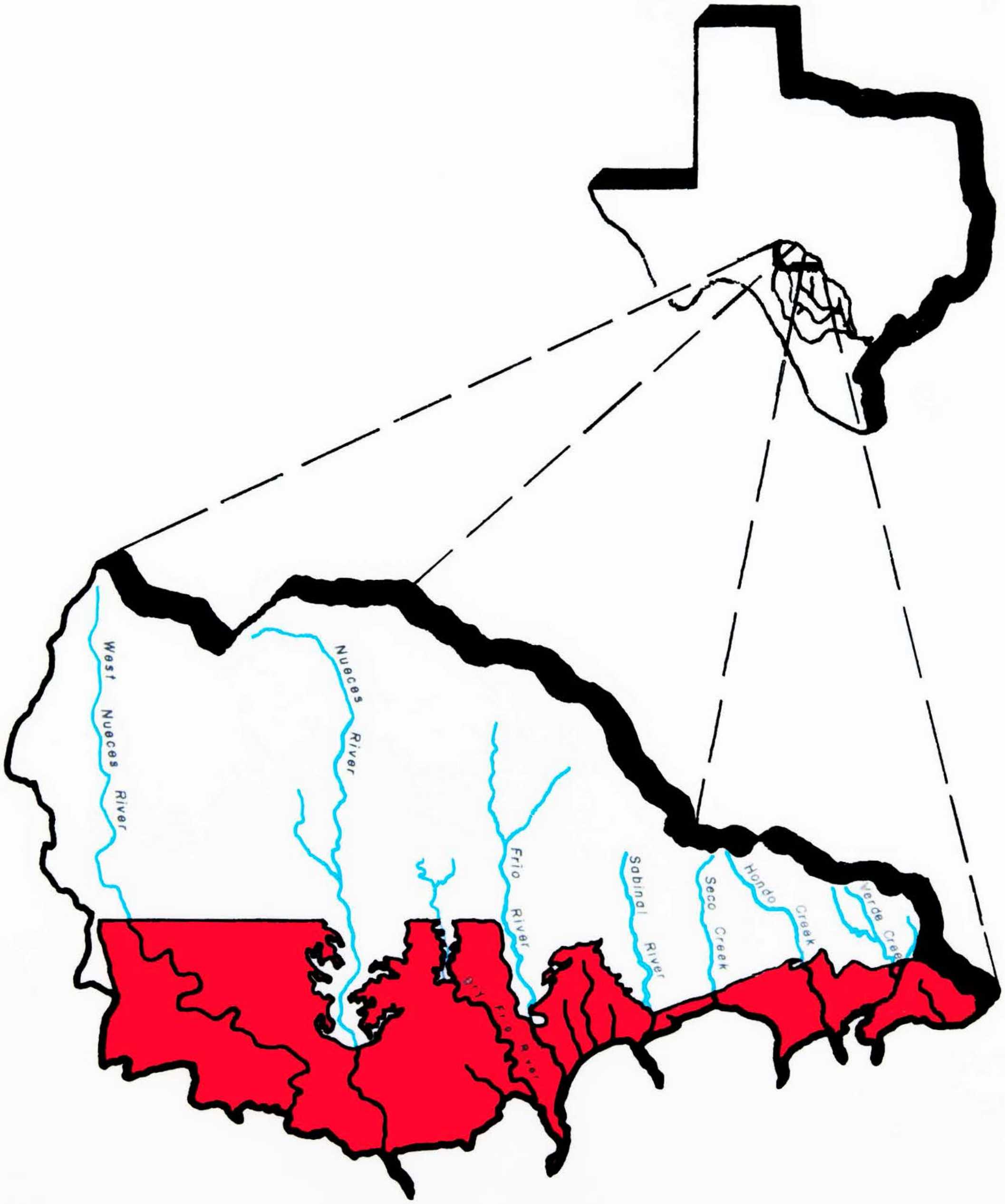

Regional Water Supply Planning Study Phase III Recharge Enhancement

Nueces River Basin

Nueces River Authority

Edwards Underground Water District

City of Corpus Christi

South Texas Water Authority

Texas Water Development Board

HDR

HDR Engineering, Inc.

In Association With
Paul Price Associates, Inc.

NUECES RIVER BASIN
REGIONAL WATER SUPPLY PLANNING STUDY
PHASE III - RECHARGE ENHANCEMENT

FINAL REPORT

Prepared for

Nueces River Authority
Edwards Underground Water District
City of Corpus Christi
South Texas Water Authority
Texas Water Development Board

by

HDR Engineering, Inc.
and
Paul Price Associates, Inc.

November, 1991

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Regional Water Supply Planning Study
Phase III

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NUECES RIVER BASIN
REGIONAL WATER SUPPLY PLANNING STUDY
PHASE III- RECHARGE ENHANCEMENT

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

NUECES RIVER BASIN
REGIONAL WATER SUPPLY PLANNING STUDY
PHASE III - RECHARGE ENHANCEMENT

1. Study Background and Objectives

The study area consists primarily of the Nueces River Basin, which covers an area of approximately 17,000 square miles in South Texas. Several entities interested in the potential effects and costs of developing additional recharge enhancement structures, along with the Texas Water Development Board (TWDB), have jointly participated in the performance of this study. These four entities are:

Nueces River Authority (Authority);
Edwards Underground Water District (EUWD);
City of Corpus Christi; and
South Texas Water Authority (STWA).

Over the past several decades, increasing water demands on the Edwards Aquifer have raised concerns about the ability of the aquifer to meet these demands without causing social, economic, and environmental problems. The headwaters of the Nueces River Basin contribute about 57% of the total volume of surface water recharged to the San Antonio portion of the Edwards Aquifer. Streams crossing the Edwards Aquifer recharge zone lose a significant portion of their flow through faults and solution cavities in the limestone formations. A large portion of the runoff from the headwater area, however, occurs during storms which exceed the natural recharge capability of the recharge zone. In this Phase III of the Nueces River Basin Regional Water Supply Planning Study, the 19 recharge enhancement reservoirs identified during Phase I have been evaluated with respect to cost and environmental concerns.

2. Description of Recharge Reservoirs

Two types of recharge reservoirs were analyzed based on hydrologic conditions for the 56-year period of record from 1934 through 1989. Type 1 reservoirs are catch-and-release structures and Type 2 are immediate recharge structures. Type 1 structures are located upstream of the recharge zone and are operated to release water at the maximum recharge rate of the downstream channel. Type 2 structures are located within the recharge zone. Water in the Type 2 structures recharges directly from the bottom of the reservoir and the entire volume is drained, usually within a period of less than one month. (The exception to this is the Indian Creek site located on the Nueces River, which may take from several months to more than a year to drain.) Figure 2.1-1 in Section 2 of this report illustrates the operation of both types of structures. The location of each of the recharge projects investigated is shown in Figure 2.1-2 in Section 2 of this report.

3. Basis for Recharge Volumes and Project Costs

In order to optimize the cost of a recharge program (i.e., get the most water for each dollar spent on the program), the 10%, 25%, 50%, and 100% (maximum) conservation capacities as determined in Phase I were analyzed for each site with respect to recharge amounts and costs. Conservation capacity is defined to be the volume of water which can be stored below the lowest uncontrolled reservoir outlet. Recharge volumes were calculated for each site using the Nueces River Basin Model developed during Phase I with some additional refinements to more accurately simulate the performance of smaller structures. Recharge enhancement volumes were calculated subject to average and drought conditions. Average conditions represent the average annual recharge rate for the entire 56-year period (1934-1989) analyzed. Drought conditions represent the average annual recharge rate for the 10-year period from 1947 through 1956 which is when the most severe drought of record occurred.

Cost estimates were prepared on the basis of 1991 construction, road relocation, land, and environmental mitigation costs, and estimated annual operation and maintenance costs. Construction cost estimates include 20% for contingencies. Engineering, legal, financial, and miscellaneous costs were assumed to total 20% of related capital costs. Annual debt service requirements were based on 25-year financing and a 7.5% interest rate. For projects impacting the water rights of the Choke Canyon/Lake Corpus Christi System (CC/LCC System), an estimated annual cost for purchase of these impacts was also included.

4. Summary of Recharge Enhancement Programs Investigated

A total of 19 recharge enhancement projects were investigated in this study including seven Type 1 projects, seven Type 2 projects on major rivers and streams, and five Type 2 projects on tributary streams. Optimal unit costs for each of the Type 2 Tributary projects proved to be substantially higher than unit costs for the Type 1 and Type 2 Mainstem projects. Collection and evaluation of daily precipitation and runoff data for the tributary subwatersheds, however, would result in improved estimates of recharge enhancement and potentially reduce the estimated unit costs for the Type 2 Tributary projects presented in this report.

Analyses of all recharge enhancement projects were performed for two different water rights scenarios. The first set of analyses was performed honoring all existing water rights (except for several small rights located downstream of Lake Corpus Christi) to the maximum extent possible within the analytical limitations of a monthly model. Under this scenario, inflows are released from the recharge reservoirs in months during which the reservoirs would have caused additional downstream shortages. Full mitigation of downstream shortages was not entirely possible within the model due, in part, to the monthly rather than daily simulation of recharge rates. A second set of analyses was performed in which, like the first scenario, additional water rights shortages were met by the release of water with one exception. This exception involved the water rights of the CC/LCC System in which case impacts were not mitigated by releases, but were assumed to be purchased.

In actual practice, under either water rights scenario, downstream water availability and operational flexibility for permittees having limited, or no storage rights will likely be improved by the implementation of recharge enhancement projects. This will occur as a result of water rights mitigation releases from the recharge projects being made at controlled rates over more extended periods than a natural storm hydrograph. In many instances, this will provide owners of irrigation rights the opportunity to divert water from the river for a period of days or even weeks after the storm flows would normally have passed.

Table ES-1 presents a ranking of all Type 1 and Type 2 Mainstem projects evaluated

TABLE ES-1
Recharge Enhancement Project Rankings

Honoring All Water Rights				Average Conditions	
Rank	Project	Type	Optimal Percentage Capacity	Recharge Enhancement (acft/yr)	Annual Cost / Unit Recharge Enhancement
1	Upper Sabinal	1	10	10,080	$163
2	Upper Verde	1	25	3,990	$210
3	Lower Sabinal	2	10	2,290	$211
4	Concan	1	10	8,190	$217
5	Upper Dry Frio	1	10	5,840	$221
6	Montell	1	10	26,370	$240
7	Upper Hondo	1	10	4,700	$248
8	Lower Frio	2	10	2,470	$271
9	Upper Seco	1	50	3,410	$335
10	Indian Creek	1/2	25	14,650	$357
11	Lower Verde	2	10	920	$410
12	Lower Hondo	2	10	1,280	$453
13	Lower Dry Frio	2	25	1,760	$498
14	Lower Seco	2	10	1,050	$567
With Purchase of Water Rights				**Average Conditions**	
Rank	**Project**	**Type**	**Optimal Percentage Capacity**	**Recharge Enhancement (acft/yr)**	**Annual Cost / Unit Recharge Enhancement**
1	Lower Sabinal	2	10	7,720	$66
2	Lower Frio	2	10	5,940	$114
3	Lower Verde	2	10	3,150	$134
4	Upper Sabinal	1	10	11,240	$146
5	Lower Hondo	2	10	3,930	$150
6	Upper Verde	1	25	4,540	$185
7	Concan	1	10	8,740	$204
8	Montell	1	10	32,090	$207
9	Indian Creek	1/2	25	26,500	$213
10	Lower Dry Frio	2	25	4,090	$216
11	Upper Dry Frio	1	10	5,840	$221
12	Lower Seco	2	10	2,520	$238
13	Upper Hondo	1	10	4,700	$248
14	Upper Seco	1	50	3,660	$313

in this study at optimal percentage capacity based on minimum annual cost per unit of recharge enhancement. Values in Table ES-1 are for average conditions subject to each of the two water rights scenarios. When honoring all water rights, Table ES-1 shows that a program of Type 1 projects would minimize the unit costs of developing the recharge enhancement potential of each subwatershed. The results of analyses of the Type 1 projects honoring all water rights are presented in Section 5 of this Executive Summary. The results of analyses of Type 1 projects with purchase of water rights in the CC/LCC System are not presented in this Executive Summary because the unit costs under this scenario are greater than for Type 2 projects.

Assuming the purchase of water rights in the CC/LCC System, Table ES-1 shows that a program of Type 2 projects with the marginal exception of the Montell Project would minimize the unit costs of developing the recharge enhancement potential of each subwatershed. The results of analyses of the Type 2 projects assuming the purchase of water rights in the CC/LCC System are presented in Section 6 of this Executive Summary. The results of analyses of Type 2 projects honoring all water rights are not presented in this Executive Summary because the unit costs under this scenario are greater than for Type 1 projects.

5. Summary of Type 1 Programs Honoring All Water Rights

Results of the analyses performed for the Type 1 projects for two sets of conservation capacities are presented in Table ES-2 and the following subsections. The two conservation capacities presented are the 100% capacity and the optimum capacity (with respect to minimum unit cost) selected from the four capacities analyzed at each site.

