demand and a 30,000 acre-foot Garwood diversion.

For a 30,000 acre-foot diversion of Garwood water in combination with maximum diversions of unappropriated Colorado River water, the surpluses to L-NRA service area needs range from a low of 46,500 acre-feet per year for the high case L-NRA service area demand projection to 71,095 acre-feet for the low case L-NRA service area demand projection.

Effects on Garwood Irrigation Company

The diversion of 30,000 acre-feet of Garwood water during the November to March period through the Garwood canal system is not expected to adversely affect Garwood's water delivery operations. In fact, such a diversion could increase economic efficiency of the system by providing revenues for conveyance of water through the canals, since such diversions would occur when the canals are not in use by Garwood. The cost of diversion and conveyance facilities with capacity in excess of 30,000 acre-feet were estimated based on separate facilities which would not affect Garwood's operations.

Effects on Other Water Rights

The analyses of Garwood diversions pertain to quantities of water which have been permitted to Garwood Irrigation Company. The exercise of Garwood rights would not impinge upon the rights of others in the Colorado River Basin.

The analyses pertaining to unappropriated Colorado River Basin water were made for flow levels above those estimated to be needed to meet downstream water rights.

However, more detailed analyses would be required to determine actual amounts available. The diversion of unappropriated flow would only be made under conditions which would not adversely affect Colorado River Basin water rights. Detailed engineering and legal analyses would be required to transfer unappropriated flow out of the Colorado River Basin.

Water Rights and Legal Feasibility of Transfer

Garwood Irrigation Company holds the senior water right on the Lower Colorado River, with a priority date of November 1, 1900. The Lavaca-Navidad River Authority (L-NRA) is considering acquiring 30,000 acre-feet or more of Garwood's appropriated rights to enhance the annual yields of Lake Texana and Palmetto Bend Stage 2. State authorization is required to enable L-NRA to utilize Garwood's right. Transfer of ownership from Garwood to L-NRA would appear to be relatively simple, so long as the necessary Texas Water commission procedures are followed. The required amendments to Garwood's water right appear to be feasible, since no unappropriated water would be involved in the proposed movement of Garwood's Colorado River water into the Lavaca River Basin. However, the effect of additional storage in Lake Texana and subsequent use by San Antonio and/or Corpus Christi will need to be independently evaluated and permitted by the Texas Water Commission. Furthermore, it is noted that the Texas Water Commission considers and evaluates water right transfers on a case-by-case basis.

Environmental Factors

The potential environmental consequences and associated mitigation for a regional water supply project that includes: (1) construction of Palmetto Bend Stage 2; (2) purchase of rights and transfer of 30,000 to 60,000 acre-feet of Garwood irrigation water annually from the Colorado River through Garwood Irrigation Company facilities; and (3) use of channels of Sandy and/or Mustang Creeks to convey Garwood water to Lake Texana are listed below.

Impacts to Bays and Estuaries: The Palmetto Bend Stage 2 reservoir will inundate 6,060 acres at a conservation pool elevation of 44 feet MSL, including 22 miles of river channel. With full implementation of Lake Texana and Palmetto Bend Stage 2, reduced inflows to Lavaca Bay are estimated to average 150,000 acre-feet annually, and any impacts are expected to be small in the context of the entire Lavaca-Tres Palacios Estuary. Average annual inflow to the Estuary for the period 1941 to 1987 was 3,080,301 acre-feet, of which the 150,000 acre-feet is 4.8 percent. Earlier studies, based upon data for the 1941 to 1976 period, showed inflows to the Estuary of 2,540,000 acre-feet annually, and inflow reductions through implementation of Lake Texana and Palmetto Bend Stage 2 at 131,400 acre-feet annually. Average inflow is 21 percent greater than previously estimated, and considering the Lavaca-Tres Palacios Estuary as a whole, an inflow difference of the magnitude mentioned above is not likely to affect salinity, nutrients, or sediment delivery to the Estuary. This is particularly evident in relation to changes associated with the Mouth of the Colorado Project which closes migratory routes through Parker and Tiger Island Cuts, and increases inflows to the Estuary by approximately 4,500,000 acre-feet per year.

Impacts on Fish and Wildlife: The area to be impacted by reservoir construction will need to be inventoried for natural and cultural resources; mitigation and archaeological recovery will probably be required.

Transfer of Garwood Irrigation water to the Lavaca-Navidad Basin in quantities of 30,000 to 60,000 acre-feet would not be expected to impact the Estuary to an extent which would require mitigation. Such transfers will increase the flows of streams (Sandy or

Mustang) in the Navidad Basin. Flows resulting from the diversions would need to be managed to avoid erosion of the channel bed and banks and the loss of stable base flow.

Impacts to Water Quality: The Lavaca-Navidad and Lower Colorado Basins have similar water quality and fish faunas. The Navidad, and subsequently, Lake Texana, presently receive irrigation return flows from lands irrigated with Garwood Irrigation Company water diverted from the Colorado River. This, together with interbasin flooding, provides migration pathways to aquatic species and water quality constituents. Thus, the use of Lake Texana and Palmetto Bend Stage 2 for conveyance and storage of Colorado River water does not appear to involve any substantial environmental consequences.

Mitigation Costs: Mitigation requirements, including studies and excavation of cultural resource sites, are estimated at $6,500,000. Environmental related costs for diversion from the Colorado River are estimated at $100,000 for the 30,000 acre-foot purchase of Garwood water and $500,000 for all other diversions.

Water Conservation and Drought Contingency Plans

Water conservation and drought contingency plans were developed for the study area in accordance with Texas Water Development Board water conservation planning guidelines. The objective of the water conservation plan is to reduce per capita water use by 15 percent over the next 20 years. This goal is to be accomplished through the use of: (1) education and information; (2) water conserving plumbing codes, including the requirements that only water efficient plumbing fixtures and appliances be offered for sale; (3) retrofit programs; (4) conservation-oriented water rate structure; (5) universal metering and meter repair; (6) water conservation landscaping; (7) leak detection and repair; (8) recycling and reuse; and (9) enforcement.

The drought contingency plan contains procedures for both voluntary and mandatory actions to temporarily reduce water use during a water shortage crisis. The six methods included in the drought contingency plan include: (1) trigger conditions; (2) drought contingency measures; including public information, lawn watering schedules, and water use limitation and curtailment measures; (3) information and education; (4) initiation procedures; (5) implementation procedures; and (6) termination notification. Water saving methods are listed for: (1) bathroom -- 14 methods; (2) kitchen -- 8 methods; (3) laundry -- 3 methods; (4) appliances and plumbing -- 7 methods; and (5) out-of-door uses -- 17 methods.

Conclusions and Recommendations

Assuming Corpus Christi and/or San Antonio desire to purchase water from L-NRA (Lake Texana augmented with diversions of Garwood Irrigation Company water and other possible sources of Colorado River water), the following steps should be taken:

- L-NRA should begin negotiations with Garwood Irrigation Company to purchase up to 60,000 acre-feet (or more if needed) from them. Garwood water is the most economical source of supplemental water to increase the firm yield of Lake Texana.

- Determine the quantity of firm yield desired from Lake Texana. The desired amount will determine how to proceed.

  If Garwood will sell only 30,000 acre-feet, needs could be met as follows:

Need (AF)	Supply Source(s)
0-25,000	30,000 AF Garwood water
25,000-38,000	30,000 AF Garwood water plus unappropriated Colorado River water or other Colorado River Water rights
38,000-86,000	30,000 AF Garwood water plus unappropriated water or other Colorado River water rights plus Stage 2

If Garwood will sell more than 30,000 acre-feet of water, needs could be met as follows:

Need (AF)	Supply Sources
0-38,000	50,000 AF of Garwood water
38,000-86,000	60,000 AF of Garwood water plus Stage 2

- The purchase of Garwood water should be contingent on obtaining an interbasin transfer permit and reasonable assurance that the sale of Garwood's water rights cannot be challenged in the future. If unappropriated Colorado River water is to be diverted, more detailed engineering and legal studies will be required. Perform the necessary studies, and obtain a water rights permit from the Texas Water Commission.

- The availability of other water rights for sale in the Colorado River should be investigated. Any water right would be expected to yield more than the estimated unappropriated amount corresponding to the same rate of diversion as the water right. If Garwood will sell only 30,000 acre-feet and the need is in excess of this amount, or if the cost of Garwood water rights is excessive, a search for other water rights should be made, and the yield and cost of the water right evaluated.

- If the amount of water to be purchased requires the construction of Stage 2, complete environmental studies and negotiations relative to environmental issues and mitigation, and initiate 404 permit application.

- Perform detailed field studies to determine channel capacities and channel losses in Garwood's canals and the creeks to be used to deliver water to Lake Texana. The amount of water to be obtained should first be determined so the required capacity can be used in the studies, thereby reducing the number of options to be evaluated.

- With reasonable assurances that San Antonio and Corpus Christi will be able to obtain their desired firm yield in Lake Texana, both cities should determine if this supply can be used to "firm up" diversions of unappropriated flows in the Guadalupe or San Antonio Rivers. TWC estimates the average unappropriated flows entering the Gulf of Mexico from the San Antonio and Guadalupe Rivers total approximately 1.7 million acre-feet per year. Since pipelines from Lake Texana to either city must cross the Guadalupe River, pumping costs could be reduced by diverting Guadalupe River water when unappropriated flows are available and using Lake Texana water as a backup. A pipeline from Lake Texana to the Guadalupe River sized to deliver both San Antonio and Corpus Christi flows could also reduce the cost to each of the cities. Also, it is possible the effective firm yield of the system could be enhanced if Guadalupe river flows are available for appropriation.

REGIONAL WATER PLANNING STUDY
Cost Update for Palmetto Bend Stage 2 and Yield Enhancement Alternative for Lake Texana and Palmetto Bend Stage 2

1.0 INTRODUCTION

Because of growth and increasing demands on their water supply systems, both the San Antonio and Corpus Christi areas are threatened with water supply shortages during periods of drought. Both areas are continuing to grow, and additional water supplies will be needed to meet their near-term and long-term needs. The San Antonio area's population is more than 1.3 million, and it is projected to reach a population of nearly 2.0 million within 20 years. The Corpus Christi area's current population is approximately 500,000, and is expected to have more than 650,000 residents within 20 years.

1.1 Study Objectives

In order to meet their water supply needs, representatives of San Antonio and Corpus Christi are considering the possibility of purchasing raw water from Lake Texana, which is operated by the Lavaca-Navidad River Authority (L-NRA). Although unused water is currently available in Lake Texana, studies have shown that all of the water in Lake Texana will be needed well before 2040 to meet the water supply needs of the Lavaca-Navidad River Basin and adjoining coastal basins.[1] Therefore, while water is currently

[1] Projected Water Demand of the Lavaca-Navidad River Basin and the Adjoining Colorado-Lavaca and Lavaca-Guadalupe Coastal Basins, HDR Engineering, Inc., Austin, Texas, October, 1989.

available, it could only be used by Corpus Christi and San Antonio for such a relatively short period of time that the time and cost of constructing facilities to deliver only that water to either city may not be justified.

However, two potential means of increasing the present project yield on a long-term basis have been identified: 1) increasing the existing project yield by constructing Palmetto Bend Stage 2; and 2) importing surface water from the Colorado River Basin by purchasing water rights. Thus, the L-NRA in conjunction with the Texas Water Development Board (TWDB) is conducting this study on behalf of Corpus Christi and San Antonio (represented by the Alamo Conservation and Reuse District). The primary purpose of the study is to determine the cost and viability of increasing the project yield. The study area is shown in Figure 1-1.

Specifically, the objectives of this study are:

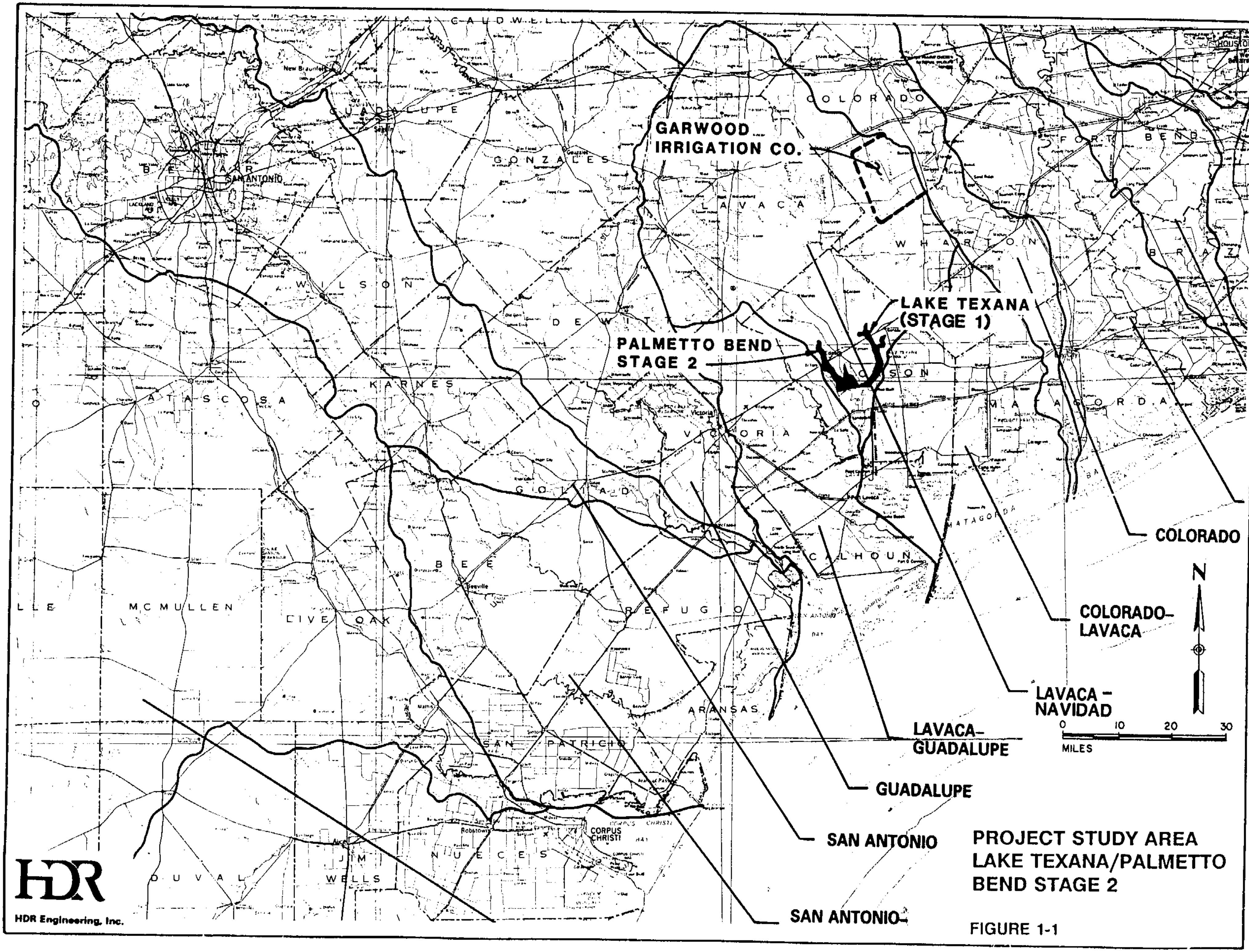
1) Update previous estimates of the costs and yield of Palmetto Bend Stage 2;

2) Estimate costs to purchase water rights from Garwood Irrigation Company, and estimate yields from conveying specified quantities of Garwood water to Lake Texana and Palmetto Bend Stage 2;

3) Present a legal opinion for transferring a part of Garwood Irrigation Company's water rights to L-NRA and its cooperators for municipal and industrial uses, including legal opinions of regulatory agency approvals and permits required for any water rights transfer;

4) Estimate increased yields of Lake Texana and Palmetto Bend Stage 2 for a range of import quantities from Garwood Irrigation Company's irrigation water and from other water that might be available for diversion from the Colorado River;

5) Estimate capital and operation and maintenance costs for diversion and conveyance facilities for a range of diversion quantities, including costs to improve and/or modify Garwood facilities to deliver water to Lake Texana and Palmetto Bend Stage 2;



PROJECT STUDY AREA
LAKE TEXANA/PALMETTO
BEND STAGE 2

FIGURE 1-1

6) Identify potentially significant environmental impacts and provide reconnaissance level estimates of mitigation costs of diversions of Garwood irrigation water to Lake Texana and Palmetto Bend Stage 2, including impacts to bays and estuaries, fish and wildlife, and water quality;

7) Estimate effects, if any, of diversion of Garwood irrigation water upon Garwood's operations and rates to customers, other water rights, and the cost of water from Lake Texana and Palmetto Bend Stage 2;

8) Estimate yield increases to Lake Texana and Palmetto Bend Stage 2 due to importing water from Garwood Irrigation Company and/or other water diversions that might be available for use outside the Lavaca-Navidad and adjoining coastal basins; and

9) Develop water conservation and drought contingency plans for the study area.

The study is a reconnaissance level investigation, designed to provide information for long-range planning purposes and furnish order-of-magnitude estimates of the quantities of water available from within the Lavaca and Navidad River Basins and from sources in the Colorado River basin. It has been assumed that water could be made available from the Garwood Irrigation Company on a long-term basis as an alternative to Garwood expanding its canal system to serve additional lands. No other long-term sources from the Colorado River have been identified at this time. Therefore, discussions of quantities of water available from the Colorado River (beyond the water available from Garwood) are only estimated values based on use of the TWDB's model of the Lower Colorado River for assumed operating criteria, from which estimates of unappropriated water were made. These estimates of unappropriated water are based on assumptions with regard to amounts to be bypassed for downstream water rights and should be treated as flows which might be diverted from the Colorado River.

Principal data and information sources include previous studies by the U.S. Bureau of Reclamation of Lake Texana and Palmetto Bend Stage 2; Garwood Irrigation Company records; hydrology and water quality data from the U.S. Geological Survey, Texas Water Development Board, and Texas Water Commission; topographic maps from the U.S. Geological Survey; and environmental information from Texas Parks and Wildlife Department and U.S. Fish and Wildlife Service.