TABLE ES-2
Summary of Recharge Enhancement Programs-Type 1 Reservoirs

Rank*	Project	Percent Capacity	Capacity (acft)	Surface Area (ac)	Average Conditions: Recharge Enhancement (acft/yr)	Average Conditions: Cost/Unit Recharge Enhancement ($/acft/yr)	Drought Conditions: Recharge Enhancement (acft/yr)	Drought Conditions: Cost/Unit Recharge Enhancement ($/acft/yr)	Reduction in Median Estuarine Inflow (acft/yr)	Reduction in CC/LCC System Yield (acft/yr)
100% Conservation Capacity										
1	Upper Dry Frio	100	60,000	1,800	9,420	$330	2,900	$1,072	0	0
2	Upper Verde	100	23,000	880	4,600	$339	1,390	$1,120	0	120
3	Upper Sabinal	100	93,300	3,110	14,670	$357	2,520	$2,078	0	30
4	Upper Hondo	100	47,000	2,000	8,360	$361	1,140	$2,647	0	0
5	Montell	100	252,300	6,190	34,200	$381	9,200	$1,415	2,460	440
6	Upper Seco	100	23,000	900	3,820	$398	290	$5,246	0	0
7	Concan	100	149,000	3,840	12,210	$486	3,085	$1,925	0	0
	Total		647,600	18,720	87,280		20,525		2,460	590
	Weighted Average					$383		$1,627		
Optimum Conservation Capacity										
1	Upper Sabinal	10	9,330	550	10,080	$163	2,520	$650	0	30
2	Upper Verde	25	5,750	350	3,990	$210	1,390	$603	0	120
3	Concan	10	14,900	710	8,190	$217	3,085	$577	0	0
4	Upper Dry Frio	10	6,000	440	5,840	$221	2,630	$491	0	0
5	Montell	10	25,230	1,460	26,370	$240	9,200	$688	2,460	440
6	Upper Hondo	10	4,700	350	4,700	$248	1,140	$1,024	0	0
7	Upper Seco	50	11,500	600	3,410	$335	290	$3,944	0	0
	Total		77,410	4,460	62,580		20,255		2,460	590
	Weighted Average					$227		$700		

*Rank is based on Cost/Unit Recharge Enhancement for Average Conditions.

100% Conservation Capacity

If all Type 1 projects are constructed at the maximum (100%) capacity, average annual recharge in the Nueces River Basin can be increased by 87,280 ac-ft per year (27%) and during the 10-year drought by 20,525 ac-ft per year (13%). These recharge volumes represent the maximum attainable recharge for the Type 1 structures. The unit cost of water under this program is $383 per ac-ft per year based on the average climatic conditions and $1,627 per ac-ft per year based on the 10-year drought period from 1947 to 1956. Total reservoir storage is 647,600 acre-feet and total capital costs for this program are in excess of $345,000,000. Under this program, the median inflow to the Nueces Estuary is reduced by 2,460 ac-ft per year (1%) and the yield of the CC/LCC System is reduced by 590 ac-ft per year (0.3%).

Optimum Conservation Capacity

If the Type 1 projects are downsized to provide the optimum unit cost of water at each site (based on the additional average annual recharge), average annual recharge in the Nueces River Basin is increased by 62,580 ac-ft per year (19%) and drought recharge is increased by 20,255 ac-ft per year (13%). The unit cost of water under this program is $227 per ac-ft per year based on average climatic conditions and $700 per ac-ft per year based on drought conditions. Although average annual recharge enhancement under this program decreases by 28% from the 100% Conservation Capacity Program, capital cost decreases by 60%. Under this program, total reservoir storage is 77,410 acre-feet and total capital costs are approximately $138,800,000. The median inflow to the Nueces Estuary is reduced by 2,460 ac-ft per year (1%) and the 1990 yield of the CC/LCC System is reduced by 590 ac-ft per year (0.3%).

6. Summary of Type 2 Programs with Purchase of Water Rights in CC/LCC System

Results of the analyses performed for the Type 2 projects for two sets of conservation capacities are presented in Table ES-3 and the following sub-sections. The two conservation capacities presented are the 100% capacity and the optimum capacity selected from the four capacities analyzed at each site.

100% Conservation Capacity

If all Type 2 projects are constructed at the maximum (100%) capacity, recharge in the Nueces River Basin can be enhanced by 96,210 ac-ft per year (30%) on the average and by 25,790 ac-ft per year (17%) during the 10-year drought. These recharge volumes represent the maximum recharge attainable with the Type 2 structures. The unit cost of water under this program is $260 per ac-ft per year based on average climatic conditions and $969 per ac-ft per year based on the 10-year drought period from 1947 to 1956. Total reservoir storage is 380,950 acre-feet and total capital costs for this program are approximately $247,600,000. The median inflow to the Nueces Estuary is reduced by 5,250 ac-ft per year (2.2%) and the 1990 yield of the CC/LCC System is reduced by 2,230 ac-ft per year (1%).

Optimum Conservation Capacity

If the Type 2 projects are downsized to provide the optimum unit cost of water at each site (based on the additional average annual recharge), average annual recharge in the

TABLE ES-3
Summary of Recharge Enhancement Programs-Type 2 Reservoirs

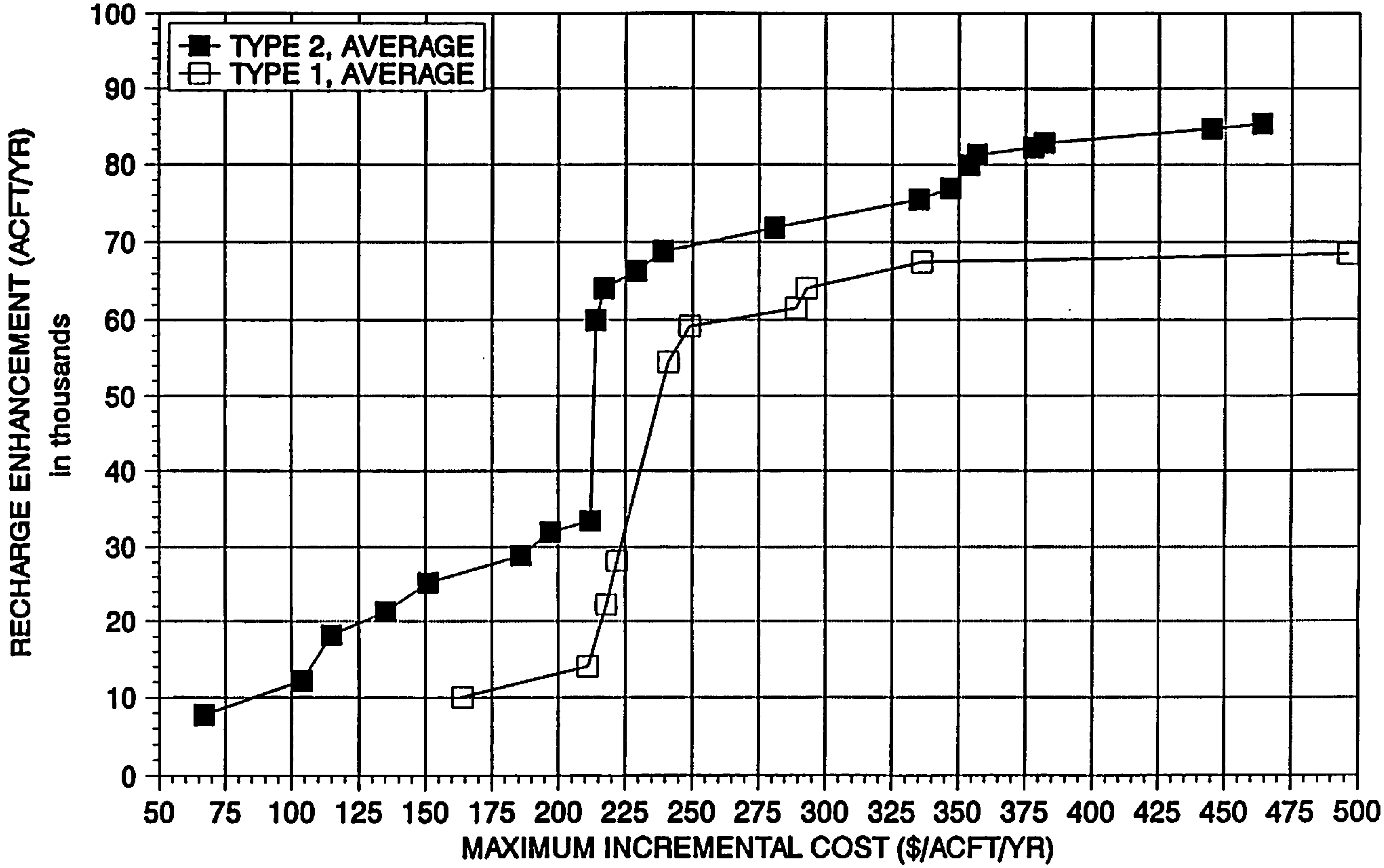
Rank*	Project	Percent Capacity	Capacity (acft)	Surface Area (ac)	Average Conditions: Recharge Enhancement (acft/yr)	Average Conditions: Cost/Unit Recharge Enhancement ($/acft/yr)	Drought Conditions: Recharge Enhancement (acft/yr)	Drought Conditions: Cost/Unit Recharge Enhancement ($/acft/yr)	Reduction in Median Estuarine Inflow (acft/yr)	Reduction in CC/LCC System Yield (acft/yr)
100% Conservation Capacity										
1	Lower Sabinal	100	35,000	1,430	18,400	$145	2,770	$965	0	30
2	Lower Verde	100	24,000	1,730	6,220	$215	1,980	$676	0	120
3	Lower Hondo	100	28,000	1,260	9,420	$255	1,190	$2,021	0	0
4	Lower Frio	100	50,000	1,760	14,400	$267	3,180	$1,211	0	0
5	Indian Creek	100	165,000	7,650	34,500	$267	14,600	$630	5,250	2,080
6	Lower Dry Frio	100	30,000	1,190	6,170	$306	1,360	$1,387	0	0
7	Lower Seco	100	28,000	1,630	5,240	$422	290	$7,632	0	0
8	Elm Creek	100	6,940	370	670	$463	120	$2,584	0	0
9	Little Blanco	100	2,930	210	390	$662	100	$2,583	0	0
10	Quihi Creek	100	1,570	120	150	$811	30	$4,057	0	0
11	Leona River	100	2,930	220	280	$911	60	$4,253	0	0
12	Blanco	100	6,580	260	370	$1,318	110	$4,434	0	0
	Total		380,950	17,830	96,210		25,790		5,250	2,230
	Weighted Average					$260		$969		
Optimum Conservation Capacity										
1	Lower Sabinal	10	3,500	280	7,720	$66	2,300	$221	0	30
2	Lower Frio	10	5,000	340	5,940	$114	2,020	$337	0	0
3	Lower Verde	10	2,400	230	3,150	$134	1,380	$306	0	120
4	Lower Hondo	10	2,800	230	3,930	$150	1,190	$494	0	0
5	Indian Creek	25	41,250	2,770	26,500	$213	12,920	$437	4,970	1,500
6	Lower Dry Frio	25	7,500	420	4,090	$216	1,360	$650	0	0
7	Lower Seco	10	2,800	220	2,520	$238	290	$2,069	0	0
8	Elm Creek	100	6,940	370	670	$463	120	$2,584	0	0
9	Little Blanco	100	2,930	210	390	$662	100	$2,583	0	0
10	Quihi Creek	100	1,570	120	150	$811	30	$4,057	0	0
11	Leona River	100	2,930	220	280	$911	60	$4,253	0	0
12	Blanco	100	6,580	260	370	$1,318	110	$4,434	0	0
	Total		86,200	5,670	55,710		21,880		4,970	1,650
	Weighted Average					$193		$492		

*Rank is based on Cost/Unit Recharge Enhancement for Average Conditions.

Nueces River Basin is increased by 55,710 ac-ft per year (17%) and drought recharge is increased by 21,880 ac-ft per year (14%). The unit cost of water under this program is $193 per ac-ft per year based on average climatic conditions and $492 per ac-ft per year based on drought conditions. Although average annual recharge enhancement under this program decreases by 42% from the 100% Conservation Capacity Program, capital cost decreases by 61%. Under this program, total reservoir storage is 86,200 acre-feet and total capital costs are approximately $97,000,000. The median inflow to the Nueces Estuary is reduced by 4,970 ac-ft per year (2.1%) and the yield of the CC/LCC System is reduced by 1,650 ac-ft per year (0.8%).

7.0 Consideration of Type 1 and Type 2 Programs

The preceding two sections of the Executive Summary present Type 1 and Type 2 recharge enhancement programs with all sites evaluated at both 100% and the optimal percentage of maximum conservation capacity. In order to select the most appropriate program, the relative merits of various groups of projects need to be considered with respect to incremental annual unit cost of recharge enhancement under average conditions. Figure ES-1 presents potential recharge enhancement versus maximum incremental cost for a range of Type 1 and Type 2 programs subject to average and drought conditions. Each point in this figure represents a specific program comprised of individual projects at conservation capacities equal to or greater than the optimal capacity. The leftmost point of each curve in the figure represents the single project of a given type having the least unit cost at its optimal capacity subject to average climatic conditions. Each point, moving to the right along the curve, represents the addition of a project or upsizing of the same project to the



MAXIMUM INCREMENTAL COST BASED ON AVERAGE CLIMATIC CONDITIONS.
SEE APPENDICES C AND D.

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NUECES RIVER BASIN
REGIONAL WATER SUPPLY
PLANNING STUDY PHASE III

INCREMENTAL COST SUMMARY OF RECHARGE ENHANCEMENT PROGRAMS

FIGURE ES-1

next higher percentage (25%, 50%, or 100%) of capacity in excess of the optimum. Type 1 and Type 2 Programs corresponding to the points in Figure ES-1 are summarized in tabular form in Appendices C and D, respectively.

Comparison of the range of Type 1 and Type 2 Programs presented in Figure ES-1 indicates that substantially greater quantities of recharge enhancement under average conditions can be obtained with Type 2 Programs for incremental unit costs less than that for Type 1 Programs. Hence, a program of selected Type 2 projects which includes mitigation of impacts to the CC/LCC System is the most feasible alternative for recharge enhancement in the Nueces River Basin. If the owners of the CC/LCC System are not agreeable to a program that allows mitigation of impacts to the CC/LCC System, then the Type 1 reservoirs would be more attractive on an incremental unit cost basis.