1.2 Background

1.2.1 Stage 1

Lake Texana (Palmetto Bend Stage 1) was constructed by the U.S. Bureau of Reclamation (BuRec), with water impoundment beginning in 1980. L-NRA and the TWDB jointly hold a water rights permit from the Texas Water Commission which allows diversion of 75,000 acre-feet of Lake Texana yield annually. L-NRA presently has water sales contracts for 32,000 acre-feet/year, with the remainder being held in reserve for future in-basin needs.

The BuRec studies, which preceded the federal government's authorization to construct Lake Texana, addressed the project as two potential stages. While both stages were found to be cost-effective (Stage 1 had a benefit-to-cost ratio of 1.97, and Stage 1 and 2 combined was 1.93), Stage 1 was constructed first because of its greater yield and more attractive cost-to-yield ratio. In 1975, bids for Palmetto Bend Dam were taken, which is located on the Navidad River about six miles southeast of Edna, Texas, and the low bid was approximately $25 million. Total cost of the project is in excess of $70 million.

While the project was being constructed, additional mapping of the reservoir area became available, and the original area and capacity of the reservoir were found to be in error. The BuRec originally calculated the reservoir would cover 11,600 acres, would initially store 192,000 acre-feet of water at a normal elevation of 44 feet MSL, and after accumulation of 100 years of sediment (33,000 acre-feet) and yield-reducing development in the watershed, would yield 75,000 acre-feet per year. Using the newer mapping, the reservoir was found to actually cover approximately 9,900 acres, store 165,900 acre-feet of water at 44 feet MSL, and currently yield (as calculated by TWDB after allowing for current water rights) about 81,000 acre-feet per year.

1.2.2 Stage 2

Palmetto Bend Stage 2, as planned by the BuRec, included a reservoir at elevation 44 feet MSL covering 6,900 surface acres and storing 93,000 acre-feet of water. The BuRec calculated that after accumulating 100 years of sediment (22,000 acre-feet), the project would yield 30,000 acre-feet per year. The last cost estimates for Stage 2 were reported by the BuRec in 1965.

1.2.3 Garwood Irrigation Company

In early 1990, L-NRA and Garwood Irrigation Company (Garwood), discussed the purchase of a portion of Garwood's water right by L-NRA for the purpose of increasing the yield of Lake Texana. Garwood holds the most senior water right in the lower Colorado River Basin, with a priority date of November 1, 1900. Garwood's water right authorizes the diversion of 168,000 acre-feet per year at a maximum rate of 750 cubic feet per second (cfs) or 1,488 acre-feet per day. Garwood's facilities and the land it irrigates are primarily located in the Lavaca-Navidad Basin (refer back to Figure 1-1). Thus, the water diverted by Garwood is taken from the Colorado River and used primarily outside of the Colorado River Basin.

Garwood's system as it presently exists has the capacity, and it has been used historically, to irrigate approximately 27,000 acres in rice each year. The present capacity of Garwood's main pumping plant is approximately 490 cubic feet per second at normal river elevations, and substantially more at higher river elevations.

For various reasons, including a long-standing dispute with LCRA, Garwood has not yet fully developed its pumping facilities and canal system to allow the annual irrigation of 32,000 acres in rice as authorized under Garwood's right. Accordingly, the amount of water authorized to be diverted and used under Garwood's right exceeds the current capacity of Garwood's system for the irrigation of rice. L-NRA desires to evaluate the acquisition of a portion of Garwood's right for purposes of increasing the yield of Lake Texana. Garwood reports recently receiving various requests to expand its canal system and supply additional water. Before it takes any such action, however, Garwood is willing to consider selling a portion of its water right to L-NRA.

1.2.4 Other Issues

Because of a provision in the original Lake Texana permit which appeared to allow the Texas Water Commission to determine whether releases should be made from Lake Texana to benefit downstream bays and estuaries, an element of uncertainty has existed concerning the 75,000 acre-feet per year yield of Stage 1. To resolve this uncertainty, the Texas Parks and Wildlife Department, the Texas Water Development Board, and L-NRA are developing an agreement to propose an operating plan for Lake Texana. Although no agreement has been reached on the operating plan, indications are that the operation of Lake Texana in accordance with the proposed plan, will reduce the yield of the reservoir to about 74,400 acre-feet per year under initial sediment conditions.

Palmetto Bend Stage 2 will inundate about 6,100 acres of land, which is mostly under private ownership and which includes some wetlands, wildlife habitats, roads, bridges, utilities, and possibly some significant archaeological sites. The location of the dam and reservoir studied for this report is the site proposed for the Texas Water Commission storage permit. Because of the many sensitive factors involved, other sites will be studied if a decision is made to develop the project. Delays imposed in dealing with these factors could impact the project significantly.

2.0 COST AND YIELD OF PALMETTO BEND STAGE 2

Since the BuRec last developed estimates of cost for Stage 2 of Palmetto dam and reservoir in 1965, there have been a number of changes in the regulatory requirements which govern the design of dams. For a large dam (one which stores more than 50,000 acre-feet), the Texas Water Commission (TWC) requires that the structure must not be overtopped while passing the probable maximum flood (PMF), defined briefly as the flood magnitude that may be expected from the most critical combination of meteorologic and hydrologic conditions that are considered to be possible for a given watershed.

In addition to impacting the design and cost of Stage 2, current regulations also have been used to evaluate Stage 1. As part of its dam safety evaluation program, BuRec recently (1989) found that the PMF for Stage 1 (Lake Texana) would overtop the dam, which has a top elevation of 55.0 feet MSL, by about 1.3 feet.

Failure of Stage 1 to pass the PMF is significant because if Stage 2 is constructed as an enlargement of Stage 1, spillway capacity will have to be added so that the combined PMF can be passed without overtopping the dam for either stage. Therefore, in order to determine the optimum plan for constructing Stage 2, PMF's were developed for Stage 1, Stage 2, and for the combined watersheds of both stages.

2.1 Flood Hydrology and Hydraulic Analysis

The PMF was calculated using models and procedures developed by the U.S. Corps of Engineers (COE) and the U.S. Soil Conservation Service (SCS). HMR 52 was used to calculate the probable maximum precipitation (PMP), and HEC-1 was used to simulate rainfall - runoff relationships in the basins. Precipitation loss was simulated by selecting SCS Curve No. 91, and conservative estimates of the runoff from the PMP were applied by assuming the basin was saturated (SCS antecedent moisture condition 3) prior to the PMP. HEC-1, in combination with the SCS dimensionless hydrograph, was used to develop the flood hydrograph and route it through the reservoir. Lag times, i.e., the time delay between the midpoint of the rainfall and the peak of the flood hydrograph, were developed using actual hydrographs of floods recorded at the Lavaca River gage near Edna and the Navidad River gage near Ganado. The lag time for the Navidad River (Stage 1) was found to be approximately 41 hours, and the lag time for the Lavaca River (Stage 2) was 39 hours. The drainage area for Stage 1 is 1,346 square miles and the drainage area for Stage 2 is 852 square miles.

The PMF was developed for three scenarios:

- The PMP centered over the Lavaca River watershed above Stage 2;
- The PMP centered over the Navidad River watershed above Stage 1; and
- The PMP centered on the combined watersheds above the two dams.

As shown in Table 2-1, the maximum combined inflow occurs when the storm is centered over the combined watersheds. The maximum inflow to each reservoir occurs when the storm is centered over the appropriate watershed.

The BuRec's original design for Stage 2 assumed it would be constructed by extending the dam for Stage 1 so there would be two reservoirs behind one dam. Under this scenario, additional spillway capacity would have to be added to discharge the excess flow from Stage 1 plus the Stage 2 PMF.

Table 2-1 Summary of Probable Maximum Floods Palmetto Bend Reservoir Stage 1 and Stage 2			
Storm Center & PMP in Inches	**Stage 1 Maximum Inflow (cfs)**	**Stage 2 Maximum Inflow (cfs)**	**Combined Maximum Inflow (cfs)**
Navidad Basin *N = 36.2" *L = 19.8"	514,000	171,000	684,000
Lavaca Basin N = 17.1" L = 39.2"	239,000	366,000	604,000
Combined Basins N = 33.1" L = 31.1"	451,000	280,000	730,000

*N - Average probable maximum precipitation for 72-hour storm above Navidad River watershed above Stage 1 dam.
*L - Average probable maximum precipitation for 72-hour storm above Lavaca River watershed above Stage 2 dam.

From Table 2-1, it should be noted that the maximum inflow shown for Stage 1 is 514,000 cfs. This is about seven percent higher than the maximum discharge of 482,000 cfs calculated by the BuRec in 1989. This is a reasonably close correlation, especially in view of the conservative conditions that were assumed for this study.

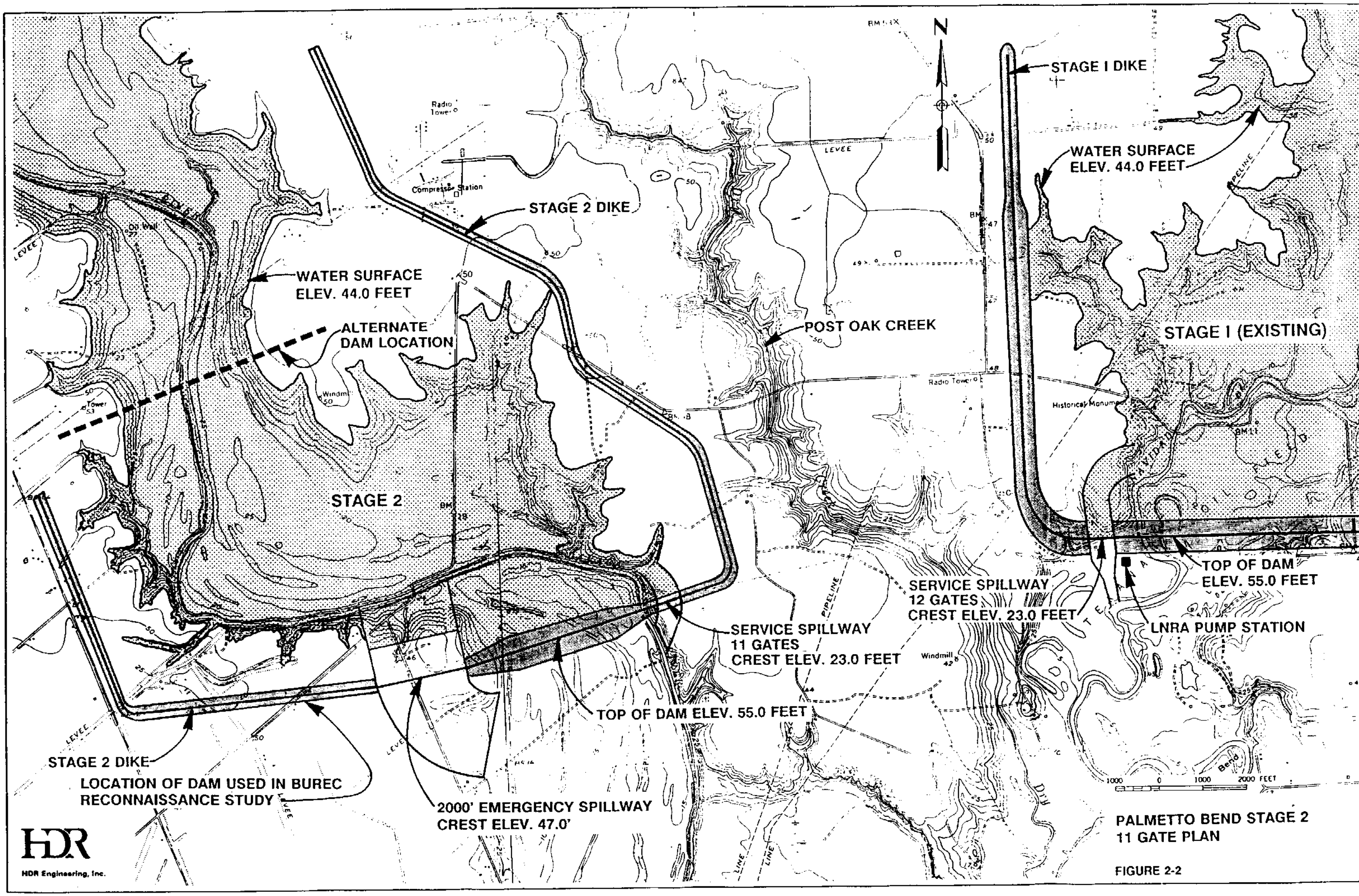
2.2 Dam and Spillway Alternatives

As discussed previously, the BuRec's original design for Stage 2 was based on tying the dams for Stage 1 and Stage 2 together to form one dam across both the Lavaca and Navidad Rivers. Since the Stage 1 spillway is not designed for PMF criteria, tying the two dams together would require either increasing the spillway capacity in Stage 1 and constructing a new spillway for Stage 2, or transmitting excess flows from Stage 1 to Stage 2 and building one large spillway for Stage 2. A very preliminary analysis of these two alternatives was performed, and it was determined that constructing two separate spillways would be significantly more expensive than transmitting excess flow from Stage 1 to Stage 2. Therefore, the two spillway alternative was discarded and more detailed studies were performed to determine the optimum spillway configuration for the single-spillway alternative.

Two alternative spillway configurations were investigated for the combination of Stage 2 and Stage 1 excess flows, as follows:

- A service spillway consisting of eighteen 35-foot wide tainter gates at a crest elevation of 23 feet MSL, plus a 2,000-foot long uncontrolled spillway at a crest elevation of 47 feet MSL; and
- An uncontrolled spillway consisting of a 6,000-foot long concrete structure utilizing roller-compacted concrete with a crest elevation of 44.75 feet MSL, plus a 2,000-foot uncontrolled spillway with a crest at elevation of 47 feet MSL.

The most economical of these two alternatives is the 18 gate service spillway with a 2,000-foot long uncontrolled spillway, as shown in Figure 2-1. This figure also shows that the most economical method of linking the two reservoirs together is a channel that would transfer excess flood flow from Stage 1 to Stage 2. This channel would need to have the capacity to transmit 258,000 cfs, which is the difference between the maximum flood for the Navidad River and the capacity of the existing Stage 1 spillway. This capacity would be provided by a 600-foot wide trapezoidal channel with bottom elevation of 12 feet MSL and 3:1 side slopes.



PALMETTO BEND STAGE 2
11 GATE PLAN

FIGURE 2-2

Since the spillway of Stage 1 is inadequate for the PMF and adds significantly to the cost of Stage 2, the option of totally separating Stage 2 from Stage 1 was studied. For this option, two alternatives were investigated:

- A service spillway consisting of eleven 35-foot wide tainter gates with a crest elevation of 23 feet MSL, plus a 2,000-foot long emergency spillway with a crest elevation of 47 feet MSL; and
- An uncontrolled 2,800 foot long roller-compacted concrete ogee with a crest elevation of 44.75 feet MSL, plus a 2,000 foot long uncontrolled emergency spillway with a crest at elevation of 47 feet MSL.

The most economical of these two alternatives is the 11 gate service spillway with a 2,000-foot long uncontrolled spillway, as shown in Figure 2-2. Note that in this alternative, the two reservoirs are completely separated and Post Oak Creek, which drains approximately 18 square miles of the Stage 2 drainage area, bypasses the dam.

It should be noted that these studies were based on the dam location used in the BuRec reconnaissance study for Stage 2. Other dam sites should be investigated when more detailed studies are performed. The alternate dam location shown on Figures 2-1, and 2-2 has several advantages including a much shorter dam and considerably less relocation of existing pipelines and roads. This site should be evaluated when more detailed studies are made.

2.3 Reservoir Yield

The firm yields of both Stage 1 and Stage 2 were determined using inflow data obtained from the Texas Water Commission. This data covered the period 1940 through 1979, which includes the 1953 to 1956 drought of record for the two reservoirs.

The area-capacity for both reservoirs was calculated during this study. For Stage 1, area data developed by the BuRec in 1981 was used, and for Stage 2, currently available USGS 7-1/2 minute mapping was used. The area-capacity for Stage 2 using current mapping differed from the BuRec's 1965 calculation by only 4 percent. Stage 2 capacity at elevation 44 feet including Post Oak Creek is estimated to be 89,400 acre-feet and without Post Oak Creek is estimated to be 82,800 acre-feet.

The rate of sedimentation used by the BuRec in its original studies was assumed to still be appropriate for both Stage 1 and Stage 2. This rate, 0.24 acre-feet per year per square mile of drainage area, results in the storage capacity of Stage 1 decreasing by 323 acre-feet each year, and Stage 2 capacity decreases by 200 to 204 acre-feet per year, depending on whether or not Post Oak Creek drains to the reservoir.

Evaporation data was calculated utilizing the average of published monthly net evaporation rates for quadrangle indeces 811 and 911, as presented in "Texas Water Development Board Report 64, Monthly Reservoir Evaporation Rates for Texas, 1940 through 1965." Evaporation rates for 1965 through 1974 were calculated using the same methodology presented in the referenced report. The actual calculation of yield was accomplished using RESOP II, a monthly simulation model developed by TWDB.

The firm yields of the two alternatives for Stage 2 (Stage 2 combined with Stage 1 and Stage 2 alone) are shown in Table 2-2. (These yields do not consider releases to bays and estuaries.) For comparison, the yield of Stage 1 has also been shown. By adding the yield shown for Stage 2 to Stage 1, it can be seen that interconnecting the two reservoirs would only slightly increase the yield by 2,218 acre-feet in 2000. As sedimentation of the reservoirs increases, the value of an interconnection increases. By 2040, the yield due to the interconnection would increase to 4,365 acre-feet, which is a 3.6 percent increase above the yield of the two separate reservoirs.

Table 2-2
Firm Yield
(acre-feet per year)

Year	Stage 1	Stage 2	Stage 2 combined with Stage 1
1985	82,645	---	---
1991	82,142	---	---
2000	81,396	48,171	131,785
2040	78,072	43,355	125,792

The yields shown in Table 2-2 are substantially higher than the yields determined by the BuRec, and they are also higher than yields which were used as a basis for obtaining the water rights permits for the reservoirs. This is true because the TWC inflow data produces more water for storage than the conservative BuRec inflow data. The L-NRA's current water rights permits include a total of 105,000 acre-feet per year for the two reservoirs, 75,000 acre-feet for Stage 1, and 30,000 acre-feet for Stage 2.

2.4 Estimated Construction Costs and Cost of Water

Estimates of construction cost for Stage 2 as a stand-alone project and as an extension of Stage 1 are shown in Table 2-3. Estimated land, environmental (mitigation costs), and permitting costs have been added to the estimated construction cost to arrive at the total estimated project cost. The cost to construct Stage 2 as a stand-alone project is significantly less than constructing Stage 2 as an expansion of Stage 1.

Table 2-3
Cost Estimate For Palmetto Bend Stage 2

Item	Stage 2	Stage 2 combined with Stage 1
Construction		
Mobilization	$2,700,000	$2,700,000
- Care of Water	1,000,000	1,000,000
- Dam	3,487,000	4,661,000
- Emergency Spillway	2,308,000	2,308,000
- Principal Spillway	14,456,000	23,528,000
- U.S. Slope Protection	1,320,000	1,644,000
- Underdrain System	892,000	1,367,000
- Channel Slope Protection	545,000	767,000
- Dam Road	1,148,000	840,000
- Revegetation	718,000	338,000
- Clearing	1,600,000	1,600,000
- Relocations	16,356,000	19,833,000
- Overflow Channel Between Reservoirs	0	14,400,000
- Design & Contingencies	11,633,000	18,747,000
Land		
- Land	$9,200,000	$10,800,000
- Legal & Survey	$1,380,000	$ 1,620,000
Environmental & Permits	$6,500,000	$ 6,500,000
Total Capital Cost	$75,243,000	$112,653,000
Annual Raw Water Cost		
- Debt Service, 8%, 25 years	$7,049,000	$10,553,000
- O&M	$ 800,000	$ 800,000
Total Annual Cost of Raw Water	$7,849,000	$11,353,000
Increase in Year 2000 Firm Yield Initial (AF)	*48,171	*50,389
Unit Cost of Raw Water		
- per AF Increase in Year 2000 Firm Yield	$163	$225
- per 1000 Gallons Maximum Firm Yield	50¢	69¢

* Amounts do not include releases for bays and estuaries.

Assuming the project can be financed at 8 percent interest for 25 years, the total annual cost of Stage 2, without including interest during construction, would be about $7,850,000, which would result in water costing $163 per acre-foot at the year 2000 yield of 48,171 acre-feet per year. This is equal to 50 cents per 1,000 gallons of firm yield.

3.0 EVALUATION OF ACQUIRING WATER RIGHTS FROM THE GARWOOD IRRIGATION COMPANY AND OTHER COLORADO BASIN SOURCES

3.1 Firm Yield Increase Due to Garwood Diversions

The general location of Garwood Irrigation Company (Garwood) was shown in Figure 1-1. Garwood's facilities consist of a channel dam and pump station located on the Colorado River, and a system of canals which deliver water throughout Garwood's service area. The pump station has a capacity at normal river elevations of approximately 220,000 gpm (490 cfs or 354,000 acre-feet per year) and lifts water approximately 40 feet from the Colorado River into the main Garwood Canal. Water is delivered from the canals through head gates that release water into open ditches, which then convey the water to the fields. The system presently is capable of irrigating a double crop of rice on over 27,000 acres of land.

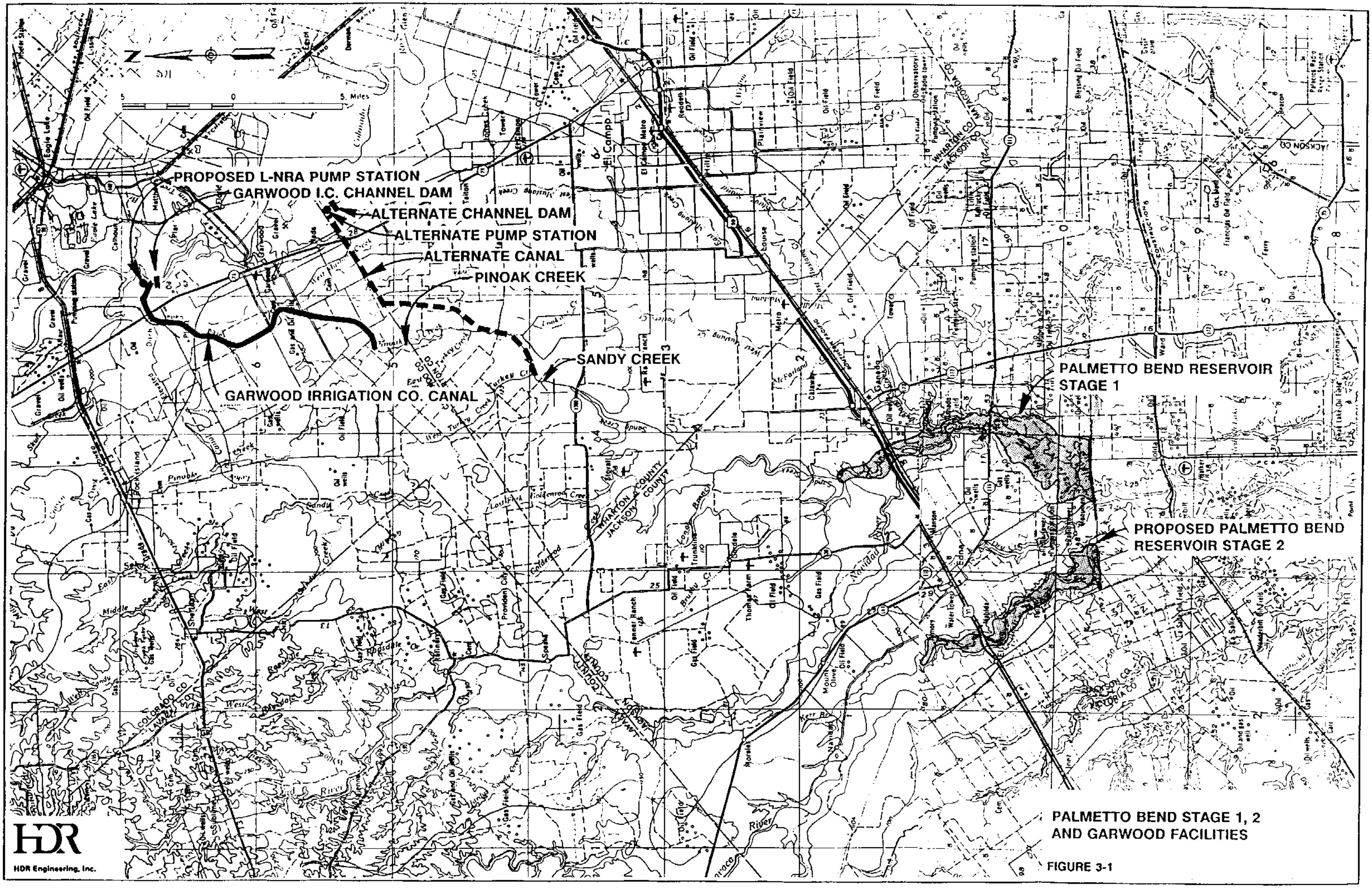
This study included a field reconnaissance of Garwood facilities and discussions with personnel responsible for the operation and maintenance of the facilities. The canals, pumps, and head gates were found to be well-maintained. From observations of the canal system, it appears that the canals are capable of handling more discharge than is presently being pumped. However, field measurements were not made, since such field work is beyond the scope of this study.

Most of the authorized Garwood service area is within the Lavaca-Navidad Coastal Basin, and the present Garwood system delivers water into the watersheds of Mustang Creek and Sandy Creek, both of which flow into Lake Texana (Stage 1). Return flows from Garwood's irrigation operations enter the creeks, tributaries, and branches of these streams. After field reconnaissance and review of area maps, Sandy Creek was determined to be preferable to Mustang Creek for delivery of the Garwood water to Lake Texana from the Garwood canal system as it presently exists, since the upper tributaries of Mustang Creek appear to have smaller channels with flatter gradients, less capacity, and more diversions than the tributaries of Sandy Creek. Based on these very preliminary studies, it appears the best place to discharge moderate flows of water from the Garwood canal system as it presently exists is Pinoak Creek, a tributary of Sandy Creek, at a location about seven miles southwest of the town of Garwood. However, above 300 cfs, it appears Pinoak Creek will flood, and larger discharges will need to be transmitted to Sandy Creek near the confluence of Pinoak Creek and Turkey Creek (see Figure 3-1).

An alternative delivery system (also shown in Figure 3-1) has been identified which would deliver higher flows. It should be emphasized that the determination of the capacity of the creeks is based on very preliminary analyses, and if L-NRA actually contracts for Garwood water, a more detailed evaluation should be made. This evaluation should include determination of the hydraulic capacities of the various sections of canals and creeks, and canal and creek channel losses should be determined for a wide range of flow rates.

Garwood has identified another option based upon expansion of its canal system to the vicinity of Sandy Creek. While this appears to be a viable option that may merit further study, it was not within the scope of work initially identified under this project.

In order to determine the optimum amount of water to divert from the Colorado River into Lake Texana, the study plan was to use total flow data and unappropriated flow data from the Texas Water Commission's Water Availability Model. However, such information was not available from TWC and could not be obtained. Therefore, flow data were obtained from the Texas Water Development Board. This was accomplished using the TWDB model, DIV-PRD, which simulates daily water availability in the Colorado River



PALMETTO BEND STAGE 1, 2
AND GARWOOD FACILITIES

FIGURE 3-1

below Lake Travis. The daily flows from the model were then summed to obtain monthly totals.

After evaluating the monthly flow data (total flow and estimates of unappropriated flow) at Garwood, it appears there are at least two possible diversion scenarios. The first would be to divert throughout the year, maintaining as constant a diversion rate as possible, thereby minimizing the size of diversion facilities. Since substantial flows occur during the five-month period of November through March when there is practically no irrigation, the second scenario limits diversions to those five months. This scenario has the added advantage of minimizing the impact on Garwood's operations, since there is no irrigation during those five months. This allows maximum utilization of Garwood's canals, but due to the previously described capacity limitations of Pinoak Creek, utilization of Garwood's facilities would still be limited. A third scenario would be to divert only during the seven months when rice irrigation generally occurs (April through October). This scenario may be a viable option which should be studied, but was not within the scope of work initially identified under this project.

After examining TWDB's Colorado River flow records, 30,000 acre-feet per year was selected as the minimum diversion for analysis. Based on the assumptions that at least 100 cfs would be allowed to pass Garwood's channel dam and Garwood will be diverting 490 cfs between April and October, the lowest annual amount of water historically available was found to be 61,487 acre-feet which occurred in 1954 (see Table 3-1). However this amount includes substantial flows occurring in excess of 1,000 cfs. The water may have to be pumped at Garwood's full 750 cfs diversion rate at some times in the driest years in order to be able to divert the full 30,000 acre-feet during those years. In the seven-month (April through October) diversion scenario, there probably would be some shortages in some years.

TABLE 3-1
ESTIMATED WATER AVAILABLE AT GARDWOOD'S CHANNEL DAM AFTER PASSING 100 CFS
AND AFTER GARWOOD DIVERTS 490 CFS BETWEEN APRIL AND OCTOBER
(ACRE-FEET)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1941	131844	97704	248736	304515	290680	474867	237928	31433	1368	26213	87415	72929	2005632
1942	26584	34726	36832	217507	28874	5991	155223	5041	62931	24797	39335	29662	667506
1943	49307	32963	51120	6921	12441	4733	10024	988	3234	452	17282	38912	228380
1944	121691	110776	184758	14989	96556	16197	799	420	40043	327	98004	163060	847619
1945	257651	128911	99023	283755	26487	62254	1598	44003	15168	30988	21391	36701	1007933
1946	114017	124596	220220	63196	149387	169963	75891	3788	67926	26410	287382	114943	1417716
1947	211527	66611	101575	40586	20566	0	335	51804	11416	5328	22682	26382	558811
1948	19051	34066	26610	498	27310	0	1271	502	4418	2011	14896	11396	142030
1949	18846	124421	66355	264701	32545	5227	1344	0	5400	104530	23800	58602	705772
1950	46002	120281	22584	90385	27651	141435	6875	0	23393	0	10197	11232	500031
1951	10903	16358	14157	5719	63	70331	0	0	19150	1481	8864	7633	154656
1952	5211	8713	6185	20447	69197	6552	2060	0	3700	734	22212	98208	243219
1953	63121	42397	23463	14226	190015	0	15775	5495	31585	73859	37122	101288	598342
1954	26211	13486	5376	593	6538	0	0	3086	0	0	3817	2382	61487
1955	5039	45928	3986	1035	53682	21595	5076	1953	916	5245	11553	13621	169626
1956	7807	34663	8485	0	9433	0	0	6	0	0	4174	9873	74442
1957	3694	9612	83032	210305	297408	268772	601	954	190465	477728	165813	84323	1792705
1958	174258	389479	114346	40199	137755	21763	6597	436	114360	37951	105611	32523	1175280
1959	20354	87625	32511	314643	40790	23157	853	5614	1993	73764	75007	61283	737593
1960	72007	96998	46946	38129	204864	276446	16869	8761	3078	129200	431299	160397	1484991
1961	224690	267455	65469	19707	6129	369185	250074	26	399515	20829	114853	43664	1781595
1962	58459	42133	34407	10082	6256	26031	5566	240	25313	15456	26806	57495	308243
1963	38641	62052	25402	16124	0	0	716	0	0	0	9818	10306	163054
1964	9126	16976	43469	0	12	32067	14	0	31712	23485	29824	18491	205177
1965	133432	275835	54253	12364	289236	95454	2041	0	9881	6970	103326	178619	1161409

SOURCE: DEVELOPED FROM DATA PROVIDED BY THE TEXAS WATER DEVELOPMENT BOARD

Those shortages could be made up by stored water supplied by LCRA, either under Garwood's current contract with LCRA or under a new contract.

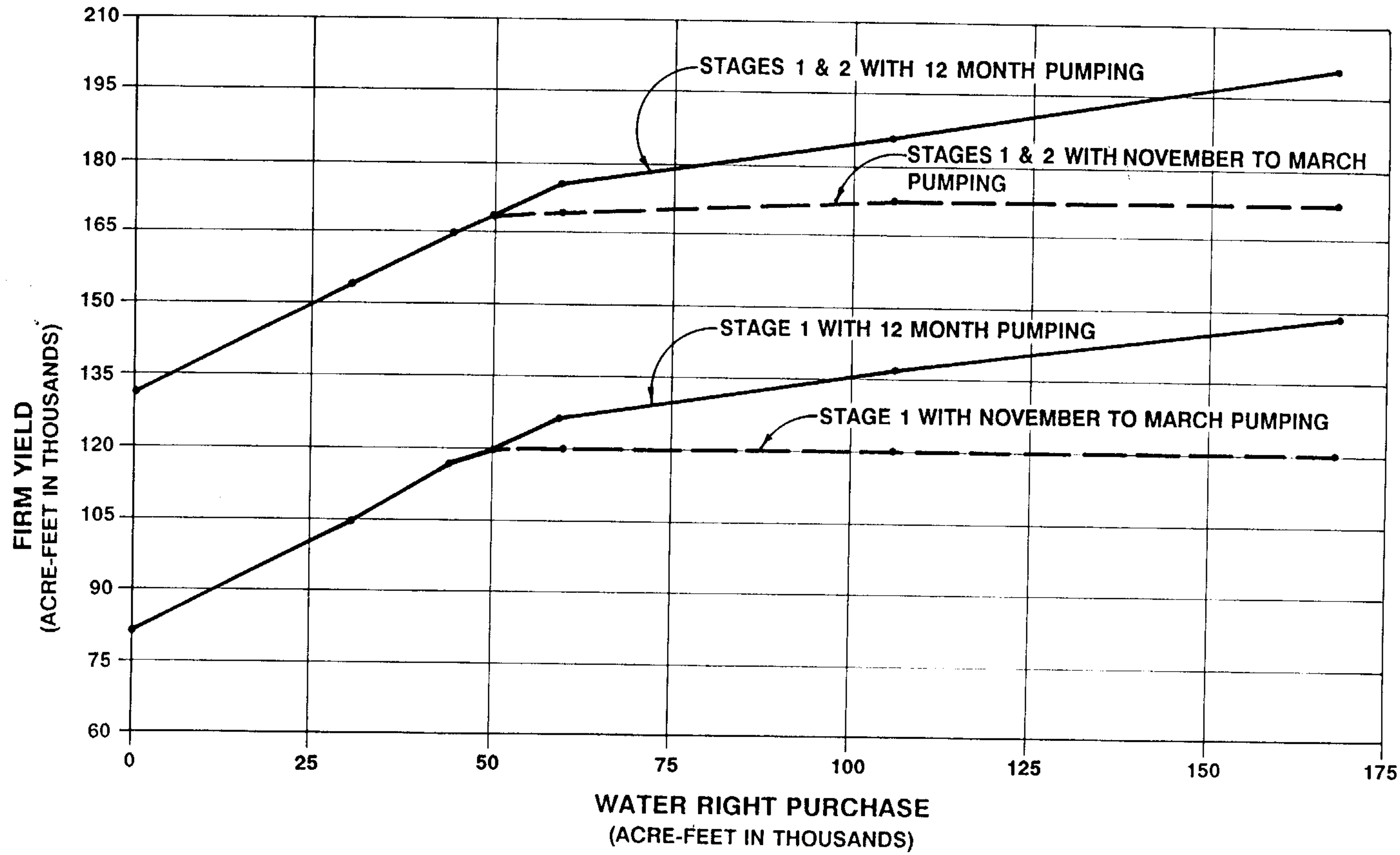
The maximum annual diversion selected for evaluation was 168,000 acre-feet, which is the total amount of Garwood's water right. (Garwood has indicated that it is not willing to consider selling more than 30,000 acre-feet, but one of this study's objectives is to determine the optimum amount of Garwood water to divert into Lake Texana.) Therefore, other diversion quantities evaluated included 44,000 acre-feet and 106,000 acre-feet (the mid point between 168,000 and 44,000). These annual diversion rates were coupled with selected maximum pumping rates to ensure realistically sized pumping facilities were used.