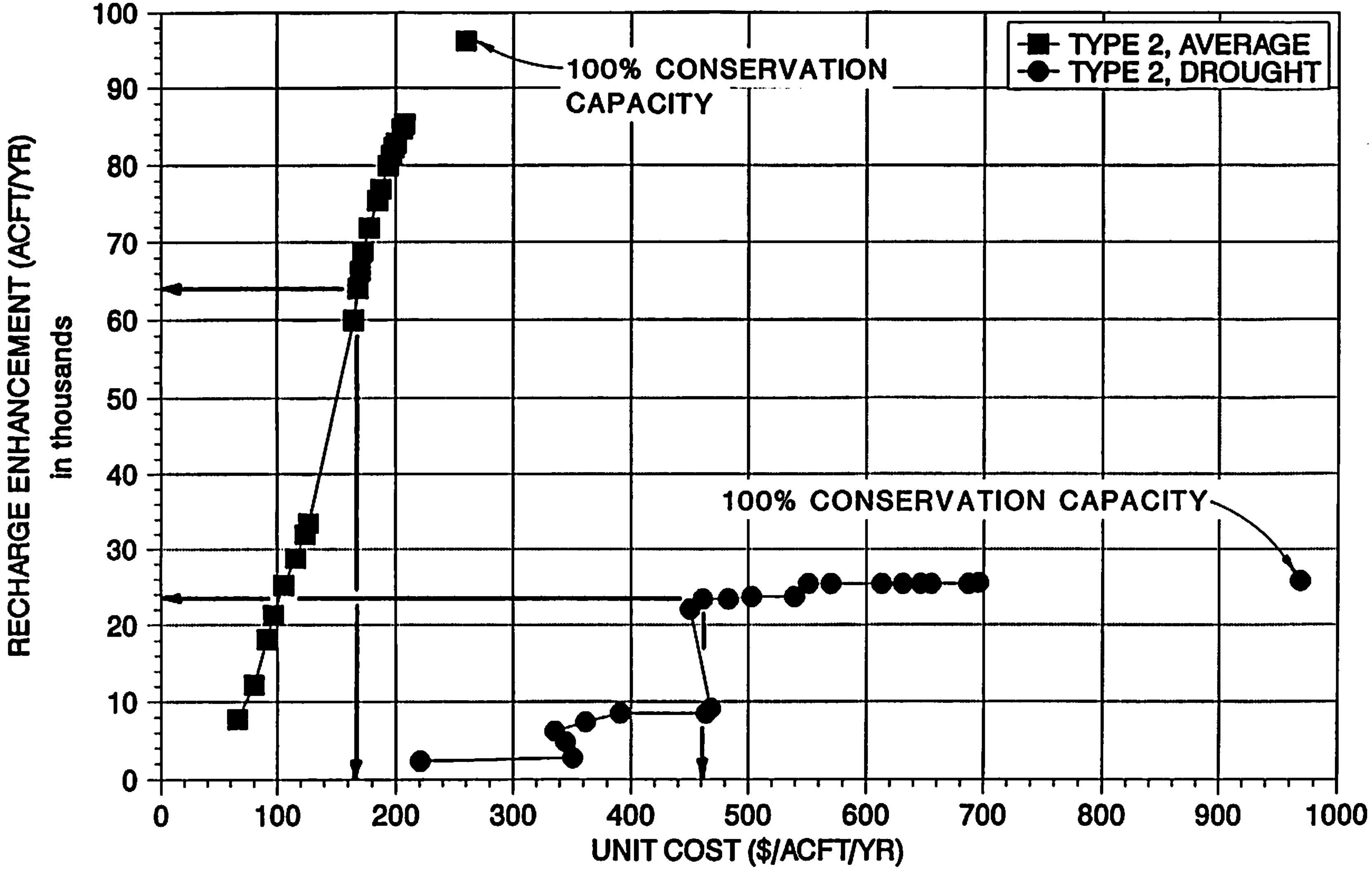
There are other advantages to the Type 2 Programs, aside from incremental unit cost, including substantially reduced environmental sensitivity, fewer affected landowners, and significantly less impact to recreational interests. Although the report prepared by Paul Price Associates, Inc. concludes that none of the projects need be dismissed on the basis of environmental considerations, it is clear that development of Type 2 project sites which have little or no base streamflow and minimal recreational use are less likely to meet with opposition than any of the Type 1 projects.

Preliminary analyses indicate that implementation of either Type 1 or Type 2 Programs will have no significant impacts on the braided reach of the Nueces River or recharge of the Carrizo-Wilcox Aquifer. On the basis of studies of the braided reach by the U.S. Geological Survey (Ref. 18) and frequency analysis of flows from the Nueces River Basin Model, it is concluded that the frequency of overbank inundation in the braided reach would be reduced by less than 1%, while the frequency of zero flows (which presently occur about 40% of the time) would be unaffected. Preliminary analyses show that implementation of either Type 1 or Type 2 Programs would reduce total recharge of the Carrizo-Wilcox Aquifer by less than 1% based on review of a Texas Water Development Board study of the Carrizo Aquifer in the Winter Garden Area (Ref. 15).

Review of the Type 2 Programs presented in Figure ES-1 and Appendix D reveals a significant breakpoint in recharge enhancement at a maximum incremental cost of approximately $217 per ac-ft per year. At this breakpoint, the program is comprised of all Type 2 Mainstem projects evaluated with the exception of the Lower Seco Project.

8.0 Example Type 2 Program

As an illustration of how the information developed in this study can be used to formulate a program for development of recharge enhancement projects, Figure ES-2 presents the same group of Type 2 programs shown in Figure ES-1 with respect to unit cost of recharge enhancement under both average and drought conditions, and Table ES-4 presents an Example Type 2 Program. This Example Program includes only the Type 2 reservoirs which provide additional recharge at an incremental unit cost of less than $217 per acre-foot per year. The six projects (and corresponding conservation capacities) which meet this criteria are (from west to east) Indian Creek (25%), Lower Dry Frio (25%), Lower Frio (25%), Lower Sabinal (50%), Lower Hondo (10%), and Lower Verde (25%). As indicated by the arrows in Figure ES-2, average annual recharge in the Nueces River Basin is increased by 64,030 ac-ft per year (20%) and drought recharge is increased by 23,390 ac-ft per year (15%) under this program. The unit cost of water under this Example



ARROWS INDICATE EXAMPLE TYPE 2 PROGRAM.
SEE APPENDIX D.

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NUECES RIVER BASIN
REGIONAL WATER SUPPLY
PLANNING STUDY PHASE III

UNIT COST SUMMARY
OF TYPE 2 RECHARGE
ENHANCEMENT PROGRAMS

FIGURE ES-2

TABLE ES-4 Example Type 2 Recharge Enhancement Program										
					Average Conditions		Drought Conditions			
Rank*	Project	Percent Capacity	Capacity (acft)	Surface Area (ac)	Recharge Enhancement (acft/yr)	Cost/Unit Recharge Enhancement ($/acft/yr)	Recharge Enhancement (acft/yr)	Cost/Unit Recharge Enhancement ($/acft/yr)	Reduction in Median Estuarine Inflow (acft/yr)	Reduction in CC/LCC System Yield (acft/yr)
Example Type 2 Program**										
1	Lower Sabinal	50	17,500	960	15,350	$104	2,770	$575	0	30
2	Lower Frio	25	12,500	820	9,530	$141	3,180	$424	0	0
3	Lower Hondo	10	2,800	230	3,930	$150	1,190	$494	0	0
4	Lower Verde	25	6,000	500	4,630	$159	1,970	$373	0	120
5	Indian Creek	25	41,250	2,770	26,500	$213	12,920	$437	4,970	1500
6	Lower Dry Frio	25	7,500	420	4,090	$216	1,360	$650	0	0
	Total		87,550	5,700	64,030		23,390		4,970	1650
	Average					$169		$461		

*Rank is based on Cost/Unit Recharge Enhancement for Average Conditions.
**Program includes projects with a Cost/Unit Recharge Enhancement for Average Conditions less than $217/acft/yr ($0.67/1,000 gallons).

$169 per ac-ft per year based on the average annual increase in recharge and $461 per ac-ft per year based on drought conditions. It is apparent in Figure ES-2 that little additional recharge enhancement could be obtained under drought conditions by development of projects larger than those comprising the Example Program.

Although average annual recharge under the Example Program is 33% less than that for the 100% Conservation Capacity Program, capital cost decreases by 61%. Total reservoir storage is 87,550 acre-feet and total capital costs are approximately $97,100,000. The median inflow to the Nueces Estuary is reduced by 4,970 ac-ft per year (2.1%) and the 1990 yield of the CC/LCC System is reduced by 1,650 ac-ft per year (0.8%). It is estimated that the total storage capacity under the Example Type 2 Program would be reduced by about 8% after 50 years of sediment accumulation based on a study by the Texas Department of Water Resources (Ref. 13). Direct percolation rates from the projects will, over time, be reduced by sediment accumulation. However, analysis of this reduction at the existing Parker Creek recharge reservoir shows that, after 17 years of operation, the recharge rate is still more than adequate to drain the reservoir within a month.

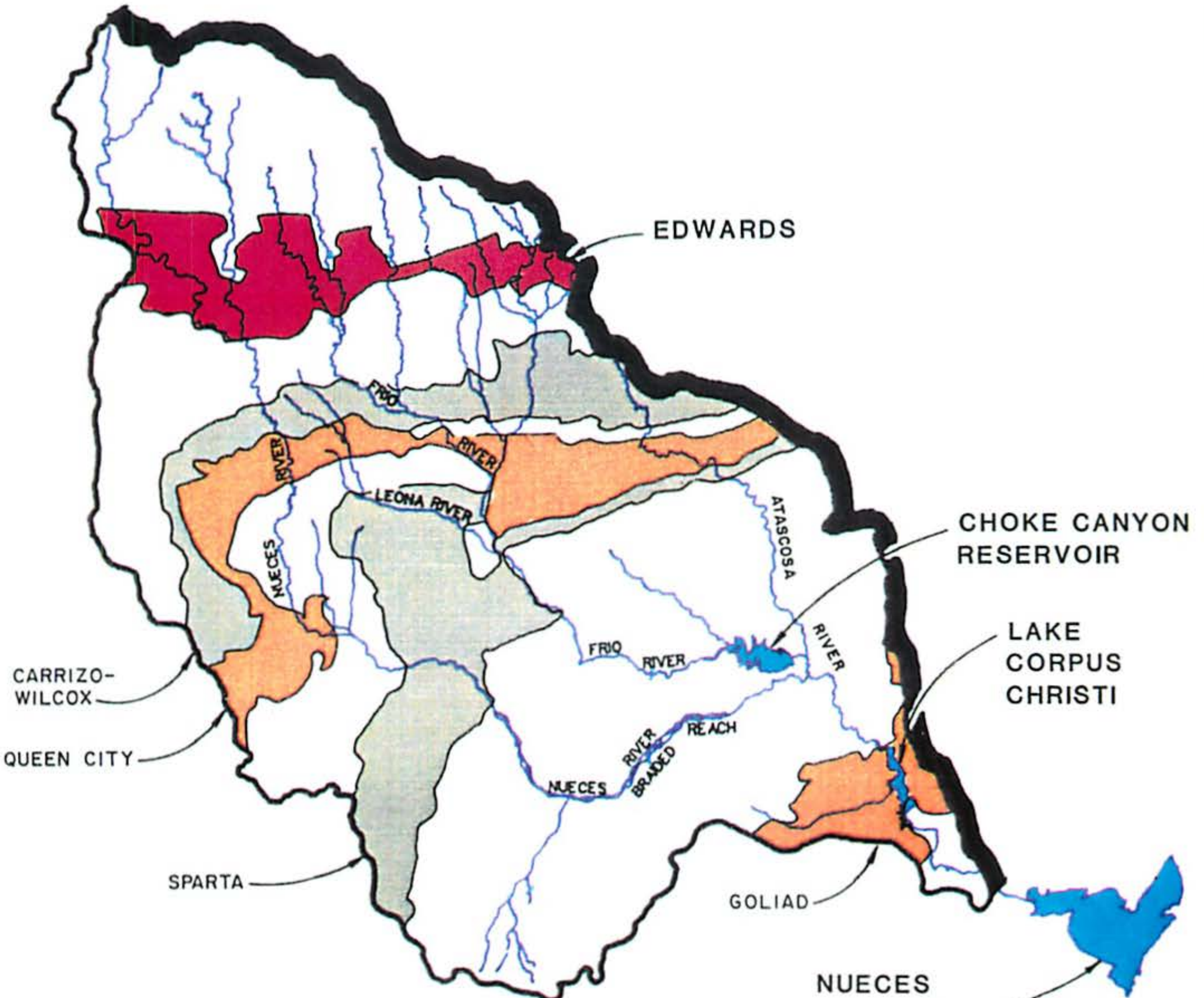
SECTION 1

NUECES RIVER BASIN
REGIONAL WATER SUPPLY PLANNING STUDY
PHASE III - RECHARGE ENHANCEMENT

1.0 INTRODUCTION

The Nueces River Basin encompasses almost 17,000 square miles extending from the headwaters on the Edwards Plateau north of Uvalde through the Rio Grande Plains and Gulf Coast Prairies to the outlet at Nueces Bay near Corpus Christi. As is apparent in Figure 1.0-1, the Nueces River Basin is crossed by five major aquifer recharge zones including the Edwards, Carrizo-Wilcox, Queen City, Sparta, and Goliad. The most transmissive of these zones is the Edwards limestone aquifer recharge zone which lies at the base of the Balcones Escarpment in the headwaters of the Nueces and Frio Rivers. Approximately 20% of the Basin lies upstream of or atop the Edwards Aquifer recharge zone. The Edwards Aquifer is the sole source of water supply for the City of San Antonio as well as numerous agricultural interests throughout Uvalde and Medina Counties. The aquifer also feeds Leona, Comal, and San Marcos Springs, creating unique environments and recreational opportunities while providing base flow to the Leona, Guadalupe, and San Marcos Rivers.