After the water is diverted from the Colorado River, water losses will occur as water flows through open earthen channels such as the creeks and Garwood's canals. Garwood has performed limited studies of the losses in their canals and based upon analysis of Garwood's loss data, a loss of 150 acre-feet per mile per year was used for the canals. HDR performed a visual survey of the creeks in the area and, based on more detailed channel loss studies HDR has performed at other locations, estimated the annual losses in creeks would be about 0.7 percent per mile of stream channel. For purposes of this preliminary report only, taking into consideration the distance the water will travel and estimated canal and creek losses, it is estimated that the total loss between the diversion point and Lake Texana will be 23 percent of the total diversion. Therefore, if 30,000 acre-feet are diverted, it is estimated that 6,900 acre-feet will be lost and 23,100 acre-feet will reach the reservoir and contribute to its yield. Similarly, if 168,000 acre-feet are diverted, it is estimated that 39,000 acre-feet will be lost and 129,000 acre-feet will reach the reservoir.

Obviously, the canals and creek channels could be lined or a conduit could be constructed to virtually eliminate channel losses. Any new facilities would initially have lower loss rates, but over time, they, too, could be expected to have increasing losses. Also, since the facilities are delivering raw water, more detailed studies will probably find that the most cost-effective delivery facilities, under current conditions, will be earthen lined canals similar to Garwood's. Therefore, the loss rates used in these studies are 23 percent for all delivery facilities, which should result in a conservative estimate of the amount of water delivered to Lake Texana. However, at some point in the future it probably will become economically feasible and/or administratively desirable to construct a pipeline from the Colorado River (or from some point on Garwood's canal system) to Lake Texana in order to maximize the benefits of acquiring a portion of Garwood's right. Thus, in the long-term, these losses may be very low.

Using 23 percent channel losses, diversion rates of 30,000, 44,000, 106,000, and 168,000 acre-feet per year, and 12-month and 5-month (November through March) pumping schedules, yield analyses were performed for both Stage 1 only and Stage 1 combined with Stage 2. Plots of these analyses indicated that the optimum diversion rate occurs between 44,000 and 106,000 acre-feet per year. Subsequent analysis at diversion rates of 50,000 and 60,000 acre-feet per year indicated that one of those two rates is the optimum amount to divert, depending on the pumping schedule, as explained below.

As shown in Figure 3-2, if pumping occurs only between November and March, diverting 50,000 acre-feet per year is the optimum amount to enhance the firm yield of either Stage 1 or Stage 1 combined with Stage 2. With year-round pumping, the optimum diversion amount is 60,000 acre feet. Table 3-2 indicates the pumping rate for each of the



BASED ON YEAR 2000 YIELDS

HDR Engineering, Inc.

YIELD OF LAKE TEXANA WITH VARIOUS DIVERSIONS FROM GARWOOD

FIGURE 3-2

diversions, the amount of water reaching the reservoir after 23 percent channel losses, and the firm yield calculated for one or both reservoirs using the two pumping schedules.

Table 3-2 Lake Texana Firm Yield with Supplemental Diversions from Garwood						
			Increase in Stage 1 Firm Yield		Increase in Stage 1 Combined w/Stage 2 Firm Yield	
Pumping Rate (cfs)	Total Amount Purchased (acre-feet)	Water* Reaching the Reservoir(s) (acre-feet)	Year Round Pumping (acre-feet)	Nov-March Pumping (acre-feet)	Year Round Pumping (acre-feet)	Nov-March Pumping (acre-feet)
0-300	30,000	23,100	23,100	23,100	23,100	23,100
0-500	44,000	33,800	33,800	33,800	33,800	33,800
0-750	50,000	38,500	38,100	38,000	37,900	37,700
0-750	60,000	46,200	45,200	38,500	44,900	38,900
0-750	106,000	81,620	55,500	38,500	55,100	41,700
0-750	168,000	129,360	67,000	38,500	70,100	41,700

*after 23% channel losses.

3.2 Cost of Purchasing Garwood Water

As discussed in the previous section, the diversion rate which optimally increases the firm yield of Lake Texana is either 50,000 acre-feet per year or 60,000 acre-feet per year. Firm yield is calculated assuming a constant rate of withdrawal from Lake Texana every day of every year, even through the drought of record. This constant rate minimizes the size of facilities needed to withdraw water and deliver it to the customer cities, and it ensures that water is always available to meet that demand, as long as a drought worse than the drought of record does not occur. The annual total of the amount of water which can be withdrawn is the firm yield.

With the November through March diversion plan, use of Garwood's existing canals can be maximized. It is estimated that Garwood's facilities could be used to divert at a rate up to 300 cfs; however, at pumping rates above 300 cfs, a separate facility would be required, such as that shown in Figure 3-1. Costs, including both capital and O & M, are presented for each diversion rate in Table 3-3.

In order to compare the cost of purchasing Garwood water in amounts above 30,000 and 44,000 acre-feet with water from other sources, assumptions had to be made about the impact such a purchase might have on Garwood's operations. Any impact on Garwood's operations might necessitate additional payments to compensate Garwood, if they were willing to sell amounts above 30,000 acre-feet. In order to estimate the potential cost of impacts to Garwood, it was assumed that the cost of water above 44,000 acre-feet would be increased to cover impacts to Garwood's operations as shown in Table 3-3. It is not certain that these costs would be required, but they have been included to provide conservative estimates.

The unit cost of raw water if 30,000 acre-feet of water is purchased from Garwood is significantly lower than the unit cost of purchasing larger volumes from Garwood. This lower cost is primarily attributable to the benefit of using Garwood's facilities and there not being any significant impact to Garwood's customers.

In any amount above 30,000 acre-feet, water purchases would impact Garwood's operations. Therefore, for all diversion rates above 30,000 acre-feet per year, it was assumed that new facilities would be required. Garwood has indicated a willingness to expand their facilities to accommodate L-NRA's flows. This should be explored if a purchase of a portion of Garwood's water rights is made. It is likely that sharing of Garwood's facilities would reduce the cost of conveying the Garwood water.

Table 3-3
Cost of Purchasing and Delivering Garwood Water to Lake Texana

Water Purchased from Garwood (AF)	30,000	44,000	50,000	60,000	106,000	168,000
Purchase Garwood's Rights						
- Purchase Water Rights at $200/AF	$6,000,000	$8,800,000	$10,000,000	$12,000,000	$21,200,000	$33,600,000
- Additional Cost if more than 44,000 A-F Purchased	--	--	1,990,000	5,300,000	20,500,000	41,100,000
- Legal & Other Professional Services	500,000	880,000	1,000,000	1,200,000	2,120,000	3,360,000
Additions to Garwood's Facilities						
- Pump Station	$2,200,000	---	---	---	---	---
- Pipeline	300,000	---	---	---	---	---
- Modifications to Garwood's System	500,000	---	---	---	---	---
- Design & Contingencies	750,000	---	---	---	---	---
Construct New Diversion Facilities						
- Diversion & Transmission Facilities	---	$24,978,000	$26,868,000	$27,813,000	$28,758,000	29,704,000
- Right of Way, Legal	100,000	800,000	825,000	838,000	850,000	862,000
- Environmental & Permits	100,000	500,000	500,000	500,000	500,000	500,000
Total Capital Cost	$10,450,000	$35,958,000	$41,129,000	$47,651,000	$73,928,000	$109,126,000
Annual Raw Water Cost						
- Debt Service (8%, 25 years)	$980,000	$3,369,000	$3,854,000	$4,465,000	$6,927,000	$10,225,000
- Annual Fee for Use of Garwood Facilities	390,000	---	---	----	---	---
- Operations & Maintenance	250,000	360,000	395,000	451,000	704,000	1,046,000
Total Annual Cost of Raw Water	$1,620,000	$3,729,000	$4,249,000	$4,916,000	$7,631,000	$11,271,000
Maximum Firm Yield (AF)	23,100	33,800	38,100	45,200	55,500	70,100
Unit Cost of Raw Water						
- per AF Purchased	$54	$85	$85	$82	$72	$67
- per AF Maximum Firm Yield	$70	$110	$112	$109	$137	$161
- per 1000 Gallons Maximum Firm Yield	22¢	34¢	34¢	33¢	42¢	49¢

3.3 Firm Yield Due to Diversion of Unappropriated Water

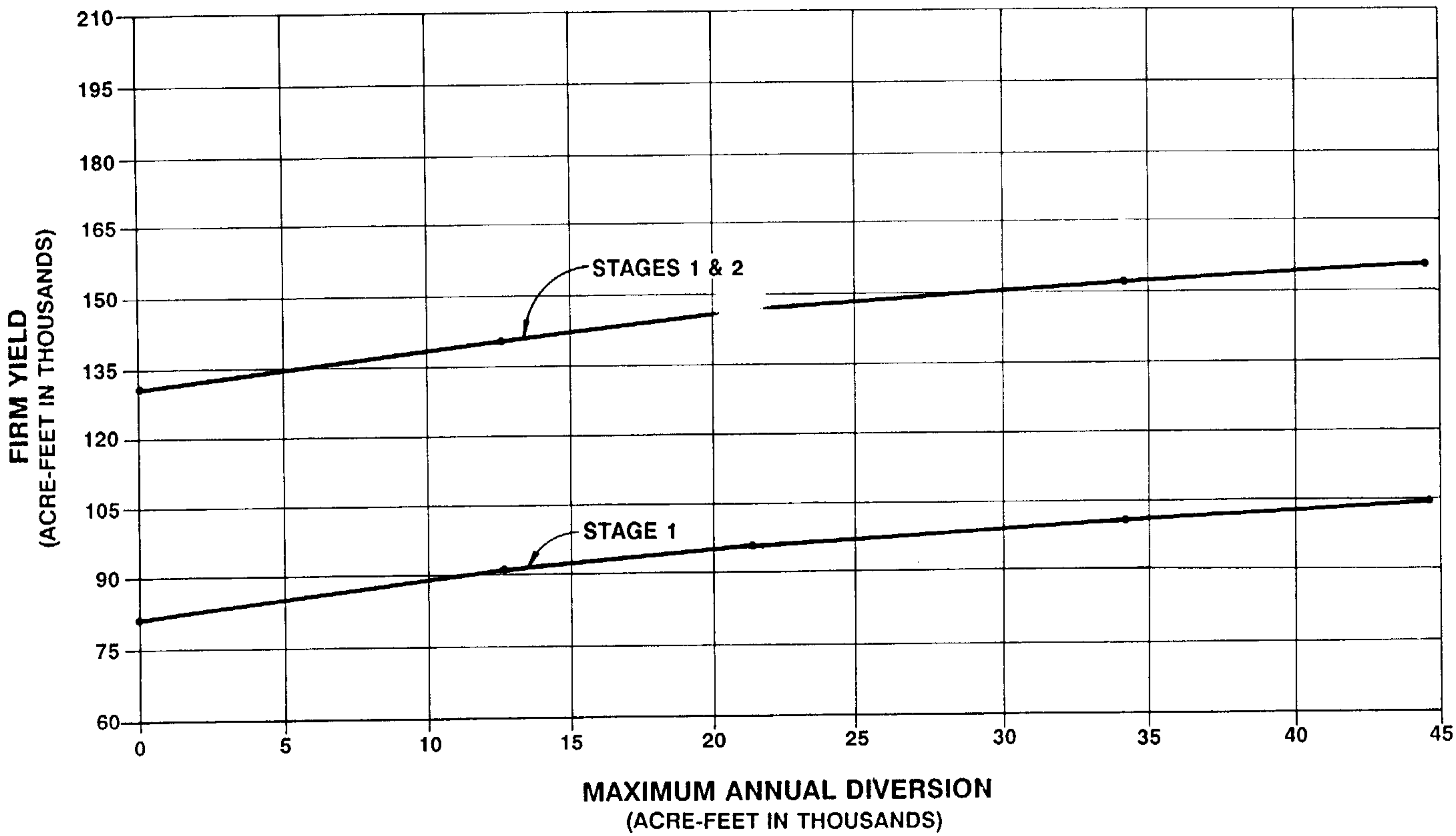
The November, 1990 Texas Water Plan, "Water for Texas, Today and Tomorrow," projects water supplies in the Colorado River Basin to exceed demands by 457,369 acre-feet in year 2000 and by 121,189 acre-feet in year 2040. As an alternative to purchasing water from Garwood Irrigation Company, the possibility of diverting unappropriated water from the Colorado River was investigated. As in the analyses using Garwood water, this analysis used flow data obtained from the TWDB model, DIV-PRD, and included assumptions regarding the quantities to be bypassed for downstream water rights. In calculating the unappropriated flow available, all existing major water rights above and below the diversion point were honored first. A bypass of 400 cfs was assumed to account for downstream water rights and to help maintain flows for preservation of bays and estuaries. The resultant monthly calculated flows available for diversion are shown in Table 3-4. These flows should be treated as approximations and more detailed analyses would be required to more accurately determine these flows. The estimates should provide realistic flow patterns suitable for estimating the effects on the yield of Lake Texana and Palmetto Bend Stage 2 from Colorado River sources of water other than Garwood although no other water rights have been identified for purchase.

Using the estimates of unappropriated Colorado River water, the firm yields which can be developed in Lake Texana for Stage 1 alone and Stage 1 combined with Stage 2 are shown in Figure 3-3. Channel loss rates were included which reduced the amount of water reaching Lake Texana by 23 percent. Table 3-5 presents the estimated increases in yield with diversions of unappropriated Colorado River water. It is expected that diversion of

TABLE 3-4
ESTIMATED WATER AVAILABLE IN THE COLORADO RIVER DOWNSTREAM OF GARWOOD'S DAM AFTER UPSTREAM DIVERSIONS AND PASSING 400 CFS
(ACRE FEET)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1941	112600	84400	211700	188300	241300	239900	193600	23400	0	30200	65200	49000	1439600
1942	9400	14300	13600	155400	18600	2300	95000	2000	46900	22800	25000	15700	421000
1943	32600	17300	33800	3300	3500	2400	4300	0	0	200	1700	19800	118900
1944	93300	94800	157100	4400	75600	8500	0	0	28000	1900	80400	120800	664800
1945	179800	108500	67600	192500	11600	47700	0	27200	12500	32900	4800	16400	701500
1946	89500	99100	145000	47600	124300	124900	49300	1900	47800	33100	210100	89100	1061700
1947	176700	43600	78500	27200	10300	0	0	48300	2500	4300	6800	7900	406100
1948	7100	22100	6900	0	20600	0	0	0	800	1300	2100	400	61300
1949	7000	65400	60000	140600	31100	1800	100	0	600	96000	4500	36700	443800
1950	25400	101100	2900	78400	19600	103500	2600	0	15500	0	700	900	350600
1951	700	2500	1800	3700	0	50200	0	0	12600	600	0	0	72100
1952	0	200	0	15500	57100	5800	0	0	0	500	11200	78600	168900
1953	32600	25100	8200	6800	140800	0	11800	3200	20900	67200	15700	63200	395500
1954	7000	0	0	0	2500	0	0	800	0	0	0	0	10300
1955	0	34100	0	0	44300	16000	1200	0	0	3200	800	2200	101800
1956	0	18300	0	0	5000	0	0	0	0	0	0	3700	27000
1957	0	3000	65900	91400	149900	192500	0	0	86400	221100	135500	56100	1001800
1958	145200	136500	80700	23500	84400	15700	2300	0	70000	36200	78700	8500	681700
1959	4600	64000	8000	220400	29300	13200	0	1700	0	73400	49400	37000	501000
1960	44500	73100	20200	22000	91000	99200	7800	1900	0	98500	214700	131000	803900
1961	195000	214000	34700	10800	600	122900	126900	0	133000	19500	92400	18300	968100
1962	36200	24000	12500	7000	4500	18000	1200	0	17700	14500	10800	32700	179100
1963	17200	42300	5200	11900	0	0	0	0	0	0	0	0	76600
1964	0	2000	24700	0	0	24800	0	0	25600	21300	10600	2900	111900
1965	60700	186500	24400	5300	180400	80900	0	0	4800	6000	79100	133600	761700

SOURCE: DEVELOPED FROM DATA PROVIDED BY THE TEXAS WATER DEVELOPMENT BOARD



BASED ON YEAR 2000 YIELDS

HDR Engineering, Inc.

YIELD OF LAKE TEXANA WITH DIVERSION OF COLORADO RIVER UNAPPROPRIATED FLOWS

FIGURE 3-3

Table 3-5 Lake Texana Firm Yield with Supplemental Diversion of Unappropriated Colorado River Water				
Pumping Rate (cfs)	**Maximum Annual Diversion (acre-feet)**	**Maximum* Amount of Water Reaching the Reservoir (acre-feet)**	**Increase in Stage 1 Firm Yield (acre-feet)**	**Increase in Stage 1 Combined with Stage 2 Firm Yield (acre-feet)**
0-250	12,600	9,700	9,700	9,700
0-500	21,300	16,400	14,600	16,200
0-1000	34,100	26,300	19,600	21,800
0-1500	44,500	34,300	23,000	25,200

*after 23% channel losses.

Colorado River water rights other than Garwood would produce similarly shaped curves as those shown in Figure 3-3.

If a water rights permit were obtained for unappropriated Colorado Basin water, the permit would stipulate the maximum pumping rate and the maximum amount of water that could be diverted annually. Similar restrictions were imposed on this analysis.

3.4 Cost of Diverting Unappropriated Water

After obtaining a permit to divert unappropriated water from the Colorado River (or any other nearby river), there would be costs to construct, operate, and maintain the diversion and conveyance facilities. As shown in Table 3-6, the cost of these facilities is significant relative to the yield obtained, because the facilities must be sized to pump at a high rate when there is flow in the river. The unit cost per acre-foot of yield is fairly level for the three lower diversion rates, but for diversions at the maximum rate of 1,500 cfs, the costs increase significantly relative to the yield. Therefore, on a cost-benefit basis, diverting

Table 3-6
Cost of Delivering Unappropriated Colorado River Water to Lake Texana

Maximum Pumping Rate (cfs)	250	500	1000	1500
Maximum Annual Diversion (AF)	12,600	21,300	34,100	44,500
Obtain Water Rights Permit	$500,000	$500,000	$500,000	$500,000
Construct New Diversion Facilities				
- Diversion & Transmission Facilities	$14,444,000	$24,978,000	$34,429,000	$44,700,000
- Right of Way & Relocations	400,000	800,000	924,000	1,019,000
- Environmental & Permits	500,000	500,000	500,000	500,000
Total Capital Cost	$15,844,000	$26,778,000	$36,356,000	$46,719,000
Annual Raw Water Cost				
- Debt Service (8%, 25 years)	$1,485,000	$2,509,000	$3,407,000	$4,378,000
- Operations & Maintenance	169,000	238,000	308,000	365,000
Total Annual Cost of Raw Water	$1,654,000	$2,747,000	$3,715,000	$4,743,000
Maximum Increase in Firm Yield (AF)	9,700	16,200	21,800	25,200
Unit Cost of Raw Water				
- per AF Maximum Annual Diversion	$131	$129	$109	$107
- per AF Maximum Firm Yield	$171	$170	$170	$188
- per 1,000 Gallons Maximum Firm Yield	52¢	52¢	52¢	58¢

a maximum of 34,100 acre-feet at a maximum rate of 1,000 cfs appears to be the optimal maximum limit of diversions of unappropriated water from the Colorado River.

3.5 Firm Yield Increase Due to Garwood Diversions Combined with Diversion of Unappropriated Colorado River Water

As shown in previous sections, the optimum amount of water to divert into Stage 1 is about 50,000 acre-feet per year, and the optimum amount to divert to the combination of Stage 1 and Stage 2 is about 60,000 acre-feet. Garwood has indicated a willingness to consider selling only 30,000 acre-feet; therefore, combining unappropriated Colorado River water with diversions of Garwood water was investigated.

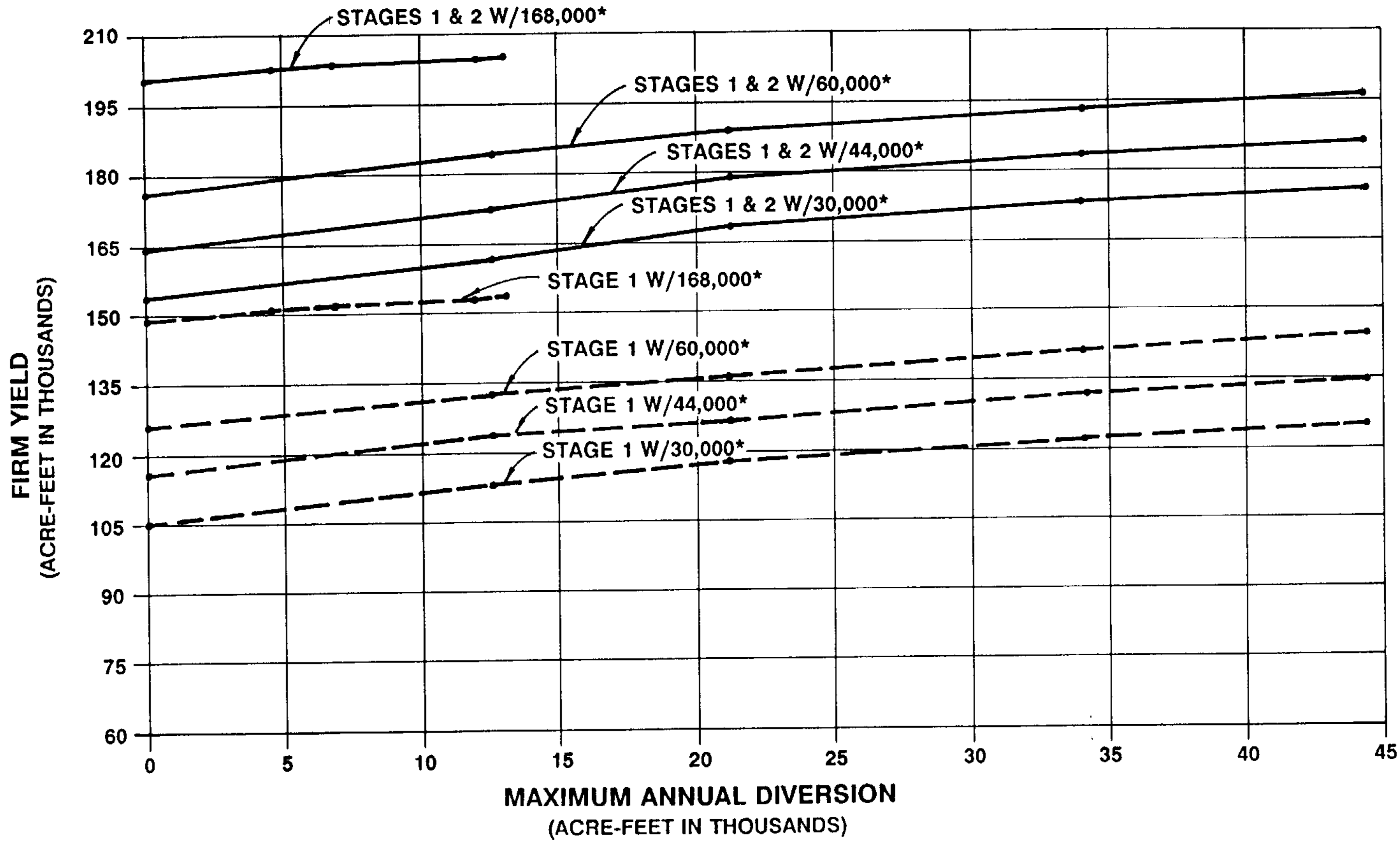
In order to display the full range of options for combining Garwood and unappropriated water, four quantities of Garwood water (30,000, 44,000, 60,000, and 168,000 acre-feet) were combined with the four pumping rates (250, 500, 1,000, and 1,500 cfs) used in the analyses of unappropriated water. Using these combinations, the firm yields which can be developed are shown in Figure 3-4. Channel loss rates were included which reduced the amount of water reaching Lake Texana by 23 percent. Table 3-7 presents the increases in yield by combining unappropriated Colorado River water with purchases of water from Garwood. Note that combining 30,000 acre-feet of Garwood water with a 500 cfs pumping rate for unappropriated water diversions results in

Table 3-7
Lake Texana Firm Annual Yield With a Combination of Diversions From Garwood and Diversions of Unappropriated Colorado River Water

Total Amount Purchased from Garwood (acre-feet)	Maximum Amount of Unappropriated Water Diverted (acre-feet)	Maximum Pumping Rate for Unappropriated Water (cfs)	Maximum* Amount of Water Reaching the Reservoir(s) (acre-feet)	Increase in Stage 1 Firm Yield (acre-feet)	Increase in Stage 1 combined w/Stage 2 Firm Yield (acre-feet)
30,000	12,600	250	32,800	32,000	32,000
"	21,300	500	39,500	36,700	37,900
"	34,100	1,000	49,400	41,100	43,300
"	44,500	1,500	57,400	44,300	46,500
44,000	12,600	250	43,600	42,400	42,400
"	21,300	500	50,300	45,900	48,300
"	34,100	1,000	60,100	50,300	53,900
"	44,500	1,500	68,100	53,500	56,000
60,000	12,600	250	55,900	51,400	53,800
"	21,300	500	62,600	54,800	58,000
"	34,100	1,000	72,500	59,300	62,500
"	44,500	1,500	80,500	62,600	65,700
168,000	4,700	250	139,100	69,300	72,400
"	6,900	500	145,800	70,400	73,600
"	12,100	1,000	155,600	71,500	74,600
"	13,100	1,500	163,600	72,200	75,300

*after 23% channel losses

a Stage 1 yield that is slightly more than the yield from purchasing 50,000 acre-feet of Garwood's water rights. Similarly, combining 30,000 acre-feet of Garwood water with a



*WATER RIGHTS PURCHASED FROM GARWOOD

BASED ON YEAR 2000 YIELD

HDR Engineering, Inc.

YIELD OF LAKE TEXANA WITH DIVERSION OF COLORADO RIVER UNAPPROPRIATED FLOWS COMBINED WITH DIVERSIONS FROM GARWOOD

FIGURE 3-4

1,000 cfs pumping rate for unappropriated water diversions results in a combined Stage 1 and Stage 2 yield that is slightly less than the yield from purchasing 60,000 acre-feet of Garwood's water rights.

3.6 Cost of Garwood Diversions combined with Diversions of Unappropriated Colorado River Water

Combining unappropriated water with Garwood water increases the yield available in Lake Texana while minimizing purchases of Garwood water. Since the cost of diverting unappropriated water is significantly greater than the cost of purchasing Garwood water (especially greater than the cost of purchasing 30,000 acre-feet of Garwood water), it was expected that the cost of combining unappropriated and Garwood water would make this option unreasonable. However, as shown in Table 3-8, the cost to obtain 32,000 acre-feet of yield is about $102 per acre-foot, which is slightly lower than the cost of $110 to obtain 33,800 acre-feet of yield by purchasing 44,000 acre-feet of Garwood yield (see Table 3-3).

Graphical comparisons of the cost of developing firm yield by combining Garwood water and unappropriated water indicates that for exactly the same firm yield in Lake Texana, the combination using 30,000 acre-feet of Garwood water results in costs slightly higher than for purchasing only Garwood water to produce the same yield. For combinations using 44,000 acre-feet or more of Garwood water, the costs are significantly more than using only Garwood water. The benefit of using Garwood's facilities to deliver the 30,000 acre-feet of water is clearly evident.

Maximum Pumping Rate (cfs)	250	500	1000	1500	250	500	1000	1500
	Combined with 30,000 acre-feet from Garwood				Combined with 44,000 acre-feet from Garwood			
Purchase Garwood's Right	$6,600,000	$6,600,000	$6,600,000	$6,600,000	$9,680,000	$9,680,000	$9,680,000	$9,680,000
Additions to Garwood's Facilities	3,750,000	3,750,000	3,750,000	3,750,000	---	---	---	---
Obtain Water Rights Permit	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Construct New Diversion Facilities	15,344,000	26,278,000	35,856,000	46,219,000	41,622,000	52,556,000	62,134,000	72,497,000
Total Capital Cost	26,194,000	37,128,000	46,706,000	57,069,000	51,802,000	62,736,000	72,314,000	82,677,000
Annual Raw Water Cost								
- Debt Service (8%, 25 years)	$2,454,000	$3,479,000	$4,376,000	$5,347,000	$4,853,000	5,878,000	6,776,000	7,747,000
- Operations & Maintenance	419,000	488,000	558,000	615,000	529,000	598,000	668,000	725,000
- Garwood Annual Fee	400,000	400,000	400,000	400,000	---	---	---	---
Total Annual Cost of Raw Water	$3,273,000	$4,367,000	$5,334,000	$6,362,000	$5,382,000	$6,476,000	$7,444,000	$8,472,000
Maximum Increase in Firm Yield (AF)	32,000	37,900	43,300	46,500	42,400	48,300	53,900	56,000
Unit Cost of Raw Water								
- per AF Maximum Firm Yield	$102	$115	$123	$137	$127	$134	$138	$151
- per 1000 Gallons Maximum Firm Yield	31¢	35¢	38¢	42¢	39¢	41¢	42¢	46¢

Maximum Pumping Rate (cfs)	250	500	1000	1500	250	500	1000	1500
	Combined with 60,000 acre-feet from Garwood				Combined with 168,000 acre-feet from Garwood			
Purchase Garwood's Right	$18,500,000	$18,500,000	$18,500,000	$18,500,000	$78,060,000	$78,060,000	$78,060,000	$78,060,000
Additions to Garwood's Facilities	---	---	---	---	---	---	---	---
Obtain Water Rights Permit	500,000	500,000	500,000	500,000	1,500,000	1,500,000	1,500,000	1, 500,000
Construct New Diversion Facilities	44,495,000	55,429,000	65,007,000	75,370,000	35,853,000	41,036,000	50,776,000	59,890,000
Total Capital Cost	63,495,000	74,429,000	84,007,000	94,370,000	115,413,000	120,596,000	130,336,000	139,450,000
Annual Raw Water Cost								
- Debt Service (8%, 25 years)	$5,949,000	$6,974,000	$7,871,000	$8,842,000	$10,814,000	$11,300,000	$12,212,000	$13,066,000
- Operations & Maintenance	620,000	689,000	759,000	816,000	758,000	766,000	774,000	779,000
- Garwood Annual Fee	---	---	---	---	---	----	---	---
Total Annual Cost of Raw Water	$6,569,000	$7,663,000	$8,630,000	$9,658,000	$11,572,000	$12,066,000	$12,986,000	$13,845,000
Maximum Increase in Firm Yield (AF)	53,800	58,000	62,500	65,700	72,400	73,600	74,600	75,300
Unit Cost of Raw Water								
- per AF Maximum Firm Yield	$122	$132	$138	$147	$160	$164	$174	$184
- per 1000 Gallons Maximum Firm Yield	37¢	41¢	42¢	45¢	49¢	50¢	53¢	46¢

Cost of Delivering Water to Lake Texana by a Combination of Diversions from Garwood and Diversions of Unappropriated Colorado River Water

Table 3-8

3.7 Yields Available for Use Outside Lavaca-Navidad River Authority Service Area

L-NRA has reserved 75,000 acre-feet per year for use within the combined Lavaca and Navidad River watersheds. This is in effect the permitted yield of Stage 1. Any other yield developed should be available for customers outside the Lavaca and Navidad River watersheds.

L-NRA's reservation of 75,000 acre-feet of water for in-basin needs is based on an earlier study by HDR ("Projected Water Demand of the Lavaca-Navidad River Authority and the Adjoining Colorado-Lavaca and Lavaca-Coastal Basins," HDR Engineering, Inc., October, 1989) which developed three possible scenarios (low, medium, and high) for growth of water demand in the basin. The low case projection indicates that the 75,000 acre-feet will meet in-basin needs almost until the year 2040. However, if medium case or high case growth occurs, shortages will occur as early as 2020.

L-NRA presently has contracts for the sale of 32,000 acre-feet of water from the firm yield of Stage 1, which leaves 42,000 to 49,000 acre-feet currently available. Ultimately, the amount available will be dependent on agreements reached regarding releases to the bays and estuaries. It currently appears such releases may reduce the yield of Lake Texana to 74,000 acre-feet, which would reduce the amount of water available to 42,000 acre-feet.

Based on projected in-basin growth, it appears the demand for Lake Texana water will gradually increase over the next 30 years. Thus, the short term surplus Lake Texana water could be made available on an interim basis to out-of-basin customers. Since the cost of Stage 1 water is about $60 per acre-foot (18¢ per 1,000 gallons), the use of this water would decrease water costs for the user until it is needed in the basin. However, such an arrangement may not be justified for an out-of-basin customer unless they also contracted for supplemental water in Lake Texana so their facilities could continue to be used after Stage 1 water could no longer be made available.

3.8 Effects on Garwood Irrigation Company

3.8.1 Operations

The diversion of 30,000 acre-feet of Garwood water during the November to March period through the Garwood canal system is not expected to adversely affect Garwood's water delivery operations. In fact, such a diversion could increase economic efficiency of the system by providing revenues for conveyance of water through the canals, since such diversions would occur when the canals are not in use by Garwood. The cost of diversion and conveyance facilities with capacity in excess of 30,000 acre-feet were estimated based on separate facilities which would not affect Garwood's operations.

3.9 Effects on Other Water Rights

3.9.1 Colorado River Basin

It is contemplated that any diversions from the Colorado River basin would be made in compliance with all required laws which would protect existing water rights in the river basin.

3.9.2 Lavaca-Navidad River Basin

In estimating the yield of Stage 1 and Stage 2, inflows available after diversions of all senior water rights have been used. Thus, the yields presented in this report are after existing water rights have been satisfied to the extent water is available to satisfy them. Therefore, no injury to senior water rights is expected.

4.0 WATER RIGHTS AND LEGAL FEASIBILITY OF TRANSFER

Douglas G. Caroom, Attorney at Law

4.1 Introduction

Garwood Irrigation Company holds the senior water right on the Lower Colorado River. Under Certificate of Adjudication No. 14-5434, which was issued by the Texas Water Commission on June 28, 1989, Garwood is recognized a right to divert and use 168,000 acre feet of water annually from the Colorado River for irrigation, with a priority date of November 1, 1900.

Conclusions 2 and 3 of the Final Determination state:

> 2. Garwood is recognized a right under Certified Filing No. 398 to divert and use not to exceed 124,106.26 acre-feet of water per year from diversion point D-4050 on the Colorado River at a maximum diversion rate of 600 cfs (270,000 gpm) for the irrigation of 27,397.87 acres of land within area T-2000 and T-2010, with a priority date of November 1, 1900.
>
> 3. Garwood may diligently develop an appropriation under Certified Filing No. 398, 398A and 398B to the extent set out in the Commission's cancellation order dated December 13, 1976, under the terms and conditions set out in that order.

The extent of development allowed under the 1976 cancellation order is set out in Finding 9 of the Final Determination:

> 9. In the 1976 cancellation order, the Commission ordered that Permits Nos. 1506 and 1790 be renumbered to Certified Filing Nos. 398A and 398B, respectively, and that Certified Filing Nos. 398, 398A and 398B be canceled save and except for the right to annually divert and use 168,000 acre-feet of water for the irrigation of 32,000 acres of land at a maximum diversion rate of 750 cfs. the waters to be so diverted to be "run of the river" or "normal flow" waters contained in the Colorado River.

To augment the Lake Texana water supply, L-NRA is considering acquiring 30,000 acre-feet-per-year or more of Garwood's right under Certificate of Adjudication No. 14-5434.[1] Authorization from the Texas Water Commission is required to enable L-NRA to utilize Garwood's right. In its current form, the right can be diverted by Garwood at a specific location for the irrigation of specified property within specified diversion limitations. The amendments that must be obtained under Section 11.122 of the Water Code with respect to the portion of Garwood's right that is conveyed to L-NRA include the following:

(1) Ownership must be transferred from Garwood to L-NRA;

(2) Municipal and industrial use must be authorized, either in addition to or in place of the currently authorized irrigation use;

(3) Temporary storage in Lake Texana must be authorized; and,

(4) If not authorized by the existing Lake Texana permit, diversion and subsequent use (e.g., by San Antonio or Corpus Christi) authorization will be required.

Additionally, statutory requirements relating to authorization of trans-basin diversions and consideration of water requirements for instream flow and bay and estuary needs will also be considered during the permit amendment process (Tex. Water Code §11.085 (interwatershed transfers), Tex. Water Code §11.147 (bays and estuaries)).