The economic and ecologic dependence of the areas served by the Edwards Aquifer has prompted a series of studies with the objectives of evaluating the potential for artificial enhancement of aquifer recharge as well as the potential impacts of such enhancement to other interests in the Nueces River Basin. The Edwards Underground Water District, Nueces River Authority, Texas Water Development Board, City of Corpus Christi, and South Texas Water Authority have sponsored a multi-phase Regional Water Supply Planning



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**NUECES RIVER BASIN
REGIONAL WATER SUPPLY
PLANNING STUDY PHASE III**

**RIVER BASIN MAP
WITH AQUIFER
RECHARGE ZONES**

FIGURE 1.0-1

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Study to accomplish these objectives. Phase I of the Study (Ref. 9) showed that potential exists for significantly enhancing recharge to the Edwards Aquifer through the development of medium to large size recharge dams. Phase I studies also quantified the maximum potential impacts of these dams on water availability to the City of Corpus Christi and the Nueces Estuary. Results of the Phase I studies were calculated without direct consideration of cost or environmental concerns. Phase II studies did not consider recharge enhancement projects, but addressed the reliability of the CC/LCC System subject to various operational and estuarine inflow constraints.

The primary objective of this phase (Phase III) of the Regional Water Supply Planning Study was to generally optimize the size of each previously identified recharge project on the basis of recharge enhancement, capital and annual costs, and potentially significant environmental impacts. The following sections of this report summarize the methodologies and site-specific considerations involved in accomplishing this objective. Section 2 details the methodologies applied in optimizing project development at the various sites including physical constraints, recharge enhancement honoring water rights, and project cost calculation. An evaluation of optimal development based on the unique characteristics of each individual recharge enhancement project is presented in Section 3. Environmental impacts and potential mitigation requirements are discussed in a report prepared by Paul Price Associates, Inc. included herein as Appendix A. Finally, Section 4 presents conclusions and recommendations concerning recharge enhancement and includes typical project development schedules for small and large projects.

SECTION 2

2.0 RECHARGE PROJECT EVALUATION METHODOLOGY

A total of 19 potential recharge enhancement projects were identified in the first phase of the Regional Water Supply Planning Study of the Nueces River Basin. The maximum potential recharge enhancement and downstream impacts were evaluated in the Phase I studies by assuming a maximum reasonable storage or conservation capacity at each site without consideration of optimal site or basin development and environmental concerns. The project evaluation methodologies applied in this study were selected in an effort to maximize recharge enhancement while minimizing project costs and impacts on the environment and downstream water rights. Annual project cost per unit of recharge enhancement was computed in this study for four storage capacities at each site including 10%, 25%, 50%, and 100% of the maximum conservation capacity considered in Phase I.

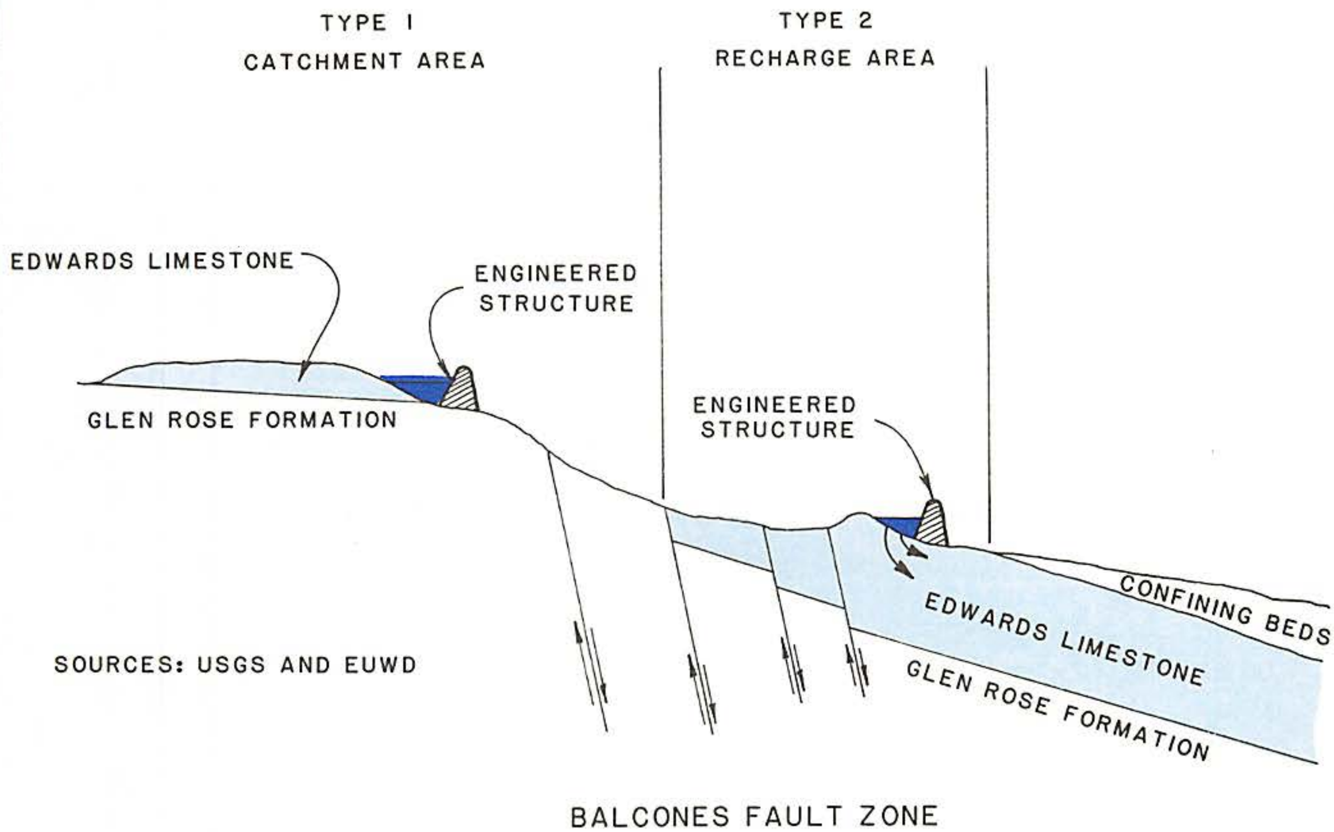
Optimum site development is defined to be the site capacity studied at which annual cost per unit recharge enhancement is minimized. Optimal basin development is defined to be the group of recharge enhancement projects by which basin-wide cost per unit recharge is minimized. In order to achieve optimal basin development, however, a specific project may be sized in excess of the "optimal" site capacity because the incremental unit cost of recharge at capacities in excess of the optimum for that project may be substantially less than the minimum unit cost for another project. The following sections summarize the physical considerations and the methodologies applied to estimate recharge enhancement potential and the related costs of dam, spillway, and outlet works construction, road relocations, land acquisition, water rights, environmental mitigation, permitting, and engineering.

2.1 Physical Considerations

2.1.1 Project Type

Recharge enhancement projects considered in this study are of two general types as indicated in Figure 2.1-1. Type 1 or "catch and release" projects are typically located immediately upstream of the recharge zone in order to maximize controlled drainage area. These structures impound both flood flows and base flows in excess of the estimated recharge capacity of the stream reach crossing the recharge zone. During months in which inflows are less than the downstream recharge capacity, releases equivalent to the downstream recharge capacity are made from storage. Hence, Type 1 recharge projects may maintain storage contents for periods of months and even years. For this reason, net evaporation losses from Type 1 reservoirs are accounted for in the calculation of recharge enhancement.

Type 2 or "direct percolation" recharge enhancement projects are typically located near the downstream boundary of the recharge zone in order to maximize both controlled drainage area and the opportunity for natural recharge as streamflows traverse the recharge zone. Continuous base flows across the recharge zone are virtually nonexistent; therefore, Type 2 structures typically impound only flood flows. Impounded flows percolate directly into the aquifer through the bottom of the reservoir at a rate accelerated by the driving head of reservoir storage. Detailed analyses of percolation rates observed at the existing project on Parker Creek indicate adequate capacity to recharge stored waters up to the assumed maximum site capacity, generally within one month. Evaporation losses were, therefore, assumed negligible for Type 2 projects and not accounted for in the calculation of recharge enhancement.



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TYPES OF RECHARGE ENHANCEMENT PROJECTS

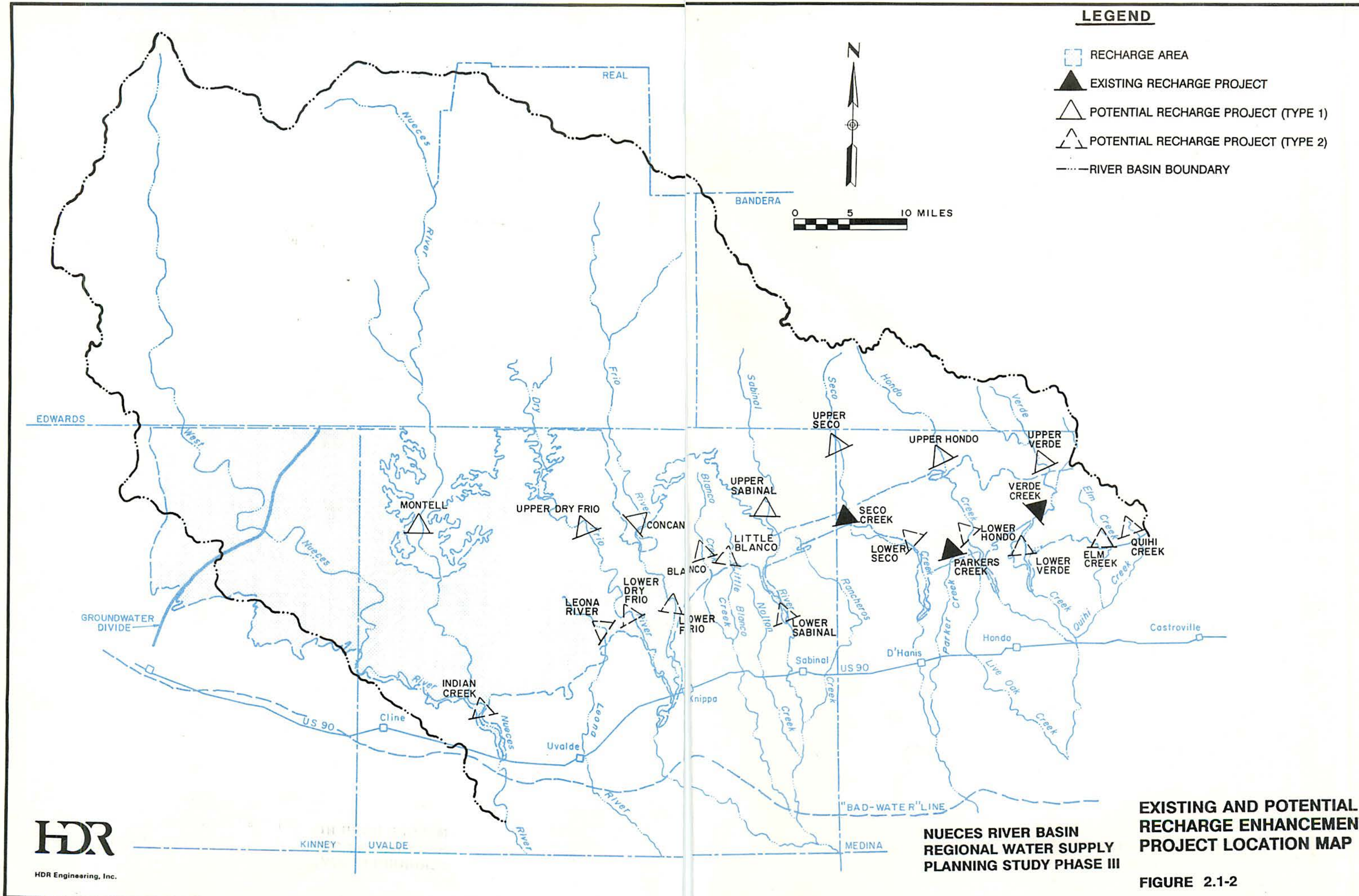
FIGURE 2.1-1

2.1.2 Site Selection

The locations of potential recharge enhancement projects evaluated in this study are presented in Figure 2.1-2 along with three existing recharge projects developed by the EUWD. The site selection criteria applied to Type 1 and Type 2 projects are summarized in the following paragraphs.

Of the seven Type 1 reservoir projects evaluated, six sites were identified during previous studies (Refs. 3 and 17). The Upper Verde Project was the only new Type 1 structure identified in Phase I of this study. Generally, the location of each of the Type 1 dams represents the first site upstream of the recharge zone which has suitable topography to impound a large volume of water and, to the extent possible, minimize relocations. For the purposes of this study, it was assumed that the geology of each site was suitable for construction of a large dam and reservoir. This assumption should be verified by field investigations and testing prior to any of these projects being considered for construction.

With the exception of the Indian Creek Project, each of the twelve Type 2 projects was identified during Phase I of this study. The Indian Creek Project was identified in a previous study performed for the Nueces River Authority (Ref. 6). Generally, the location of each Type 2 dam was selected to be as close as possible to the downstream limit of the recharge zone considering suitable topography for a large storage reservoir, minimization of relocations, and avoiding identified faults at the immediate dam site (Refs. 1 and 2). Site geology was assumed to be satisfactory for the construction of a dam and reservoir, although field investigations and testing will be required prior to any of these projects being considered for construction.



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EXISTING AND POTENTIAL RECHARGE ENHANCEMENT PROJECT LOCATION MAP

FIGURE 2.1-2

2.1.3 Basic Physical Data Development

Once site selection was accomplished for both the Type 1 and Type 2 projects, the basic physical data necessary to evaluate recharge enhancement potential and project cost was developed for each site. The relationship between water surface elevation, surface area, and storage capacity (E-A-C) was established using a polar planimeter to measure surface area from successive elevation contours on available topographic maps. These measurements were performed using 7.5-minute quadrangle topographic maps at a scale of 1 inch to 2,000 feet prepared by the U.S. Geological Survey. Storage volume calculations were generally performed using the average end area method. The E-A-C relationship was particularly important in establishing normal pool elevations for comparison with known sites of archaeological significance and in accurately estimating depletions of storage due to net evaporation at Type 1 sites. A centerline profile or valley cross section was also obtained from the topographic mapping in order to estimate dam construction quantities.