4.2 Transfer of Ownership

The transfer of ownership of an appropriated water right is essentially a clerical function. An appropriated water right is a vested interest in the use of water that is assignable, and therefore, salable. See, Clark v. Briscoe Irr. Co., 200 S.W.2d 674, 679 (Tex. Civ. App.--Austin, 1947, writ dism'd w.o.j.). Section 297.82 of the Commission's rules

[1] For purposes of this analysis, the acquisition of perfected rights is assumed, although since adoption of the Cancellation Act, infra, the distinction may be irrelevant.

imposes a duty on the owner of a water right to inform the Executive Director of any transfer of that right (31 Tex. Admin. Code. § 297.82). A written instrument evidencing the transfer must also be recorded with the county clerk, and certified copies of the records establishing chain of title must be filed with the Executive Director (31 Tex. Admin. Code. § 297.83).

4.3 Change in Purpose and Location of Use

An appropriated water right carries with it the incidental right to change the purpose or place of use, subject to Commission approval (Clark v. Briscoe Irr. Co., 200 S.W.2d at 679). Before authorizing a change in purpose and/or location of use, the Texas Water Commission evaluates the anticipated impact of the requested amendment on other appropriations within the river segment. If previously unaffected appropriators would be adversely affected under law by the amendment (e.g., by a significant change in the authorized consumptive pattern of use), the Commission may require a modification of the water right, or it may condition the amendment to avoid the adverse impacts. The modification or condition may take the form of amending the priority date of the transferred water right to reflect the date of the amendment, or the subordination of that right to the rights of any adversely affected water rights holders. Hard and fast rules regarding such modifications or conditions are unavailable. The Texas Water Commission prefers to evaluate each amendment on a case-by-case basis.

The Commission should grant the needed amendments without imposing a later priority date or other conditions, because the proposed changes in Garwood's authorized place of use are "transparent" to other users of Colorado River water. Because return flows from Garwood's use are not now available to downstream users in the Colorado Basin, a change in location and purpose of use would not affect them.[2]

4.4 Transbasin Diversion

Although Garwood diverts water from the Colorado River, it is authorized to conduct virtually all of its irrigation outside of the Colorado River Basin. The return flows from Garwood's out-of-basin irrigation do not contribute to water supplies or ecosystems downstream in the Colorado Basin. As a result, the Garwood right is a pre-existing authorization of trans-basin diversion, and such authorization for municipal and industrial purposes either is not needed, or is duplicative of the existing authorization and should be considered routine.

4.5 Use Authorization from Lake Texana

Amendment of Lake Texana's Certificate of Adjudication No. 16-2095 will be required to allow temporary storage of Garwood water in the reservoir and subsequent use by San Antonio or Corpus Christi (Tex. Water Code § 11.085). Authority for such trans-basin diversion from the Lavaca River Basin should not present a problem, because the water is a new supply to the basin; it is developed by L-NRA. Moreover, L-NRA plans to reserve a supply under Certificate of Adjudication 16-2095 to satisfy anticipated in-basin needs.

[2]The only practical impact may be that LCRA will need to modify winter reservoir operating procedures to occasionally allow inflows to pass for L-NRA, if sufficient inflows are not available downstream of LCRA reservoirs. This pass through, however, is one that LCRA is currently required to make under existing water rights if Garwood decided to use water for irrigation in the winter, which Garwood is presently authorized to do.

4.6 Bay and Estuary Requirements and Instream Flows

Texas Water Code § 11.147 (b) provides:

> In its consideration of an application for a permit to store, take or divert water, the commission shall assess the effects, if any, of the issuance of the permit on the bays and estuaries in Texas. For permits issued within an area that is 200 river miles of the coast, to commence from the mouth of the river thence inland, the commission shall include in the permit, to the extent practicable when considering all public interests, those conditions considered necessary to maintain beneficial inflows to any affected bay and estuary system.

So far as the Colorado Basin is concerned, the requirements of § 11.147 do not appear to present an obstacle to the project. A new appropriation is not taking place; no water will be leaving the basin or ecosystem, which was not previously authorized to leave.

While § 11.147 may come into play for the amendment of Lake Texana's Certificate of Adjudication No. 16-2095, its requirements should impose no additional burden. Any impact of the Garwood water on Lavaca-Tres Palacios Bay and Estuary System should result in additional freshwater reaching the system due to reduced availability of storage capacity in Lake Texana and, therefore, greater spills of natural Lavaca Basin inflows from Lake Texana.

4.7 Cancellation

One issue that might be raised before the Commission by opponents to the proposed transfer to L-NRA is why Garwood's right should not be partially canceled, rather than amended to allow water to be used for municipal and industrial purposes. Unused water rights are subject to total or partial cancellation under the Cancellation Act, §§ 11.171 Texas Water Code et seq. Section 11.173, as recently amended by H.B. 529 (effective

September 1, 1991), provides as follows:

> (a) Except as provided by Subsection (b) of this section, if all or part of the water authorized to be appropriated under a permit, certified filing, or certificate of adjudication has not been put to beneficial use at any time during the 10-year period immediately preceding the cancellation proceedings authorized by this subchapter, then the permit, certified filing, or certificate of adjudication is subject to cancellation in whole or in part, as provided by this subchapter, to the extent of the 10 years nonuse.
>
> (b) A permit, certified filing, or certificate of adjudication or a portion of a permit, certified filing, or certificate of adjudication is exempt from cancellation under Subsection (a) of this section:
>
> > (1) to the extent of the owner's participation in the Conservation Reserve Program authorized by the Food Security Act, Pub.L. No. 99-198, Secs. 1231-1236, 99 Stat. 1354, 1509-1514 (1985) or a similar governmental program; or
> >
> > (2) if any portion of the water authorized to be used pursuant to a permit, certified filing, or certificate of adjudication has been used in accordance with a water management plan approved by the commission.

Cancellation does not appear to pose a serious threat to permit amendment for several reasons. First, Garwood is confident that adequate justification exists for not fully developing its right before now. For example, long-standing disputes with LCRA concerning the nature and extent of the parties' relative rights have been resolved only with the recent conclusion of the water rights adjudication. The existence of such disputes has precluded additional capital expenditures that would be required for full development of the right. Garwood is now considering such options, along with the option of selling a portion of the right for municipal and industrial use.

Second, it is premature to consider Garwood's right for partial cancellation at this time. The Texas Water Code allows a five year "grace period" following partial cancellation before further cancellation may be considered. Section § 11.186 provides:

September 1, 1991), provides as follows:

> (a) Except as provided by Subsection (b) of this section, if all or part of the water authorized to be appropriated under a permit, certified filing, or certificate of adjudication has not been put to beneficial use at any time during the 10-year period immediately preceding the cancellation proceedings authorized by this subchapter, then the permit, certified filing, or certificate of adjudication is subject to cancellation in whole or in part, as provided by this subchapter, to the extent of the 10 years nonuse.
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Second, it is premature to consider Garwood's right for partial cancellation at this time. The Texas Water Code allows a five year "grace period" following partial cancellation before further cancellation may be considered. Section § 11.186 provides:

> Once cancellation proceedings have been initiated against a particular permit, certified filing, or certificate of adjudication and a hearing has been held, further cancellation proceedings shall not be initiated against the same permit, certified filing, or certificate of adjudication within the five-year period immediately following the date of the hearing.

The Commission has interpreted this provision to include the quantification or definition of water rights which is accomplished by water rights adjudication. On June 28, 1989, the date on which Garwood's Certificate of Adjudication No. 14-5434 was issued, the adjudication of Garwood's water right was finally complete. Using that date as a reference point, the five year statutory period would expire on June 28, 1994.

Moreover, it should be noted that the Texas Water Commission allows even more latitude than provided by Section 11.186. The Water Commission staff has informally adopted a 10-year rule, whereby cancellation proceedings will not be brought until at least 10 years have elapsed since the water right was adjudicated or partially cancelled. Utilizing the Water Commission staff's 10-year rule, Garwood's water right would not be subject to cancellation until at least June 28, 1999.

Finally, it is arguable that Garwood's right even then would not be subject to cancellation under the recent amendment to Section 11.173 of the Water Code. Water under Garwood's right could be considered to be used "in accordance with a water management plan approved by the commission." A plan, which addresses all major rights downstream of and including the Highland Lakes, was approved by the Commission by order dated September 7, 1989.

4.8 Summary

Transfer of ownership from Garwood to L-NRA should be relatively simple, so long as the necessary procedural steps are taken. Obtaining the needed amendments to Garwood's water right should be feasible, since no new authorization to move water from the Colorado River Basin into the Lavaca River Basin will be involved. However, the impact of additional storage in Lake Texana and subsequent use by San Antonio or Corpus Christi will need to be independently evaluated.

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5.0 ENVIRONMENTAL FACTORS
Prepared by Paul Price & Associates

5.1 Introduction

The purpose of this section is to assess the potential environmental consequences and associated mitigation needs of a regional water supply project that includes: (1) construction and operation of Stage 2 of the Palmetto Bend Project; (2) purchase of water rights and transfer of 30,000 acre feet or more of water annually from the Colorado River using the Garwood Irrigation Company intake works or new diversion facilities; (3) and use of the channels of Sandy and/or Mustang Creeks to convey the water to Lake Texana.

5.2 Impacts to Bays and Estuaries

Stage 2 of the Palmetto Bend Project will involve construction and operation of a water supply reservoir on the Lavaca River. This reservoir will cover 6,060 acres at a conservation pool elevation of 44 feet MSL, and will inundate about 22 miles of river channel. This reservoir differs from the Stage 2 project outlined in the Palmetto Bend EIS (Bureau of Reclamation, 1974) in that it will have an embankment separate from the existing Lake Texana dam, it will not include equalization channels, and it will not include the basin of Post Oak Creek. The almost 83,000 acre-foot reservoir will, in addition to water that may be imported from the Colorado River, yield 48,000 acre-feet of water annually (HDR, 1990) and impose a net evaporation of about 10,000 acre feet per year on the system.

Information on habitats and species in terrestrial, freshwater, and brackish environments in the region are given in Bureau of Reclamation, 1974, and supporting studies; McGowan et al, 1976; TDWR, 1980; Ward and Armstrong, 1980; Wiersma et al, 1982; Ward et al, 1982; Connor and Suttkus, 1986; Britton and Morton, 1989; PPA, 1989; EH&A, 1990; and numerous Federal Aid Project reports from the Texas Parks and Wildlife Department's Coastal and Inland Fisheries, and Wildlife divisions.

Inflow reductions to Lavaca Bay on full implementation of both phases of the Palmetto Bend Project are projected to average about 150,000 acre-feet annually (125,000 acre feet diverted, 25,000 acre-feet net evaporation). This reduction is about 14 percent greater than the 131,400 acre-foot average inflow reduction assumed in the Matagorda Bay Study (Ward et al, 1982), but the relationship of that yield estimate to potential inflow reductions is at present unknown. Even if it is shown that the larger yield is obtained at the expense of estuarine inflows, any impacts will be small in the context of the entire Lavaca-Tres Palacios Estuary. Ward et al (1982) and TDWR (1980) used inflows to the Lavaca-Tres Palacios Estuary for the period 1941-1976 that averaged 2,540,000 acre feet annually. Including more recent data in the period of record (1941-1987) yields an annual average total inflow of 3,080,301 acre feet, approximately 21 percent more freshwater inflow than was reflected in the earlier period of record (TWDB, 1990). In any case, 131,400 and 150,000 are 5.1 and 5.9 percent, respectively, of 2,540,000.

Considering the Lavaca-Tres Palacios Estuary as a whole, a difference of that magnitude is not likely to be evident as either a change in salinity modeling results, or in real world parameters. That this difference is minor is particularly evident when one considers the ongoing perturbations associated with the Mouth of the Colorado Project, including inflow increases on the order of 4,500,000 acre feet per year and closing of the migratory routes associated with Parker and Tiger Island Cuts (USCE, 1980; Ward et al, 1982). The same considerations apply to potential associated changes in nutrient and sediment delivery. Inflow reductions to the Lavaca-Tres Palacios Estuary as a result of construction and operation of the complete Palmetto Bend Project should not require mitigation or even study beyond that already accomplished as a result of the Palmetto Bend EIS (Bureau of Reclamation, 1974), and the subsequent studies and agreements among the Texas Water Development Board, Texas Parks and Wildlife Department, and Texas Water Commission. However, it is recognized that requests for additional studies can be expected from resource agencies and environmental groups.

When consideration is restricted to the upper portion of Lavaca Bay and the remaining tidal river channels where impacts would be greatest (Bureau of Reclamation, 1974), the projected increase in reservoir yield could possibly raise concern about potential inflow reductions. If it is shown that, in fact, the enhanced yield does not come at the expense of inflows to Lavaca Bay, there would not be a need for additional environmental studies, or mitigation, as the freshwater inflow aspects of the entire Palmetto Bend Project have been assessed (Ward et al, 1982). However, increased inflow reductions as a result of diversions from the Stage 2 reservoir that exceed the already assessed 131,400 acre feet per year by as little as 10 to 20 percent will likely result in calls for additional studies. Although additional biological effects would probably be undetectable in the bay at that level of difference, salinity modeling might indicate increased impacts to shellfish production. If these additional impacts, are found, they would have to be evaluated in relation to the benefits of the additional renewable water resource relative to the status and importance of the adversely impacted estuarine resources.

5.3 Impacts on Fish and Wildlife

The area to be impacted by reservoir construction and inundation will need to be inventoried for natural and cultural resources. Mitigation requirements for loss of terrestrial wildlife habitat will probably be determined by use of the U.S. Fish and Wildlife Service's Habitat Evaluation Procedure (HEP). At present, environmental mitigation typically requires acquisition of appropriate property in the vicinity of the project area, and provision for a management program for that land that will result in a net increase in wildlife habitat sufficient to replace that lost in reservoir construction. Five to ten thousand contiguous acres of land, a substantial proportion of which will have to be suitable for development of bottomland hardwood forest, and provision for necessary management activities over a 50- to 100-year period, may be required. In addition to these requirements, potential impacts to endangered species will be considered. At present, the only known potential conflict involves the bald eagle nests said to be present in the lower Lavaca River floodplain. The preferred mitigation strategy for dealing with endangered species is modification of the project, or its schedule, to avoid the impact.

Mitigation or compensation for losses of flowing water (lotic) habitats and the biological communities they support will probably not be required. Potential changes in the Lavaca River fauna are expected to be similar to those outlined for the Navidad River and Lake Texana in the Environmental Impact Statement (Bureau of Reclamation, 1974). The presence of Lake Texana has probably adversely affected the distributions of some of the river-adapted forage species (e.g., red and blacktail shiners, tadpole, and freckled madtoms), and some of the migratory species such as the American eel. These impacts were expected but not considered significant in the EIS because they only involve changes in species distributions and relative abundances, rather than losses or local extinctions, and do not affect endangered, threatened, or unique aquatic resources. There is no method available to compensate for losses of lotic habitat.

Cultural resources on the proposed reservoir site will have to be inventoried with a 100 percent pedestrian survey, and sites having the potential for nomination to the National Register will need to be subjected to test excavation. Because of the project location, largely on a well-developed floodplain, a geomorphology study to determine the potential for buried archaeological sites will probably be required, along with additional historical investigation. The cultural resource studies conducted by McGuff (1978) and McGuff and Fawcett (1978) provide a guide to the minimum mitigation requirements likely for the proposed Stage 2 reservoir site.

Transfer of Colorado River water may be accomplished by purchase of a senior water right from the Garwood Irrigation District, and use of portions of the existing distribution system or a proposed distribution system to convey the water to the Navidad River drainage. Also, under consideration is the use of unappropriated Colorado River flows. Legal issues aside, it is difficult to see how much estuarine impact can be expected to result from an increased diversion of 30,000 to 60,000 acre feet out of an average annual flow of 1,768,061 acre-feet (1.7 percent-3.4 percent; TWDB, 1990). If Garwood water rights are purchased, actual (net) diversion from the Colorado River will be less than the 30,000 to 60,000 acre-feet per year to the extent that the Garwood water right has been exercised and water has previously been diverted from the flows entering the estuarine zone. The fraction of Colorado River flow to be diverted into Matagorda Bay by the Mouth of the Colorado Project does not appear to be known to within 30,000 acre feet. Calls for additional studies on the consequences of this diversion can be expected, but impacts great enough to require mitigative measures are unlikely to be evident.

Transfer of Colorado River water into the Navidad basin will result in some habitat changes in the streams carrying the flow (Sandy or Mustang Creeks). The portion of the creek channel used for conveyance will experience higher average flow, greater depth, and higher average current velocity. The extent to which these changes will be generally beneficial or adverse to the resident lotic communities depends on system operation. Significant beneficial effects would be expected only if water was sent on a relatively constant basis during seasons (e.g. summer) when streamflow has historically been very low or zero. On the other hand, adverse effects would not occur unless slug flows sufficient to significantly increase erosion of the channel bed and banks were passed. Because the sandy channels of these streams have developed under a regime of occasional very high flows, they are capable of carrying substantial flows without experiencing significant increases in erosion and consequent reservoir sedimentation.

5.4 Impacts to Water Quality

Comparison of water quality data from the Colorado and Lavaca-Navidad River basins indicates little basis on which to expect any substantial effects due to differing water quality (SMN Stations 1402.0200, 1602.0100; TWDB, 1980; TWC, 1989). Water in both basins tends to have typical dissolved solids levels in the 200-500 mg/l range, bicarbonate as the dominant anion, cation abundance generally $Ca>Na>Mg=K$, and comparable, generally high levels of phosphorus (>0.1 mg/l). Since Lake Texana presently receives irrigation drainage from the Garwood Irrigation Company, direct transfer of Colorado River water instead should result in some marginal improvement in water quality.

The potential for adverse impacts as a result of the transfer of aquatic organisms from the Colorado to the Lavaca-Navidad River basins is not substantial because of the close similarity of their biological assemblages (Hubbs, 1957; 1982; Connor and Suttkus, 1986). Both the Lavaca-Navidad and the lower Colorado basins are located in the coastal plain portion of the Texan Biotic Province, and, as such, are expected to have similar fish faunas (Blair, 1950; Hubbs, 1957). Faunal similarity in these basins is due to the frequency of interbasin flooding, temporary freshening of estuarine zones, and interbasin transfer of irrigation water, all of which provide migration pathways to strictly aquatic species, and to the relatively uniform water quality and habitat characteristics of the region. Use of Lake Texana and the Stage 2 reservoir for conveyance and storage of Colorado River water does not appear to involve any substantial environmental consequences beyond some increase in the annual replacement rate (turnover) in the two basins (annual inflow/capacity). Although the effects would tend to be beneficial in this case, the volume of water involved seems too small to result in any perceptible limnological consequences. For example, 300,000 acre feet of annual inflow would fill the 170,000 acre foot Lake Texana basin 1.76 times per year, while a 330,000 inflow would fill it 1.94 times, about a 10 percent change.

Information on the number, alternative routes, and characteristics of water delivery pipelines has not yet been obtained. Potential impacts of pipeline construction and operation will depend on specific routes and construction practices and the extent to which wetland areas and areas of significant cultural resources are disturbed. An environmental characterization of the pipeline route, particularly stream crossings or other wetlands, and provisions for erosion control and revegetation in disturbed areas, will likely be required if a U.S. Army Corps of Engineers permit is necessary. Mitigation would generally consist of avoidance of sensitive habitats. A pedestrian survey of the pipeline corridor and testing of potential cultural resource deposits will also probably be required. Mitigation would include either avoidance or salvage, study, and curation of material and data from significant sites.

5.5 Estimates of Mitigation Costs

Mitigation costs, including the studies necessary to obtain all required permits and to determine the extent of necessary mitigation or compensation can only be determined roughly at this time. Environmental studies of the proposed regional system would focus on the proposed reservoir site, the pipeline routes and, probably, on upper Lavaca Bay. These studies would have to include necessary habitat evaluations (HEP), coordination and agency negotiations, special studies or reports to address particular permitting needs, and development of a comprehensive Environmental Assessment Report (EA). The environmental studies are expected to fall into a cost range of $75,000 to $150,000, depending on the intensity of project opposition, the extent of need to address potential estuarine impacts, and the likelihood of a need to support production of an Environmental Impact Statement. If environmental mitigation is assumed to be confined to terrestrial habitat replacement, land acquisition will be the major cost, and will depend on specific habitat replacement objectives, available management alternatives, local land prices, and the availability of suitable tracts. Long-term management responsibility may be assumed by L-L-NRA, or it may be taken over by another entity agreeable to the permitting agencies, typically Texas Parks and Wildlife Department. In any case, provision for initial preparation (e.g., fencing, selective clearing, etc.) and long-term management will have to be made. Annual maintenance costs of about $5 per acre per year for a 50- to 100-year period can be anticipated.

Costs for cultural resources studies, focusing on the reservoir site are included in the $6,500,000 item for Environmental & Permits shown in Table 2-3. Mitigation requirements, also included in the $6,500,000 estimate, cannot be estimated without some indication of the number and type of sites involved, but if extensive excavation is required, costs exceeding $1 million could be incurred under today's regulatory climate.

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6.0 WATER CONSERVATION AND DROUGHT CONTINGENCY PLANS

6.1 Purpose

Water used in residential and commercial sectors of the Lavaca-Navidad River Authority's service area (Lavaca-Navidad River Basin and adjoining Colorado-Lavaca and Lavaca-Guadalupe Coastal Basins) involves day-to-day living and business activities, and includes water used for drinking, bathing, cooking, toilet flushing, fire protection, lawn watering, swimming pools, laundry, dish washing, car washing, and sanitation. The objective of this water conservation plan is to bring about a permanent reduction in the quantity of water required for each activity through the implementation of efficient water supply and water use practices. The area to which this plan applies was shown in Figure 1-1 and includes all or parts of nine counties: Fayette, Lavaca, Colorado, DeWitt, Victoria, Jackson, Wharton, Calhoun, and Matagorda. Major cities of the area are Point Comfort, Weimar, Yoakum, Schulenberg, Edna, Ganado, Hallettsville, Shiner, Moulton, Palacios, El Campo, and Victoria (approximately one-third of Victoria is located within the area).

The drought contingency plan provides procedures for both voluntary and mandatory actions to temporarily reduce water usage during a water shortage crisis. Drought contingency procedures may include water conservation and prohibition of certain uses. Both are tools that officials will have available to effectively operate during a wide range of conditions within the public water supply service area.

6.2 Goals

Average daily water use within cities of the service area ranges between 111 and 190 gallons per person or per capita per day (Table 6-1). Under dry weather conditions, per capita water use within the cities is 18 percent higher than the average, and ranges between

127 and 241 gallons per person per day (Table 6-1). It is a goal of this study to develop a municipal water conservation plan which can be used by each city to reduce per capita water use by 15 percent over the next 20 years. Achieving this goal would, in effect, increase the customer service capacity of both the water and wastewater facilities by 15 percent.

Table 6-1
Per Capita Water Use Within Cities Of The Lavaca-Navidad River Authority Service Area

City	Average 1976-1987 (gallons)	Drought 1980, 1984 (gallons)
Edna	173	209
El Campo	128	155
Ganado	151	179
Hallettsville	187	212
Moulton	119	129
Palacios	149	180
Point Comfort	111	127
Schulenberg	154	178
Shiner	190	241
Victoria	145	165
Weimar	164	208
Yoakum	140	152
12 County Average	151	178
Difference (Ave/Dry)	27	27
Difference (Percent)	---	18

Source: Texas Water Development Board

The drought contingency plan includes those measures that can significantly reduce water use on a temporary basis. These measures involve voluntary reductions, restriction and/or elimination of certain types of water use, and water rationing during periods of severe water shortages. Because the onset of an emergency condition is often rapid, it is important that each city be prepared in advance. Further, the citizen or customer must know that certain measures not used in the water conservation plan may be necessary if a drought or other emergency condition occurs. It is the goal of the drought contingency plan to reduce water use during an emergency situation or prolonged drought in sufficient quantities to respond to the severity of the conditions that necessitate the use of the plan.

Nine principal water conservation methods are included in the water conservation plan:

1. Education and Information;
2. Water Conserving Plumbing Code;
3. Retrofit Programs;
4. Conservation Oriented Water Rate Structure;
5. Universal Metering and Meter Repair;
6. Water Conservation Landscaping;
7. Leak Detection and Repair;
8. Recycling and Reuse; and
9. Implementation and Enforcement.

Six methods are included in the drought contingency plan:

1. Trigger Conditions;
2. Drought Contingency Measures;
3. Information and Education;
4. Initiation Procedures;
5. Termination Notification; and
6. Implementation Procedures.

6.3 Water Conservation Plan

The water conservation plan addresses nine aspects of water conservation, including public information and education, recommended water conserving plumbing codes, water conservation retrofit programs, water conservation-oriented rate structures, universal metering and meter repair and replacement, water conserving landscaping, leak detection and water audits, and wastewater reuse and recycling. A summary of each of these items follows.

6.3.1 Public Information and Education

A committee will be appointed to engage in an ongoing education program. The committee will be responsible for the following:

- Provide qualified individuals to speak at institutions, organizations, and groups throughout the area at regular intervals;
- Conduct or sponsor exhibits on conservation, water saving devices, and other methods to promote water conservation and efficiency;
- Provide and distribute brochures and other materials to the citizens of the area. Materials available from agencies such as the Texas Agricultural Extension Service and the Texas Water Development Board will be used;
- Work in cooperation with builders, developers, and governmental agencies to provide exhibits of xeriscape landscaping for new homes;
- Work in cooperation with schools to establish an education program within these institutions and to provide them with landscape videos, brochures, and other training aids; and
- Develop welcome packages for new citizens to educate them in the benefits of conservation and inform them of water efficient plans, trees, shrubs, and grasses best suited to this area.

6.3.2 Water-Conserving Plumbing Codes

The following plumbing code is recommended to encourage the use of water-conserving plumbing fixtures for new residential and commercial construction.

(a) Toilets: Toilets shall be installed for which the maximum flush will not exceed 1.6 gallons of water.

(b) Urinals: Urinals shall be installed for which the maximum flush will not exceed one gallon of water.

(c) Showerheads: Showerheads, except where provided for safety reasons, shall be installed with a flow limitation device which will not allow a water flow rate in excess of 2.75 gallons per minute at 80 pounds per square inch pressure.

(d) Faucets: All lavatory, kitchen, and bar sink faucets shall be installed and equipped with a flow control device or aerator to limit flow rates to 2.2 gallons per minute.

(e) Hot Water Piping: All hot water lines not in or under a concrete slab shall be insulated.

(f) Automatic Dishwashers: All automatic dishwashers installed in residential dwellings shall be a design that uses a maximum of six gallons of water per cycle.

(g) Automatic Clotheswashers: All automatic clotheswashers installed in residential dwellings shall be a design that uses a maximum of 14 gallons of water per cycle.

(h) Water Fountains: Use self closing type.

All new plumbing fixtures that replace or renovate existing plumbing fixtures follow the requirements for new residential and commercial construction.

6.3.3 Water Conservation Retrofit Program

Retrofit of existing plumbing fixtures will be accomplished through the voluntary efforts of individual consumers for their homes and businesses. Adoption of a water conservation plumbing code will provide a gradual up-grading of plumbing fixtures in existing structures. Information on retrofitting will be provided through public education.

6.3.4 Water Conservation - Oriented Rate Structure

All water customer entities adopt either a flat or an increasing block rate structure.

6.3.5 Universal Metering and Meter Repair and Replacement

All water service connections to water supply utilities are to be metered. A recommended schedule for testing meters is as follows:

1. Production or master meters, test once per year;
2. Meters large than 1", test once every three years; and
3. Meters 1" or less, test once every 10 years.

6.3.6 Water-Conserving Landscaping

Water-conserving landscaping will be initiated through public information and education. Well-designed and properly maintained demonstration landscapes located in highly visible areas will be created to promote the water-conserving landscape concept.

6.3.7 Leak Detection and Water Audits

Leak detection and water audits will be accomplished through the voluntary efforts of each water supplier. Technical assistance will be requested from the Texas Water Development Board.

6.3.8 Wastewater Reuse and Recycling

L-NRA encourages reuse and recycling whenever it is found to be fiscally, environmentally, and institutionally practical and prudent.

6.3.9 Means of Implementation and Enforcement

The Water Conservation Plan will be implemented by water supply utilities. The following methods are suggested:

- Encourage service tap applicants to utilize water conservation plumbing fixtures. Water utility staff will check to insure that water saving plumbing devices are being installed in new buildings.
- Adopt a rate structure that will encourage retrofitting of old plumbing fixtures which are using large amounts of water.
- Require the water rate structure as a condition for receiving service.

6.4 Drought Contingency Plan

Drought and other uncontrollable circumstances can disrupt the normal availability of water supplies from either ground or surface sources. During drought periods, consumer demand is typically 15 to 25 percent higher than under normal conditions. Limitations on the supply of either ground or surface water, or on facilities to pump, treat, store, or distribute water can also present a public water supply utility with an emergency demand management situation. The drought contingency plan establishes temporary methods designed to be used only as long as the emergency exists. The plan includes the following elements:

1. Trigger conditions signaling the start of an emergency period;
2. Drought contingency measures;
3. Information and education;
4. Initiation procedures;
5. Termination notification actions; and
6. Implementation procedures.

6.4.1 Trigger Conditions and Measures for Surface Water Systems

The water supply utility will initiate drought contingency measures upon occurrence of the following conditions:

6.4.1.1 Mild Conditions

a. Daily water demand reaches the level of 90 percent of system capacity for three consecutive days; or

b. Distribution pressure remains below normal for more than six consecutive hours.

6.4.1.2 Moderate Conditions

a. Daily water demands reach 100 percent of system capacity for three consecutive days;

b. The supply of water is continually decreasing on a daily basis and the water supply utility is advised to conserve by the Lavaca-Navidad River Authority, the Texas Water Commission, or the Texas Department of Health; or

c. Decrease in the water pressures in the distribution system as measured by the pressure gauges and customer complaints.

6.4.1.3 Severe Conditions

a. The imminent or actual failure of a major component of the system which would cause an immediate health or safety hazard;

b. Water demand is exceeding 100 percent of system capacity for three consecutive days; or

c. The full allotment of raw water is being pumped from the system's supply source.

6.4.2 Drought Contingency Measures

The following actions will be taken when trigger conditions are met for the area.

The water utility will monitor water pressure in the distribution system and water levels in the storage tanks.

6.4.2.1 Mild Condition

a. Inform public by giving notice of a mild drought to the customers served by the system, post the notice, and notify news media of the mild drought;

b. Included in the information to the public will be the recommendation that water users look for ways to conserve water (see Section 6.7).

c. Through the news media, the public will be advised daily of the trigger condition situation.

6.4.2.2 Moderate Condition

a. Inform the public through the news media that a trigger condition has been reached, and they should look for ways to voluntarily reduce water use. Specific steps which can be taken will be provided through the news media;

b. Notify major commercial water users of the situation and request voluntary water use reductions;

c. The following mandatory lawn watering schedule shall be implemented: Customers with even numbered street addresses may water on even numbered days of the month. customers with odd numbered street addresses may water on odd numbered days of the month. Watering shall occur only between the hours of 6-10 a.m. and 8-10 p.m; and

d. During winter months, request water users to insulate pipes rather than running water to prevent freezing; and

6.4.2.3 Severe Condition

a. Continue implementation of all relevant actions in preceding phase;

b. Car washing, window washing, and pavement washing are prohibited except when a bucket is used;

c. The following public water uses, not essential for public health or safety, are prohibited:

   1). Street washing;
   2). Water hydrant flushing;
   3). Filling pools;
   4). Athletic field watering; and
   5). Park Watering.

d. Certain industrial and commercial water use which are not essential to the health and safety of the community will be prohibited; and

e. Through the news media, the public will be advised daily of the trigger conditions.

6.4.3 Information and Education

Once trigger conditions have been reached, the public will be informed of the conditions, and measures to be taken. The process for notifying the public includes:

1. Posting the Notice of Drought conditions at City Hall, County Courthouse, Post Office, Public Library, Senior Citizens Center, and Major Supermarkets;

2. Copy of notice to newspapers, and hold press conferences; and

3. Copy of notice to local radio and television stations.

6.4.4 Termination Notification

Termination of the Drought measures will take place when the trigger conditions which initiated the drought measures have subsided, and an emergency situation no longer exists. The public will be informed of the termination of the drought measures in the same manner that they were informed of the initiation of the drought measures through the City Officials in charge.

6.5 Attachment A - Utility Evaluation Form[4]

1. Population of Service Area ____________

2. Area of Primary Service ____________

3. Number and Type of water connections in service area ____________

   a. Residential ____________
   b. Commercial ____________
   c. Industrial ____________

4. Net Annual Rate of New Connections in last five years (Additions minus Disconnects)

   a. Residential ______ ______ ______ ______ ______
   b. Commercial ______ ______ ______ ______ ______
   c. Industrial ______ ______ ______ ______ ______

5. Water Use Information (period ________________) in millions of gallons per day:

Month	Raw Water Pumped	Treated Water Billed	Well Water Billed
January	________	________	________
February	________	________	________
March	________	________	________
April	________	________	________
May	________	________	________
June	________	________	________
July	________	________	________
August	________	________	________
September	________	________	________
October	________	________	________
November	________	________	________
December	________	________	________
Total	________	________	________

   d. Average Daily Water Use (Billed) ____________ gallons
   e. Unaccounted Water ____________ gallons

6. Wastewater Information

   a. Percent of potable water customers served by wastewater system ___ (percent)

   b. Percent of potable water customers who have septic tanks or other private disposal systems ___ (percent)

[4] Source: Texas Water Development Board, Austin, Texas.

c. Percent of potable water customers served by another wastewater treatment facility _____ (percent)

d. Average daily wastewater treated _____ (gallons)

e. Peak daily wastewater flow rate _____ (gallons)

f. Estimated percent of wastewater flows to the City's wastewater facilities that originate from the following:

1. Residential _____ %
2. Industrial _____ %
3. Commercial _____ %
4. Stormwater _____ %
5. Other _____ %

7. Safe Annual Yield of Current Supply ____________________ (gallons)

8. Peak Daily Design Capacity of Water System (Supply) ____________________ (gallons)

9. Major Water Customers

(1) ______________________________
(2) ______________________________
(3) ______________________________
(4) ______________________________
(5) ______________________________
(6) ______________________________
(7) ______________________________
(8) ______________________________
(9) ______________________________
(10) ______________________________

10. Percent of Water Supply Connections in System Which are Metered ________ %

11. Water Rate Structure

$________ for ________ thousand gallons
$________ for ________ thousand gallons
____
____

6.6 Attachment B -- Water Conservation Literature[5]

Single copies of all the following publications and materials can be obtained at no charge. The * indicates those publications that are available free to political subdivisions in small quantities. To make a request, write: CONSERVATION, Texas Water Development Board, Capitol Station, Austin, Texas 78711-3231.

Agricultural Conservation Literature

Title	Published By[6]	Description	Length
Agricultural Water Conservation in Texas*	TWDB	Pamphlet with Tear-out	8 pages
Have Your Irrigation Evaluated Free*	TWDB	Pamphlet	4 pages
LEPA Irrigation*	TWDB	Pamphlet	6 pages
Drip Irrigation*	TWDB	Pamphlet	6 pages
Plastic Ruler*	TWDB	6"x1-1/4"	--
Furrow Dikes*	HPUWCB #1	Pamphlet	4 pages
Soil Moisture Monitoring*	HPUWCB #1	Pamphlet	4 pages
Center Pivot Irrigation Systems L-2219*	TAEX	Pamphlet	4 pages
Surge Flow Irrigation L-2220*	TAEX	Pamphlet	4 pages
Surge Irrigation*	SCS	Pamphlet	6 pages
Coloring Poster for for Children*	TWDB	Coloring Poster	1 page
Water Conservation Coloring Book* (No. 1)	TWDB	Booklet	4 pages

[5] Source: Texas Water Development Board, Austin, Texas.