2.2 Recharge Enhancement Potential

2.2.1 Nueces River Basin Models

The recharge enhancement potential at each project site was calculated using the Nueces River Basin Model which was developed as a portion of Phase I of this Regional Water Supply Planning Study. Capabilities of the basin model include calculation of Edwards Aquifer recharge subject to the implementation of recharge projects operating under various upstream and downstream water rights constraints. The Lower Nueces Basin and Estuary Model (NUBEST) developed under separate contract with the Nueces River Authority and the City of Corpus Christi was used to quantify the impacts of recharge projects on the firm yield and storage of the Choke Canyon Reservoir / Lake Corpus Christi (CC/LCC) System and inflows to the Nueces Estuary.

The two models were used in tandem to determine the recharge enhancement under average and drought conditions, reductions in CC/LCC System yield and median storage, and reductions in average estuarine inflow resulting from the implementation of each potential project. Each of these parameters was computed assuming percentages of maximum conservation capacity for each recharge enhancement project of 10%, 25%, 50%, and 100%. Average conditions are based on the 56-year (1934 through 1989) historical period, while drought conditions are based on the 10-year (1947 through 1956) historical period. All simulations of CC/LCC System operations in this study are based on Phase IV of the City of Corpus Christi reservoir system operation plan and do not reflect as yet undetermined monthly estuarine inflow requirements and operational constraints being considered by the Texas Water Commission.

2.2.2 Water Rights Considerations

Potential recharge enhancement for each site at the four percentages of maximum storage or conservation capacity was computed subject to two water rights scenarios. Under both scenarios, all upstream and downstream water rights excluding those associated with the CC/LCC System were honored to the extent which they could have been without any additional recharge enhancement projects. Under the first scenario, inflows are passed through the recharge structures in order to fully honor the storage and diversion rights (up to the firm yield) associated with the CC/LCC system to the extent possible. In other words, no flows which would have reached the CC/LCC System under existing conditions were impounded by a recharge structure upstream of Choke Canyon Reservoir unless the CC/LCC System was full and spilling. (Note: Historically, there are many months when runoff over the recharge zone did not reach Choke Canyon Reservoir.) For recharge enhancement projects on the Nueces River, only the storage in Lake Corpus Christi, rather than the entire CC/LCC System, was considered in simulating operations. Under the second scenario, it was assumed that water rights could be purchased from the owners of the CC/LCC System by trading monetary compensation for the right to impound and recharge flows when the CC/LCC System is not spilling.

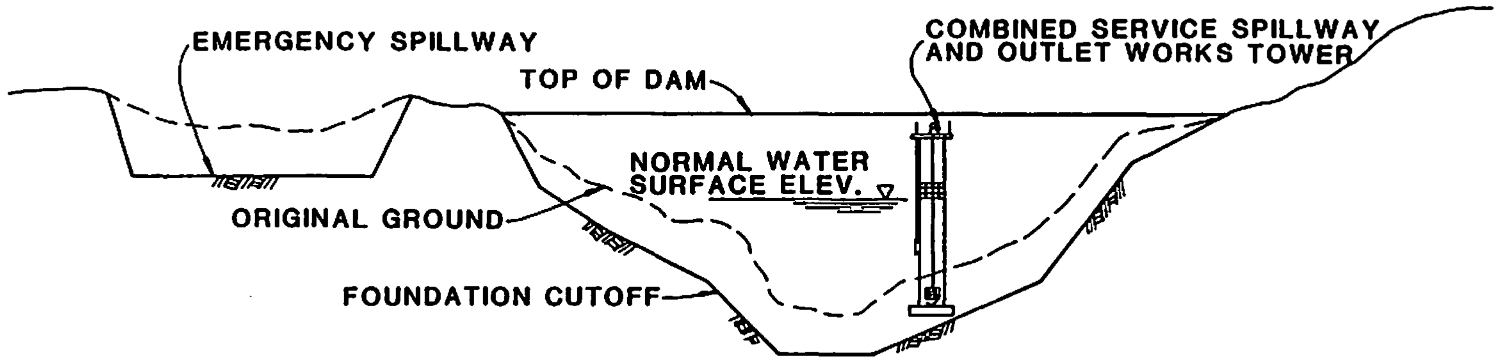
It is important to note that impacts to CC/LCC System storage rights and estuarine inflows cannot be completely avoided due to reservoir storage effects or hydrograph attenuation. Controlled release of all flood flows entering a Type 1 recharge project will result in Edwards Aquifer recharge rates in excess of those which would have occurred naturally, potentially causing reduced water availability downstream. Similarly, temporary impoundment of flood flows by a Type 2 recharge structure will result in percolation rates in excess of those which would have occurred naturally, potentially causing reduced water availability downstream. Once downstream of the Edwards Aquifer recharge zone, however, controlled releases could be subject to reduced channel loss rates due to the more continuous saturation of the streambed and reduced frequency of overbank flooding. Reduced channel losses will serve to mitigate, in part, the impacts of recharge projects on downstream water availability. Compensation for any remaining impacts could occur in the form of monetary compensation or mitigation by reservoir and water rights accounting procedures which could result in deferred compensation to affected water rights owners by releasing water in a month other than that in which the impact occurred.

2.3 Recharge Enhancement Costs

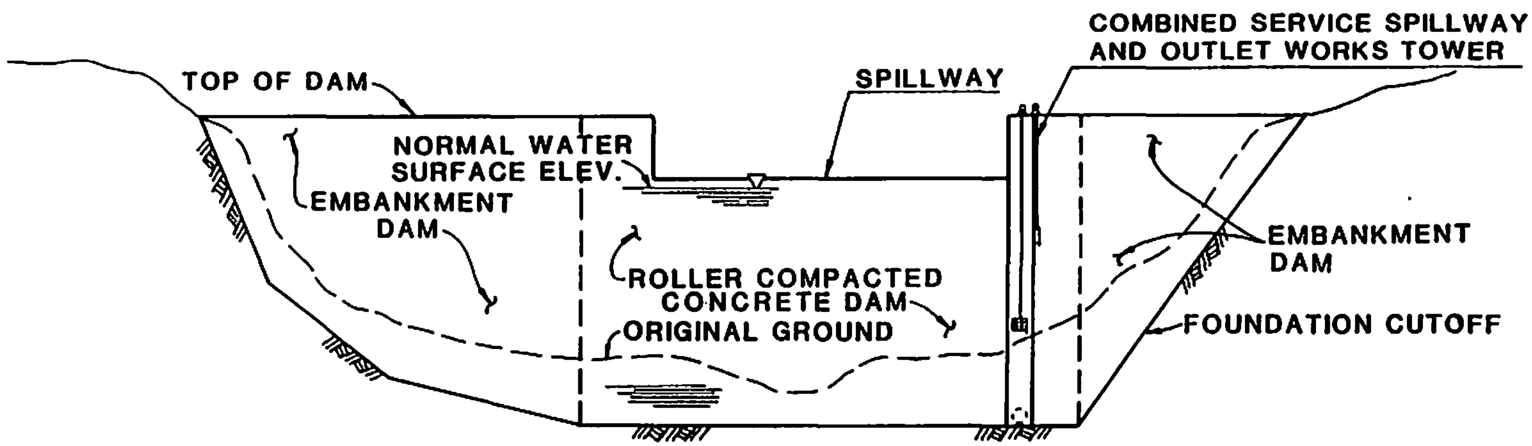
2.3.1 Conceptual Dam Designs

Based on knowledge gained through field visits to 14 of the proposed dam sites and a review of existing topographic and geologic information, two different dam types were considered appropriate for the recharge enhancement projects: 1) Embankment dams with a thin, central-clay core, rockfill shells, and an emergency spillway (Figures 2.3-1 and 2.3-2); and 2) Composite dams consisting of a roller compacted concrete (RCC) gravity overflow section connected to each abutment with embankment "wing" dams as previously described (Figures 2.3-1 and 2.3-3). The selection and conceptual design of each of these dam types was based on three observations/assumptions regarding the project sites: 1) Availability of clayey materials for use in a dam core is believed to be limited; 2) There is an abundance of natural sand, gravel, and cobble deposits for use in constructing dam shells and for producing roller compacted concrete; and 3) Foundation strengths are adequate to support an RCC gravity dam and/or the relatively steep slopes of a rockfill dam.

Review of the centerline profile and topographic features adjacent to the dam resulted in selection of the dam type best suited to each site. For the composite dam, the crest elevation of the RCC overflow spillway section was set at one foot above the normal water surface elevation. Properly designed RCC can withstand frequent overtopping flows without jeopardizing the structural integrity of the spillway and dam. For the embankment dams, the earth/rock cut emergency spillway was set at an elevation equal to the 25-year flood level in the reservoir. Depending on the integrity of the natural materials in which this type of spillway is excavated, it is typically desirable to minimize the frequency of flows through the spillway to reduce the potential for erosion damage. The criteria selected for



EMBANKMENT DAM WITH EMERGENCY SPILLWAY



COMPOSITE EMBANKMENT/ROLLER COMPACTED CONCRETE DAM WITH OVERFLOW SPILLWAYS

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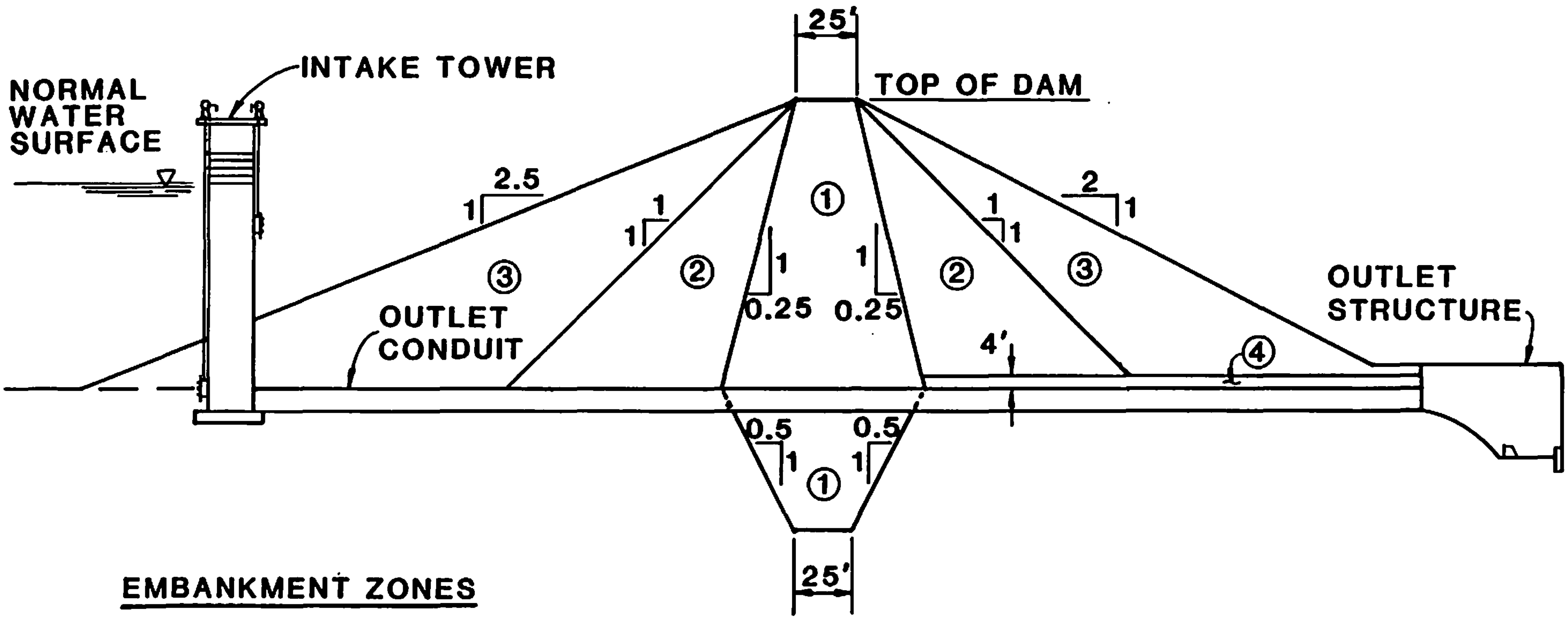
CONCEPTUAL SITE DEVELOPMENT PROFILES