[6] Abbreviations:

HPUWCD #1	High Plans Underground Water Conservation District No. 1
NXC	National Xeriscape Council, Inc.
SCS	USDA-Soil Conservation Service
TAEX	Texas Agricultural Extension Service
TDA	Texas Department of Water Resources
TDWR	Texas Department of Water Resources
TWDB	Texas Water Development Board

Municipal Conservation Literature

Title	Published By	Description	Length
Water Half-A-Hundred Ways to Save It*	TWDB	Pamphlet	8 pages
Water Saving Ideas for Business and Industry*	TWDB	Pamphlet	8 pages
How to Save Water Outside The Home*	TWDB	Pamphlet	8 pages
Toilet Tank Leak Detector Tablets*	TWDB	Pamphlet	--
Municipal & Commercial Water Conservation Services	TWDB	Pamphlet with Tear-out	8 pages
A Homeowner's Guide to Water Use and Water Conservation	TWDB	Booklet	22 pages
Guidelines for Municipal Water Conservation and Drought Contingency Planning and Program Development	TWDB	Loose-leaf	36 pages
How to Xeriscape	NXC	Pamphlet	10 pages
Texas Sesquicentennial Native Plant Landscape	TDA/TWDB	Pamphlet	8 pages
Municipal Water Conservation Workshop Notebook	TWDB	Notebook	6 sections
Water Conservation Coloring Book* (No. 2)	TWDB	Booklet	4 pages

Texas Water Resources and Planning Literature

Title	Published By	Description	Length
TWDB Report 294 - Surveys of Irrigation in Texas	TWDB	Book	243 pages
Summary of Water for Texas (C-20)	TWDR	Pamphlet	8 pages
Water Planning in Texas	TDWR	Booklet	27 pages

Title	Published By	Description	Length
Texas Water Development Board (Funding Programs)	TWDB	Pamphlet	4 pages
Water for Texas (GP-4-1) Volume 1 (Comprehensive Plan) Volume 2 (Technical Appendix)	TWDR (Available for purchase only from the Texas Water Commission P. O. Box 13087 Austin, Texas 78711)	Books	72 pages 530 pages
Texas Water Facts	TWDR	Booklet	12 pages

The following water conservation publications and audiovisual materials are available for a loan of up to two weeks from TWDB.[7] To borrow any of these write to: CONSERVATION, Texas Water Development Board, Capitol Station, Austin, Texas 78711-3231.

Publications

Title	Published By	Description	Length
Water Audit and Leak Detection Guidebook	California Dept. of Water Res.	Book	142 pages
Example Brochures and Promotional Material	Compiled by TWDB	Ringbinder	32 pages
Regional Teachers Guide Supplements	California Dept. of Water Resources	Books	Nos. 1-7
Audiovisual Materials			
The Alternative is Conservation	Water Films	16 mm Film VCR/VHS Format	28 minutes
Water Follies	American Water Works Assoc. (AWWA)	16 mm Film VCR/VHS Format	7.5 minutes
Orangutans (Public Service Announcement)	AWWA VCR/VHS Format	16 mm Film VCR/VHS Format	30 seconds
Gooney Birds (public Service Announcement)	AWWA VCR/VHS Format	16 mm Film VCR/VHS Format	30 seconds
Spot Announcements	Lower Colorado River Authority	Audio Cassette	30 seconds

[7] The films, video cassettes, and publications are provided for review purposes only. Permission to use any of this material for print or broadcast must be obtained from the producer or publisher of the material.

6.7 Attachment C - Water Saving Methods For Individuals[8]

In-home water use accounts for an average of 65 percent of total residential use, while the remaining 35 percent is used for exterior residential purposes such as lawn watering and car washing. Average residential in-home water use data indicate that about 40 percent is used for toilet flushing, 35 percent for bathing, 11 percent for kitchen uses, and 14 percent for clothes washing. Water saving methods that can be practiced by the individual water user are listed below.

Bathroom

1. Take a shower instead of filling the tub and taking a bath. Showers usually use less water than tub baths.

2. Install a low-flow shower head which restricts the quantity of flow at 60 psi to no more than 2.75 gallons per minute.

3. Take short showers and install a cutoff valve or turn the water off while soaping and back on again only to rinse.

4. Do not use hot water when cold will do. Water and energy can be saved by washing hands with soap and cold water, hot water should only be added when hands are especially dirty.

5. Reduce the level of the water being used in a bath tub by one or two inches if a shower is not available.

6. Turn water off when brushing teeth until it is time to rinse.

7. Do not let water run when washing hands. Instead, hands should be wet, and water should be turned off while soaping and scrubbing and turned on again to rinse. A cutoff valve may also be installed on the faucet.

8. Shampoo hair in the shower. Shampooing in the shower takes only a little more water than is used to shampoo hair during a bath and much less than shampooing and bathing separately.

9. Hold hot water in the basin when shaving instead of letting the faucet continue to run.

10. Test toilets for leaks. To test for a leak, a few drops of food coloring can be added to the water in the tank. The toilet should not be flushed. The customer can then watch to see if the coloring appears in the bowl within a few minutes. If it does, the fixture needs adjustment or repair.

11. Use a toilet tank displacement device. A one-gallon plastic milk bottle can be filled with stones or with water, recapped, and placed in the toilet tank. This will reduce the amount of water in the tank but still providing enough for flushing. (Bricks which some people use for this purpose are not recommended since they crumble eventually and could damage the working mechanism, necessitating a call to the plumber).

12. Install faucet aerators to reduce water consumption.

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[8] Source: Texas Water Development Board, Austin, Texas.

13. Never use the toilet to dispose of cleaning tissues, cigarette butts, or other trash. This can waste a great deal of water and also places an unnecessary load on the sewage treatment plant or septic tank.

14. Install a new low-volume flush toilet that uses 1.6 gallons or less per flush when building a new home or remodeling a bathroom.

Kitchen

1. Use a pan of water (or place a stopper in the sink) for rinsing pots and pans and cooking implements when cooking rather than turning on the water faucet each time a rinse is needed.

2. Never run the dishwasher without a full load. In addition to saving water, expensive detergent will last longer and a significant energy saving will appear on the utility bill.

3. Use the sink disposal sparingly, and never use it for just a few scraps.

4. Keep a container of drinking water in the refrigerator. Running water from the tap until it is cool is wasteful. Better still, both water and energy can be saved by keeping cold water in a picnic jug on a kitchen counter to avoid opening the refrigerator door frequently.

5. Use a small pan of cold water when cleaning vegetables rather than letting the faucet run.

6. Use only a little water in the pot and put a lid on it for cooking most food. Not only does this method save water, but food is more nutritious since vitamins and minerals are not poured down the drain with the extra cooking water.

7. Use a pan of water for rinsing when hand washing dishes rather than a running faucet.

8. Always keep water conservation in mind, and think of other ways to save in the kitchen. Small kitchen savings from not making too much coffee or letting ice cubes melt in a sink can add up in a year's time.

Laundry

1. Wash only a full load when using an automatic washing machine.

2. Use the lowest water level setting on the washing machine for light loads whenever possible.

3. Use cold water as often as possible to save energy and to conserve the hot water for uses which cold water cannot serve. (This is also better for clothing made of today's synthetic fabrics.)

Appliances and Plumbing

1. Check water requirements of various models and brands when considering purchasing any new appliance that uses water. Some use less water than others.

2. Check all water line connections and faucets for leaks. If the cost of water is $1.00 per 1,000 gallons, one could be paying a large bill for water that simply goes down the drain because of leakage. A slow drip can waste as much as 170 gallons of water EACH DAY, or 5,000 gallons per month, and can add as much as $10.00 per month to the water bill.

3. Learn to replace faucet washers so that drips can be corrected promptly. It is easy to do, costs very little, and can represent a substantial amount saved in plumbing and water bills.

4. Check for water leakage that the customer may be entirely unaware of, such as a leak between the water meter and the house. To check, all indoor and outdoor faucets should be turned off, and the water meter should be checked. If it continues to run or turn, a leak probably exists and needs to be located.

5. Insulate all hot water pipes to avoid the delays (and wasted water) experience while waiting for the water to "run hot".

6. Be sure the hot water heater thermostat is not set too high. Extremely hot settings waste water and energy because the water often has to be cooled with cold water before it can be used.

7. Use a moisture meter to determine when house plants need water. More plants die from over-watering than from being too dry.

Out-Of-Door Uses

1. Water lawns early in the morning during the hotter summer months. Much of the water used on the lawn can simply evaporate between the sprinkler and the grass.

2. Use a sprinkler that produces large drops of water, rather than a fine mist, to avoid evaporation.

3. Turn soaker hoses so the holes are on the bottom to avoid evaporation.

4. Water slowly for better absorption, and never water on windy days.

5. Forget about watering the street or walks or driveways. They will never grow a thing.

6. Condition the soil with compost before planting grass or flower beds so that water will soak in rather than run off.

7. Fertilize lawns at least twice a year for root stimulation. Grass with a good root system makes better use of less water.

8. Learn to know when grass needs watering. If it has turned a dull grey-green or if footprints remain visible, it is time to water.

9. Do not water too frequently. Too much water can overload the soil so that air cannot get to the roots and can encourage plant diseases.

10. Do not over-water. Soil can absorb only so much moisture and the rest simply runs off. A timer will help, and either a kitchen timer or an alarm clock will do. An inch and one-half of water applied once a week will keep most Texas grasses alive and healthy.

11. Operate automatic sprinkler systems only when the demand on the town's water supply is lowest. Set the system to operate between four and six a.m.

12. Do not scalp lawns when mowing during hot weather. Taller grass holds moisture better. Rather, grass should be cut fairly often, so that only 1/2 to 3/4 inch is trimmed off. A better looking lawn will result.

13. Use a watering can or hand water with the hose in small areas of the lawn that need more frequent watering (those near walks or driveways or in especially hot, sunny spots).

14. Learn what types of grass, shrubbery, and plants do best in the area and in which parts of the lawn, and then plant accordingly. If one has a heavily shaded yard, no amount of water will make roses bloom. In especially dry sections of the state, attractive arrangements of plants that are adapted to arid or semi-arid climates should be chosen.

15. Consider decorating areas of the lawn with rocks, gravel, wood chips, or other materials now available that require no water at all.

16. Do not "sweep" walks and driveways with the hose. Use a broom or rake instead.

17. Use a bucket of soapy water and use the hose only for rinsing when washing the car.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Assuming Corpus Christi and/or San Antonio desire to purchase water from L-NRA (Lake Texana augmented with diversions of Garwood Irrigation Company water and other possible sources of Colorado River water), the following steps should be taken:

- L-NRA should begin negotiations with Garwood Irrigation Company to purchase up to 60,000 acre-feet (or more if needed) from them. As shown in Figure 7-1, Garwood water is the most economical source of supplemental water to increase the firm yield of Lake Texana.

- Determine the quantity of firm yield desired from Lake Texana. The desired amount will determine how to proceed.

  If Garwood will sell only 30,000 acre-feet, needs could be met as follows:

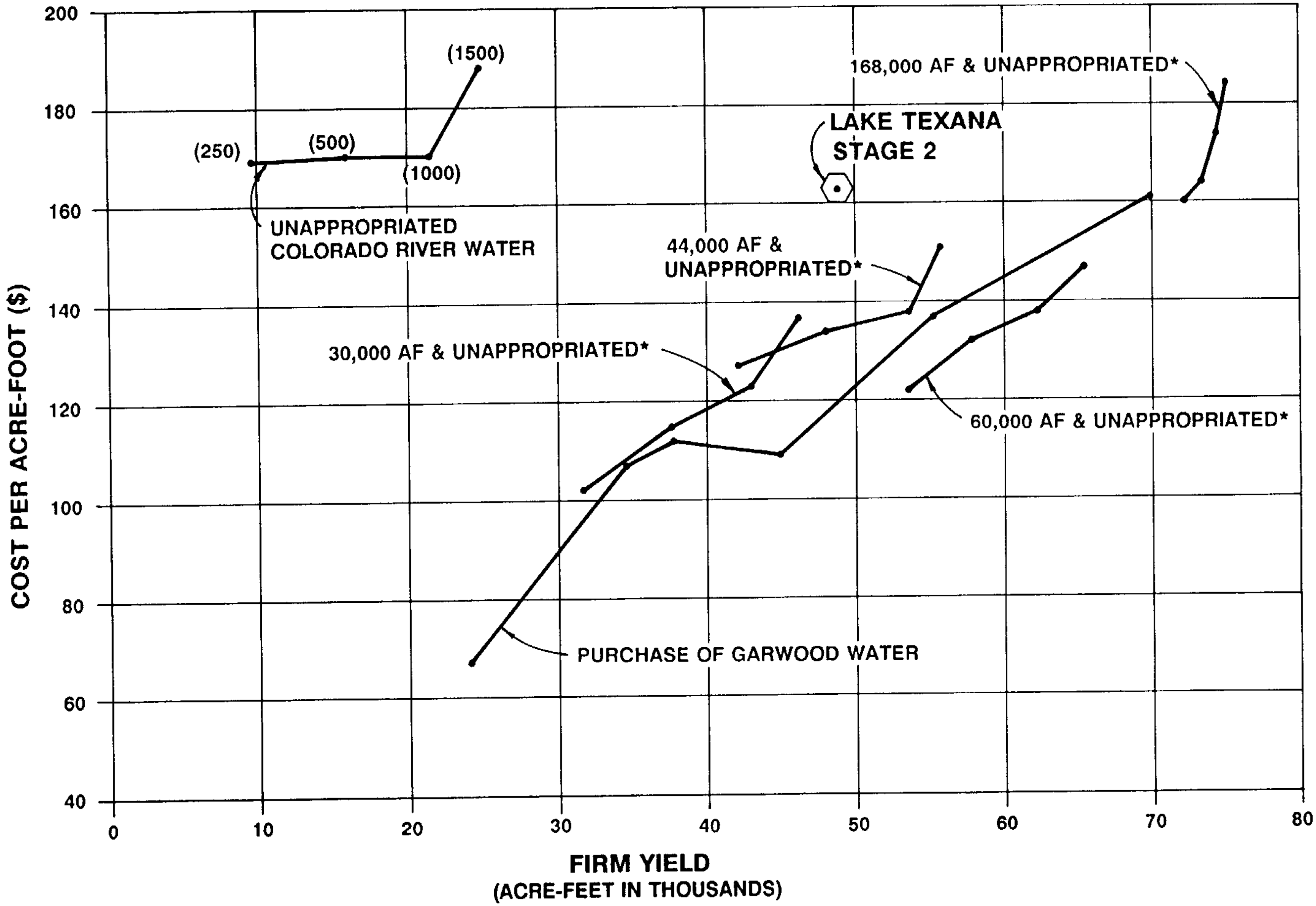
Need (AF)	Supply Source(s)
0-25,000	30,000 AF Garwood water
25,000-38,000	30,000 AF Garwood water plus unappropriated Colorado River water or other Colorado River water rights
38,000-86,000	30,000 AF Garwood water plus unappropriated water or other Colorado River water rights plus Stage 2

  If Garwood will sell more than 30,000 acre-feet of water, needs could be met as follows:

Need (AF)	Supply Sources
0-38,000	50,000 AF of Garwood water
38,000-86,000	60,000 AF of Garwood water plus Stage 2

- The purchase of Garwood water should be contingent on obtaining an interbasin transfer permit and reasonable assurance that the sale of Garwood's water rights cannot be challenged in the future. If unappropriated Colorado River water is to be diverted, more detailed studies will be required. Perform the necessary studies, and obtain a water rights permit from the Texas Water Commission.

- Other water rights may be available for sale in the Colorado River. Any water right would be expected to yield more than the estimated unappropriated amount corresponding to the same rate of diversion as the water right. If Garwood will



*INDICATES VOLUME OF WATER PURCHASED FROM GARWOOD PLUS UNAPPROPRIATED WATER AT RATE OF 250, 500, 1000, OR 1500 CFS.

HDR Engineering, Inc.

COST OF FIRM YIELD
IN LAKE TEXANA

FIGURE 7-1

sell only 30,000 acre-feet and the need is in excess of this amount, a search for other water rights should be made, and the yield and cost of the water right evaluated.

- If the amount of water to be purchased, requires the construction of Stage 2, complete environmental studies and negotiations relative to environmental issues and mitigation, and initiate 404 permit application.

- Perform detailed field studies to determine channel capacities and channel losses in Garwood's canals and the creeks to be used to deliver water to Lake Texana. The amount of water to be obtained should first be determined so the required capacity can be used in the studies, thereby reducing the number of options to be evaluated.

- With reasonable assurances that San Antonio and Corpus Christi will be able to obtain their desired firm yield in Lake Texana, both cities should determine if this firm yield can be used to "firm up" diversions of unappropriated flows in the Guadalupe or San Antonio Rivers. TWC estimates the average unappropriated flows entering the Gulf of Mexico from the San Antonio and Guadalupe Rivers total approximately 1.7 million acre-feet per year. Since pipelines from Lake Texana to either city must cross the Guadalupe River, pumping costs could be reduced by diverting Guadalupe River water when unappropriated flows are available and using Lake Texana water as a backup. A pipeline from Lake Texana to the Guadalupe River sized to deliver both San Antonio and Corpus Christi flows could also reduce the cost to each of the cities. Also, it is possible the effective firm yield of the system could be enhanced if Guadalupe river flows are available for appropriation.

6.0 WATER CONSERVATION AND DROUGHT CONTINGENCY PLANS

6.1 Purpose

Water used in residential and commercial sectors of the Lavaca-Navidad River Authority's service area (Lavaca-Navidad River Basin and adjoining Colorado-Lavaca and Lavaca-Guadalupe Coastal Basins) involves day-to-day living and business activities, and includes water used for drinking, bathing, cooking, toilet flushing, fire protection, lawn watering, swimming pools, laundry, dish washing, car washing, and sanitation. The objective of this water conservation plan is to bring about a permanent reduction in the quantity of water required for each activity through the implementation of efficient water supply and water use practices. The area to which this plan applies was shown in Figure 1-1 and includes all or parts of nine counties: Fayette, Lavaca, Colorado, DeWitt, Victoria, Jackson, Wharton, Calhoun, and Matagorda. Major cities of the area are Point Comfort, Weimar, Yoakum, Schulenberg, Edna, Ganado, Hallettsville, Shiner, Moulton, Palacios, El Campo, and Victoria (approximately one-third of Victoria is located within the area).

The drought contingency plan provides procedures for both voluntary and mandatory actions to temporarily reduce water usage during a water shortage crisis. Drought contingency procedures may include water conservation and prohibition of certain uses. Both are tools that officials will have available to effectively operate during a wide range of conditions within the public water supply service area.

6.2 Goals

Average daily water use within cities of the service area ranges between 111 and 190 gallons per person or per capita per day (Table 6-1). Under dry weather conditions, per capita water use within the cities is 18 percent higher than the average, and ranges between