FIGURE 2.3-1



EMBANKMENT ZONES

① – IMPERVIOUS CORE
② – SAND & GRAVEL TRANSITION
③ – COBBLE & BOULDER ROCKFILL SHELLS
④ – PROCESSED FILTER/DRAIN

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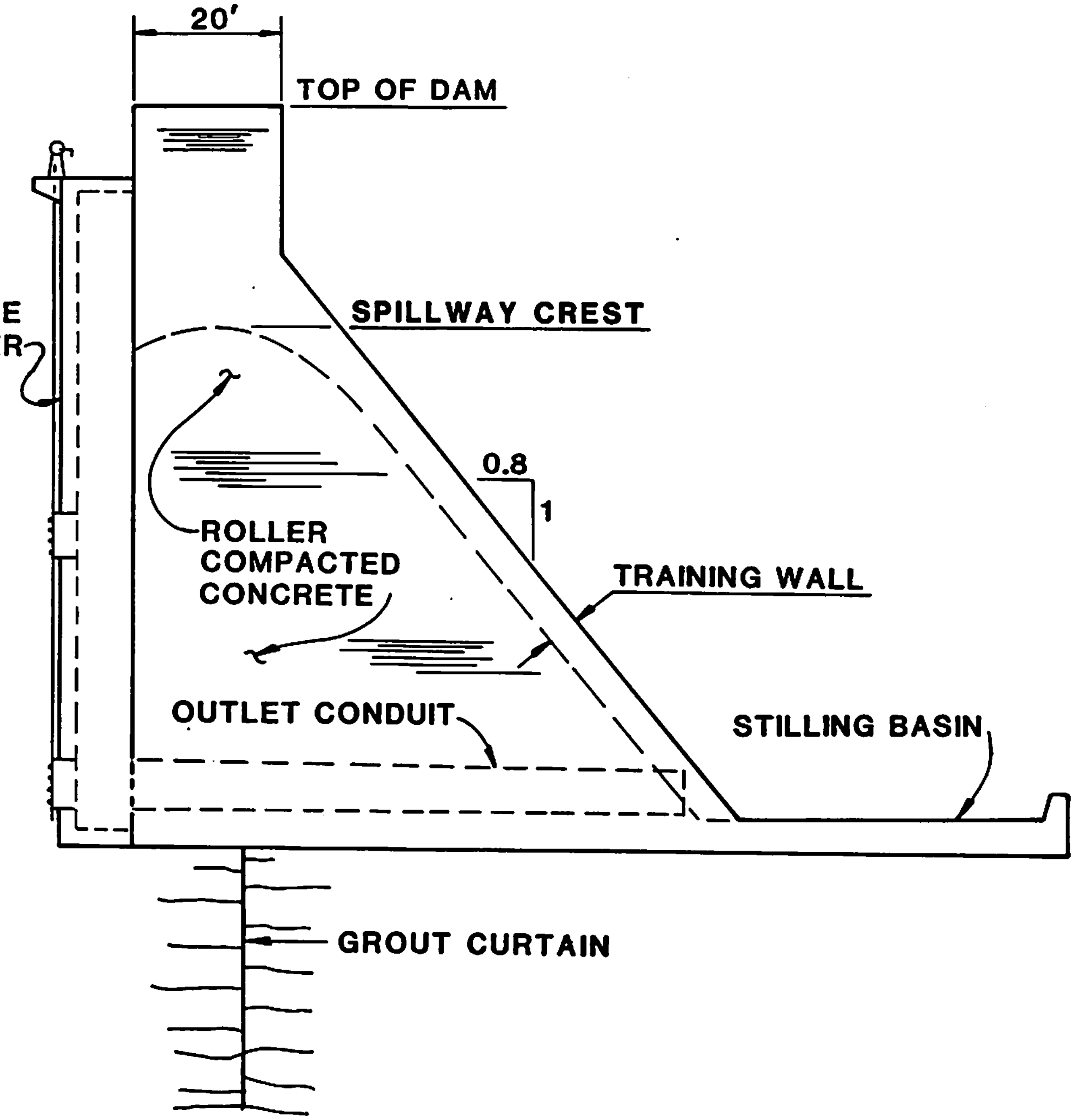
TYPICAL EMBANKMENT DAM SECTION

FIGURE 2.3-2



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TYPICAL ROLLER COMPACTED
CONCRETE DAM SECTION

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FIGURE 2.3-3

establishing the emergency spillway crest elevation necessitates higher dam crest elevations for the embankment dam option than for the composite dam option in order to pass the Probable Maximum Flood (PMF) without overtopping.

At six of the mainstem sites, topographic and hydrologic constraints dictated the use of the composite dam design arrangement. For the other eight mainstem sites, both composite and embankment dam arrangements were considered. In general, composite dams proved more cost effective for smaller percentages (10%, 25%, and 50%) of maximum conservation capacity, while embankment dams proved more cost effective for maximum conservation capacity. At the smaller capacities, the composite dam option consisted of an RCC overflow section for virtually the entire dam length. At the larger capacities, the relatively higher cost of the RCC material compared to the earth and rock fill tended to inflate the total dam cost, making the embankment dam more economical. Embankment dams with excavated spillways similar to the existing Parker Creek project design were assumed for the five small Type 2 tributary projects.

Emergency spillway widths were selected to limit the depth of flow through the spillway to less than 25 feet during the PMF for the mainstem sites and 15 feet for the tributary sites. The potential for using other types and combinations of spillways to reduce dam height and cost should be investigated during the preliminary design phase of the selected projects.

A combined service spillway and low-flow outlet works was incorporated into each conceptual dam design. For the embankment dam alternatives, the outlet works would consist of a concrete intake tower near the upstream toe of the dam, a conduit passing through the base of the dam, and an energy dissipation structure at the downstream end of the conduit as shown in Figure 2.3-2. For the composite dams, the concrete intake tower would be cast into the vertical upstream face of the RCC section as indicated in Figure 2.3-3. Flow would discharge from the conduit directly onto the spillway stilling basin, eliminating the need for a separate energy dissipation structure. The intake tower in either case would include an uncontrolled overflow crest to maintain the reservoir at the normal pool elevation. Multiple gates would also be provided in the intake tower to selectively discharge flows through the dam. The top of the intake tower was assumed to be five feet above the emergency spillway elevation. Outlet conduits were sized to pass the maximum required water rights release within a one-month time period. Conduits through the RCC section were limited to eight feet in diameter in order to spread the discharge out along the downstream stilling basin. For embankment dams, a single conduit was selected to concentrate flow into the energy dissipation structure.

2.3.1.1 Flood Hydrology

Flood hydrology is the primary factor affecting the cost of many of the recharge enhancement projects as the results of hydrologic analyses determine dam height and spillway width. The Texas Water Commission (TWC) has promulgated dam design flood criteria specifying the applicable percentage of the PMF each structure must pass based on dam hazard potential and size classification. Table 2.3-1 summarizes the TWC hydrologic criteria for dams. The PMF was assumed to be the design flood event for the structures considered in this study due to size and hazard classification. In addition, the 25-year and 100-year flood elevations were used in determining emergency spillway elevations, land acquisition requirements, and major road relocations.

Table 2.3-1 Texas Water Commission Hydrologic Criteria For Dams		
Hazard Classification	**Size Classification**	**Design Flood Event**
Low Hazard	Small Intermediate Large	¼ PMF ¼ PMF to ½ PMF PMF
Significant Hazard	Small Intermediate Large	¼ PMF to ½ PMF ½ PMF to PMF PMF
High Hazard	Small Inermediate Large	PMF PMF PMF

Notes:

Hazard Classification:

- Low hazard dams are defined as those dams where failure may damage farm buildings, limited agricultural improvements, and county roads. For low hazard dams, no loss of human life would be expected.
- Significant hazard dams are defined as those dams where failure would not be expected to cause loss of human life, but may cause damage to isolated homes, secondary highways, minor railroads, or cause interruption of service or use of relatively important public utilities.
- High hazard dams are defined as those dams where failure would be expected to cause loss of human life, extensive damage to agricultural, industrial, or commercial facilities, important public utilities, main highways, or railroads.

Size Classification:

- Small size dams are classified as those dams which have a total height less than 40 feet and have a total reservoir storage at top of dam of less than 1,000 acre-feet.
- Intermediate size dams are classified as those dams which have a total height between 40 feet and 100 feet and a total reservoir storage at top of dam between 1,000 acre-feet and 50,000 acre-feet.
- Large dams are classified as those dams which have a total height in excess of 100 feet and have a total reservoir storage at top of dam greater than 50,000 acre-feet.

Estimates of the 25-year, 100-year, and the PMF hydrographs were developed using the HEC-1 Flood Hydrograph Package, a computer program developed by the U.S. Army Corps of Engineers (Ref. 16). HEC-1 computes runoff hydrographs, peak flows, and reservoir stages resulting from a particular rainfall event. Soil Conservation Service (SCS) methodology (Ref. 11) was selected as the most appropiate option to model each of the watersheds. Key input information required for application of the SCS methodology in HEC-1 includes watershed area, curve number, basin lag time, and precipitation depth. The watershed area and curve number applicable to each recharge enhancement project location were obtained from the Phase I report and project files. Average antecedent moisture conditions were assumed in modelling the 25-year and 100-year flood events. In compliance with TWC criteria, saturated antecedent moisture conditions and a full reservoir were assumed in modelling the PMF. Basin lag times were computed using the Kirpich formula (Ref. 4).

Precipitation depths for the 25-year and 100-year storm events were obtained from the National Weather Service (NWS) publications Hydro-35 (Ref. 5) and TP-40 (Ref. 19). These two storm events were distributed according to "balanced storm" criteria and were assumed to occur over the entire watershed. Areal rainfall reduction factors recommended by the NWS, which convert the point rainfall amounts to an average depth of rainfall for large watersheds, were applied for these storm events. Precipitation depths for the probable maximum storm were obtained from NWS Hydrometeorological Report No. 51 (Ref. 10). These rainfall amounts were distributed according to a 24 hour, SCS Type II Rainfall Distribution in order to obtain an estimate of the magnitude of the peak runoff rate for the PMF.

A comprehensive summary of the flood hydrology on which recharge enhancement project costs were based as well as a comparison with historical flood peaks near several project locations is provided in Table 2.3-2.

TABLE 2.3-2
FLOOD HYDROLOGY SUMMARY TABLE

Recharge Enhancement Project	Watershed Data			25-Yr Flood		100-Yr Flood		PMF		Historical Records		
	Watershed Area (sq.mi)	Basin Lag Time (hours)	Average Travel Velocity (fps)	24-hr Rainfall (inches)	Peak Flow (cfs)	24-hr Rainfall (inches)	Peak Flow (cfs)	24-hr Rainfall (inches)	Peak Flow (cfs)	Maximum Peak Flow (cfs)	Year	Period of Record (years)
Upper Verde	55	1.9	5.0	7.5	39,100	9.7	52,200	38.2	277,500	N/A	N/A	N/A
Lower Verde	105	3.8	5.1	7.5	44,300	9.5	58,800	36.4	307,000	N/A	N/A	N/A
Upper Hondo	96	2.1	5.6	7.5	60,200	9.5	81,000	36.4	428,500	69,800	1958	37
Lower Hondo	149	3.7	5.4	7.5	62,400	9.5	83,000	35.5	432,700	51,800	1987	29
Upper Seco	45	1.5	5.5	7.4	37,600	9.4	51,300	38.7	269,800	38,500	1973	29
Lower Seco	168	4.1	5.1	7.3	63,300	9.2	84,900	32.5	414,300	35,800	1987	29
Upper Sabinal	206	4.8	5.1	7.4	72,000	9.3	94,800	34.0	474,000	55,800	1987	47
Lower Sabinal	241	6.6	5.2	7.4	66,400	9.4	88,600	33.7	433,300	73,300	1958	37
Upper Dry Frio	126	6.5	4.6	7.3	34,100	9.2	46,000	33.5	228,200	123,000	1966	37
Lower Dry Frio	184	6.7	5.0	7.3	48,500	9.3	64,900	30.0	290,200	N/A	N/A	N/A
Concan	389	7.0	4.9	7.3	106,600	9.3	140,200	31.1	618,000	162,000	1932	67
Lower Frio	447	8.6	5.0	7.3	97,200	9.3	130,000	30.0	585,300	N/A	N/A	N/A
Montell	737	8.0	4.8	7.1	173,700	9.0	231,300	28.6	971,900	307,000	1955	67
Indian Creek	1861	19.9	4.5	7.1	208,300	9.1	281,700	23.8	978,000	616,000	1935	62
Blanco	25.5	1.9	5.3	7.3	20,200	9.3	26,000	39.3	132,500	N/A	N/A	N/A
Little Blanco	11.4	0.9	5.5	7.3	15,000	9.3	19,600	38.9	102,100	N/A	N/A	N/A
Quihi	6.1	1.1	3.9	7.5	7,600	9.7	9,800	38.9	45,500	N/A	N/A	N/A
Elm	26.9	2.0	4.5	7.5	21,200	9.7	27,700	38.9	132,800	N/A	N/A	N/A
Leona	11.4	1.1	5.0	7.3	12,000	9.3	16,200	38.9	84,800	N/A	N/A	N/A

2.3.1.2 Quantity and Cost Calculations

Computer spreadsheets were developed for each dam type to facilitate calculation of material quantities and construction costs. The average end area method was used to calculate quantities based on the dam centerline profile and top of dam elevation determined from the PMF analyses for each reservoir size. Unit cost data were selected by reviewing bid tabulations for similar earth, rockfill, and RCC dam projects constructed in Texas. The unit costs used for various materials are presented in Table 2.3-3.

TABLE 2.3-3
Unit Cost Data for Projects

Item	Cost/Cubic Yard ($)
Impervious Clay Core	3.00
Sand & Gravel Transitions	2.00
Rockfill Shells	4.00
Processed Filter/Drain	12.00
Foundation Excavation	2.50
Reinforced Concrete-Walls	400.00
Reinforced Concrete-Slabs	120.00
Roller Compacted Concrete	40.00

2.3.2 Road Relocations

Road relocations necessitated by the development of each recharge enhancement project were determined using 7.5-minute topographic maps prepared by the USGS. State and U.S. Highways were relocated above the 100-year flood level to assure unrestricted travel in times of emergency. Private gravel and paved roads providing access to houses or other structural improvements were relocated above the normal pool level. Road relocation cost estimates were developed for 10% and 100% of the maximum conservation capacity at each site. In general, relocation costs associated with the 25% and 50% conservation capacities were calculated by linear interpolation from the costs at the 10% and 100% capacities.

Relocated highway alignments were selected to minimize cost by avoiding mountainous terrain and stream crossings whenever possible. Both highway and private road relocation costs were calculated using unit prices per linear foot based on consultation with the local offices of the State Department of Highways and Public Transportation in Uvalde and Medina Counties and on recent bid tabulations for comparable work. Highway relocation costs were calculated by classifying segments of the revised alignment according to terrain. Terrain classifications and associated unit costs in dollars per linear foot ($/lf) were flat, rolling, and mountainous at $125/lf, $175/lf, and $225/lf, respectively. Highway bridge costs were based on $1,260/lf of bridge deck. Private road relocation costs were calculated for paved and gravel roads at $50/lf and $25/lf, respectively.

2.3.3 Land Acquisition

A significant component of capital cost for many of the recharge enhancement projects evaluated in this study was the cost of land acquisition. For the purposes of this study, it was assumed that all periodically inundated land up to the 25-year flood level would be purchased outright and that a flood easement would be obtained for land between the 25-year and 100-year flood levels. Review of rural land prices (Refs. 7 and 8) for Uvalde and Medina Counties resulted in the selection of estimated purchase and easement costs of $800 per acre and $500 per acre, respectively. An additional cost of $50,000 per unit was included for purchase of structural improvements noted on the topographic maps as being within the 25-year flood pool. For projects located on stream segments having a significant base flow and existing or potential recreational opportunities, the land acquisition cost included a 1,000-foot wide "premium acreage" strip along the stream up to the 25-year flood level. The purchase cost of this strip was assumed to be $10,000 per acre.

2.3.4 Environmental Mitigation

Estimated environmental mitigation costs were developed by Paul Price Associates, Inc. (PPA) for the maximum (100%) conservation capacity for each recharge enhancement project. These costs include environmental studies and reports, archaeological work, and, if necessary, costs for habitat evaluations and acquisition and management of mitigation lands. Environmental mitigation costs for the 10%, 25%, and 50% conservation capacities at each site were estimated by reduction of the projected cost at the 100% capacity based on the ratios of normal pool acreage at the lesser capacities to that at the 100% capacity. For a detailed summary of pertinent environmental considerations and a more thorough explanation of environmental mitigation costs, please refer to Appendix A.

2.3.5 Water Rights Mitigation

For the various recharge enhancement projects which impacted the water rights of the CC/LCC System, costs for water rights mitigation were included in the cost estimates. Costs were calculated on the basis of two components. The first component included payment of replacement cost for the reduced yield of the CC/LCC System. For the purposes of this study, a cost of $321.00 per acre-foot per year was used as compensation for any reduction in the system yield. This amount is equivalent to about $0.99 per 1,000 gallons and is based on the approximate cost for the City of Corpus Christi to develop a comparable source of water to replace the reduced firm yield. The second cost component addresses the long-term average impacts on reservoir inflows, lake levels, and inflows to the Nueces Estuary. It was assumed that all of these impacts are reflected in the change in average annual inflows to the Nueces Estuary. For each recharge project evaluated, the resulting average annual reduction in estuarine inflow was multiplied by a unit cost of $16 per acre-feet per year. This unit cost is approximately 5% of the unit cost of firm-yield water which is consistent with the concept of "interruptible" supply as implemented by the Lower Colorado River Authority, City of Austin, and Texas Water Commission. Although the selection of these cost values for mitigation of water rights impacts is arbitrary, it represents what is believed to be reasonable compensation. A mutually acceptable cost for mitigation of water rights impacts would ultimately need to be negotiated by the parties involved.

2.3.6 Miscellaneous Project Costs

Based on comparable reservoir projects, the miscellaneous engineering, permitting, legal, and other costs associated with recharge enhancement project development were assumed to be approximately 20% of related capital costs. Project capital costs were annualized based on a 25-year finance period and an annual interest rate of 7.5 percent. Annual operations and maintenance (O&M) costs were assumed to be approximately 0.4 percent of the total capital cost of each project and annual management costs for mitigation lands were assumed to be $10 per acre per year.

SECTION 3

3.0 RECHARGE ENHANCEMENT PROJECT EVALUATIONS

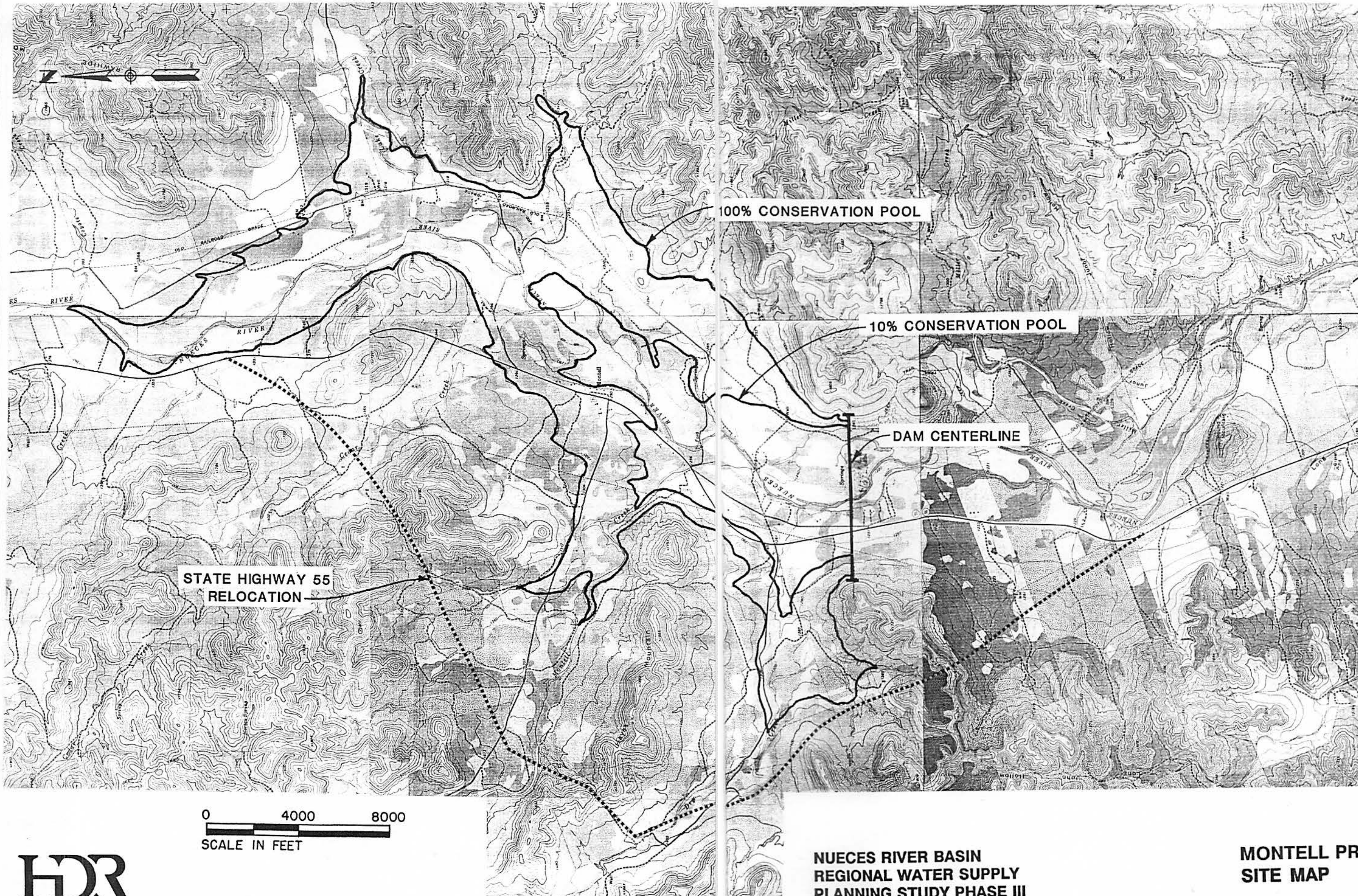
An evaluation of each of the potential recharge enhancement projects considered in this study is presented in this section. The evaluations provide a brief description of any items of interest or concern noted during the field reconnaissance conducted in May, 1991 and present any conclusions regarding the feasibility of project development at the site. A site map, project cost and data summary tables subject to the two water rights scenarios, and a graphical project evaluation summary assuming purchase of water rights are included in each section.

3.1 Type 1 Recharge Enhancement Projects

3.1.1 Montell Project

The Montell Project is located on the Nueces River at the community of Montell near the upstream edge of the Edwards Aquifer recharge zone. The project site was identified in a previous study (Ref. 17) and has the largest maximum conservation capacity (252,000 ac-ft) of any of the projects considered in this study. As indicated in Figure 3.1-1, development of this project would necessitate the relocation of State Highway 55 and the acquisition of substantial improved riverfront property and numerous dwellings. Environmental considerations at this site include the possibility of threatened or endangered species and the proximity of identified sites of archaeologic or historical significance, including the Nuestra Señora de la Candelaria del Cañon Mission and aqueduct. Purchase and management of wooded mitigation lands would be required.

The composite embankment / roller compacted concrete dam type was selected for this site due to the flood potential associated with the relatively large upstream drainage



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REGIONAL WATER SUPPLY
PLANNING STUDY PHASE III

MONTELL PROJECT
SITE MAP

FIGURE 3.1-1

area, topographic constraints, and the availability of construction materials. Steep, massive rock abutments beyond the floodplain and extensive gravel to cobble deposits were noted near the dam site.

Recharge enhancement was calculated assuming both the release of flows across the recharge zone downstream of the dam site and the diversion of up to 2,000 ac-ft of water per month to the Dry Frio River for subsequent natural recharge. Cost estimates for the Montell Project included the capital costs of a small diversion dam, pump station, and raw water pipeline to the Dry Frio River, as well as annual power costs for operation of the pump station. Calculated recharge enhancement was greater for this project than any other project evaluated.

Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.1-1a and 3.1-1b, and Figure 3.1-2 graphically summarizes project evaluation. As indicated in the tables and figures, optimal site development is at about 10% of the maximum conservation capacity at a minimum cost per unit recharge enhancement of $207 per ac-ft per year assuming limited purchase of water rights from the owners of the CC/LCC System.

3.1.2 Concan Project

The Concan Project is located on the Frio River at the community of Concan near the upstream edge of the Edwards Aquifer recharge zone. The project site was identified in a previous study by the U.S. Army Corps of Engineers (Ref. 17). At a maximum conservation capacity of 149,000 ac-ft, Concan is the second largest of the Type 1 projects and the third largest of all projects evaluated in this study. Development of this project

TABLE 3.1-1a
Montell Project Cost and Data Summary

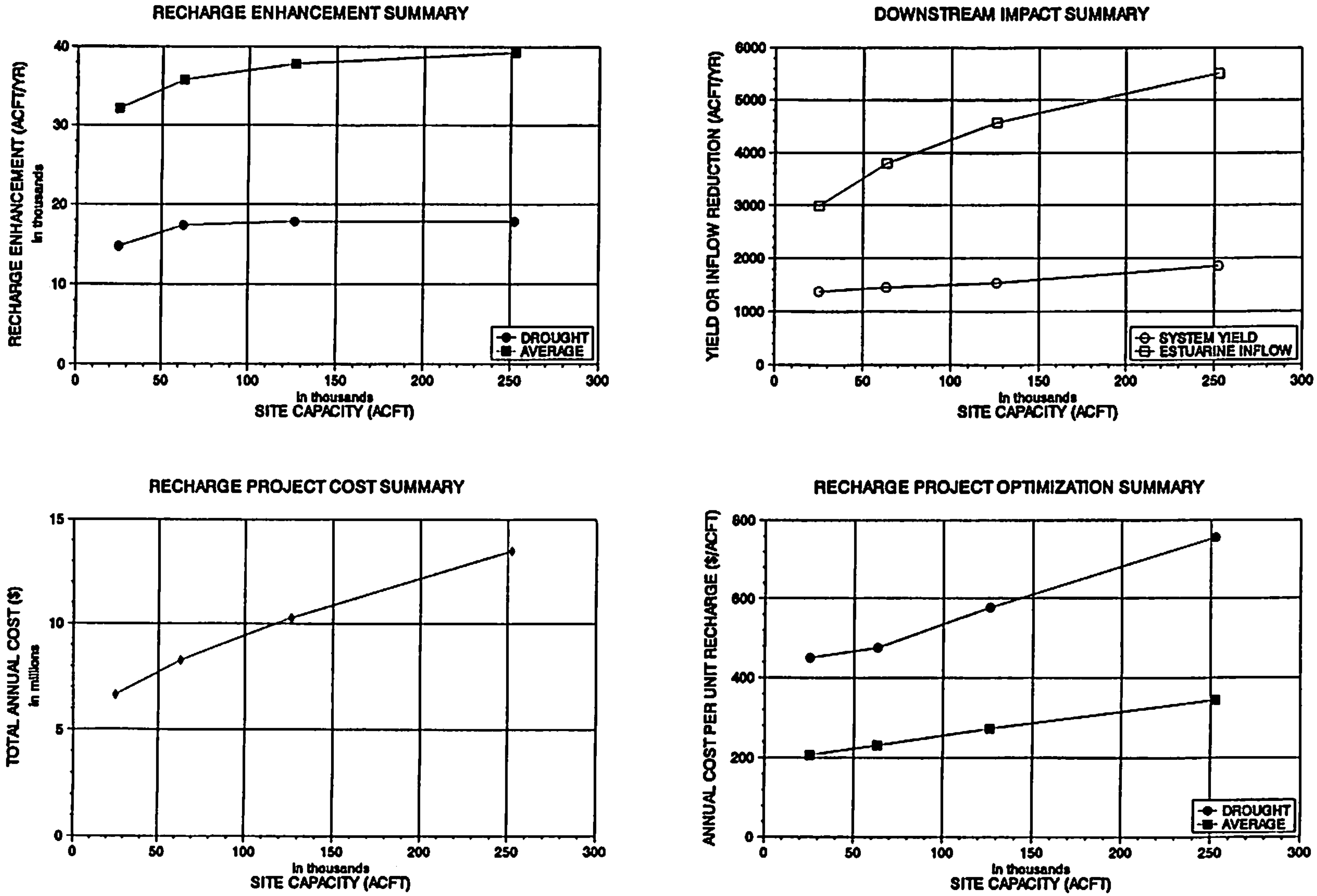
Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	1272.7	1291.1	1310.2	1334.9
Surface Area (ac)	1,460	2,640	4,010	6,190
Capacity (acft)	25,230	63,075	126,150	252,300
25-Year Flood Pool:				
Elevation (ft-msl)	1282.9	1301.0	1319.7	1343.6
Surface Area (ac)	2,140	3,310	4,910	6,960
100-Year Flood Pool:				
Elevation (ft-msl)	1285.0	1303.3	1321.8	1345.6
Surface Area (ac)	2,260	3,460	5,090	7,180
Top of Dam Elevation (ft-msl)	1302.4	1320.8	1339.9	1364.6
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	9,200	9,200	9,200	9,200
Average Conditions	26,370	29,140	31,710	34,200
CC/LCC System Yield Reduction (acft/yr)	440	440	440	440
Median CC/LCC System Storage Reduction (%)	0.1	0.1	0.1	0.1
Estuarine Inflow Reduction (acft/yr)	2,460	3,060	3,720	4,510
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$30,481,690	$40,022,580	$52,230,850	$71,654,770
Road Relocations	$5,915,000	$7,316,667	$8,718,333	$10,120,000
Land Acquisition	$7,946,000	$10,093,100	$12,994,300	$17,773,900
Environmental Mitigation	$1,421,389	$2,570,183	$3,903,952	$6,026,300
Engineering, Legal, Financial, and Misc.	$9,152,816	$12,000,506	$15,569,487	$21,114,994
Total Capital Cost	$54,916,895	$72,003,035	$93,416,922	$126,689,964
Capital Cost / Unit Capacity	$2,177	$1,142	$741	$502
Annual Capital Cost	$4,926,045	$6,458,672	$8,379,498	$11,364,090
Operations and Maintenance	$1,226,527	$1,276,490	$1,339,023	$1,438,519
Water Rights Mitigation	$180,600	$190,200	$200,760	$213,400
Total Annual Cost	$6,333,172	$7,925,363	$9,919,281	$13,016,009
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$688	$861	$1,078	$1,415
Average Conditions	$240	$272	$313	$381

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.1-1b
Montell Project Cost and Data Summary With Purchase of Water Rights

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	1272.7	1291.1	1310.2	1334.9
Surface Area (ac)	1,460	2,640	4,010	6,190
Capacity (acft)	25,230	63,075	126,150	252,300
25-Year Flood Pool:				
Elevation (ft-msl)	1282.9	1301.0	1319.7	1343.6
Surface Area (ac)	2,140	3,310	4,910	6,960
100-Year Flood Pool:				
Elevation (ft-msl)	1285.0	1303.3	1321.8	1345.6
Surface Area (ac)	2,260	3,460	5,090	7,180
Top of Dam Elevation (ft-msl)	1302.4	1320.8	1339.9	1364.6
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	14,750	17,390	17,850	17,850
Average Conditions	32,090	35,750	37,810	39,220
CC/LCC System Yield Reduction (acft/yr)	1,380	1,450	1,540	1,860
Median CC/LCC System Storage Reduction (%)	-0.2	-0.2	-0.2	-0.2
Estuarine Inflow Reduction (acft/yr)	2,990	3,800	4,570	5,510
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$30,481,690	$40,022,580	$52,230,850	$71,654,770
Road Relocations	$5,915,000	$7,316,667	$8,718,333	$10,120,000
Land Acquisition	$7,946,000	$10,093,100	$12,994,300	$17,773,900
Environmental Mitigation	$1,421,389	$2,570,183	$3,903,952	$6,026,300
Engineering, Legal, Financial, and Misc.	$9,152,816	$12,000,506	$15,569,487	$21,114,994
Total Capital Cost	$54,916,895	$72,003,035	$93,416,922	$126,689,964
Capital Cost / Unit Capacity	$2,177	$1,142	$741	$502
Annual Capital Cost	$4,926,045	$6,458,672	$8,379,498	$11,364,090
Operations and Maintenance	$1,226,527	$1,276,490	$1,339,023	$1,438,519
Water Rights Mitigation	$490,820	$526,250	$567,460	$685,220
Total Annual Cost	$6,643,392	$8,261,413	$10,285,981	$13,487,829
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$450	$475	$576	$756
Average Conditions	$207	$231	$272	$344

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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PLANNING STUDY PHASE III**

**MONTELL PROJECT
EVALUATION SUMMARY**

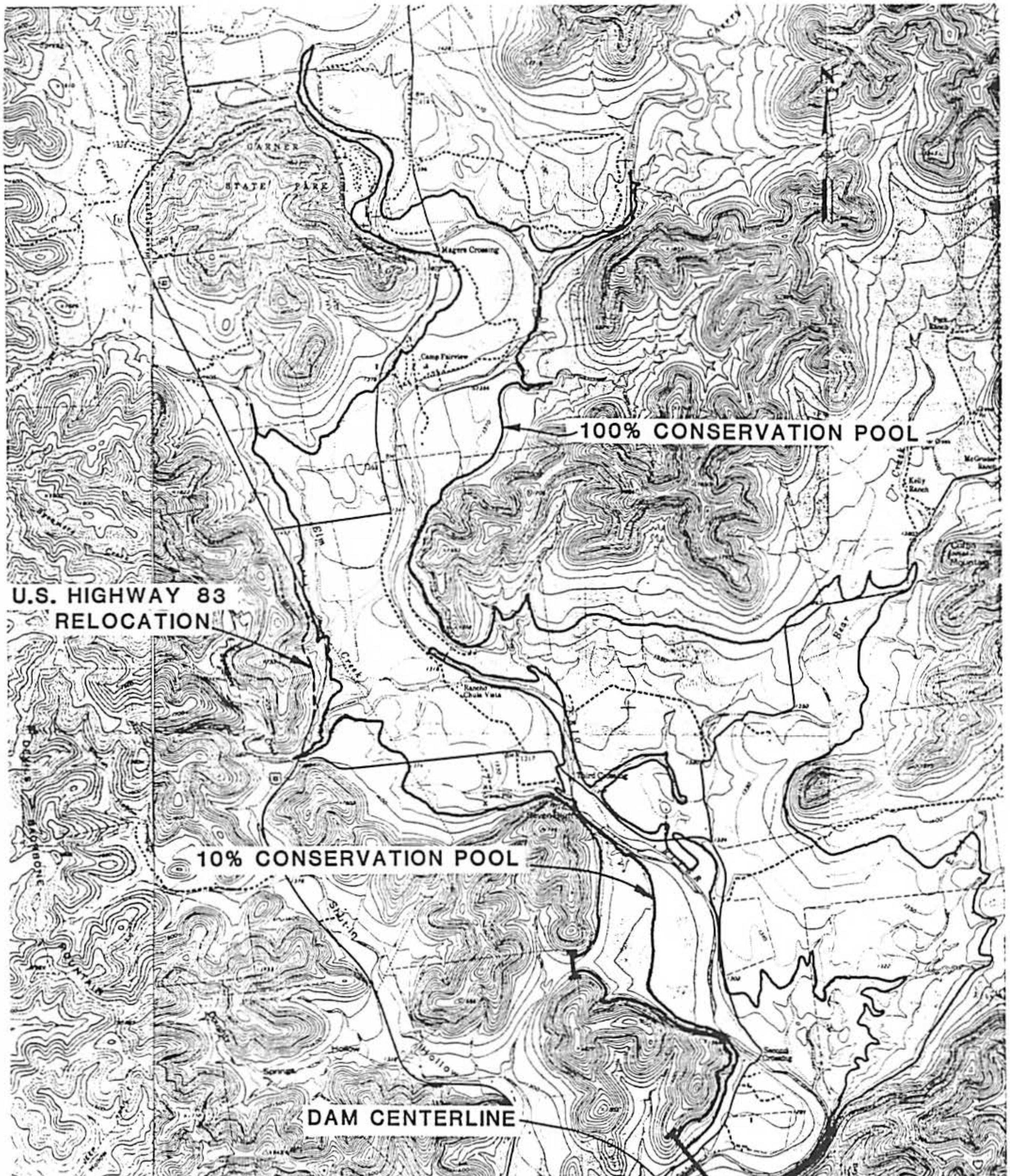
FIGURE 3.1-2

would necessitate the acquisition of extensive riverfront property and numerous dwellings and could necessitate a relatively minor relocation of U.S. Highway 83 on the west side of the reservoir as indicated in Figure 3.1-3.

Environmental considerations at this site are numerous and include potential presence of threatened or endangered species and several sites of archaeological or historical significance. A portion of Garner State Park would be affected by the headwaters of the Concan Project if developed at maximum conservation capacity. Purchase and management of wooded mitigation lands would be required.

The composite embankment / roller compacted concrete dam type was selected for this site due to the flood potential associated with the relatively large upstream drainage area, topographic constraints, and the availability of construction materials. The dam site is located in a broad, flat valley with very steep massive rock abutments. Extensive sands and gravels were noted in the river channel and it appears that the valley consists of sand and gravel terrace deposits.

Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.1-2a and 3.1-2b and Figure 3.1-4 graphically summarizes project evaluation. Due to the high recharge capacity of the Frio River bed, the Concan Project would have no significant impact on the yield of the CC/LCC System because waters originating above Concan would not have arrived at Choke Canyon Reservoir during the critical drought under natural conditions. The Concan Project would, however, reduce inflows to the CC/LCC System during years outside of the critical drought period. As indicated in the tables and figures, optimal site development is at about 10% of the



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PLANNING STUDY PHASE III

CONCAN PROJECT
SITE MAP

FIGURE 3.1-3

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TABLE 3.1-2a
Concan Project Cost and Data Summary

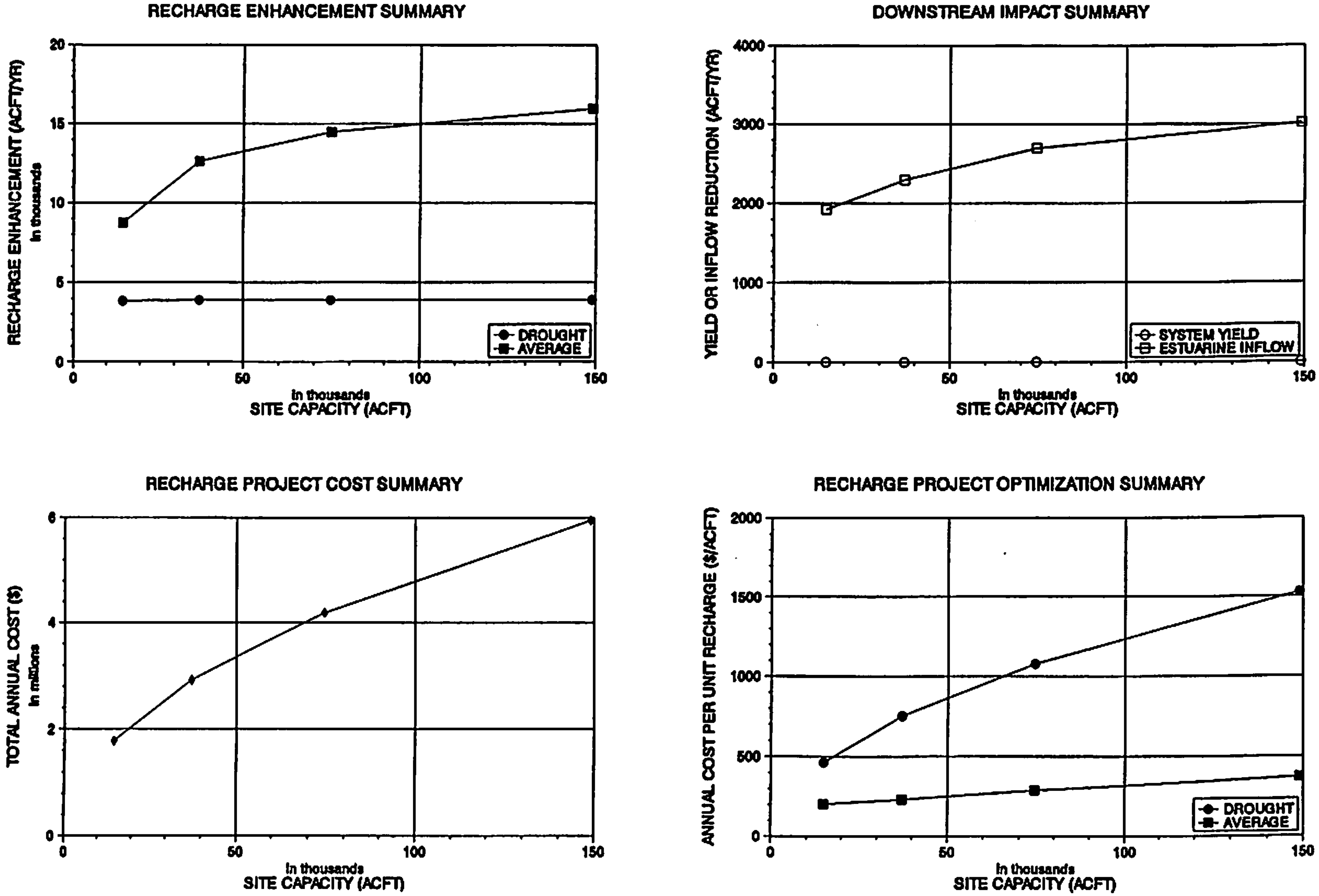
Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	1300.5	1321.8	1341.2	1365.3
Surface Area (ac)	710	1,450	2,400	3,840
Capacity (acft)	14,900	37,250	74,500	14,9000
25-Year Flood Pool:				
Elevation (ft-msl)	1312.0	1332.7	1351.4	1374.2
Surface Area (ac)	1,030	1,990	2,900	4,450
100-Year Flood Pool:				
Elevation (ft-msl)	1314.3	1335.1	1353.7	1376.5
Surface Area (ac)	1,130	2,110	3,060	4,610
Top of Dam Elevation (ft-msl)	1326.9	1354.5	1373.9	1398.0
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	3,085	3,085	3,085	3,085
Average Conditions	8,190	9,860	11,300	12,210
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.4	0.4	0.4	0.4
Estuarine Inflow Reduction (acft/yr)	1,610	1,800	2,110	2,310
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$10,082,790	$16,547,920	$23,207,380	$33,182,180
Road Relocations	$80,000	$391,667	$703,333	$1,015,000
Land Acquisition	$4,988,800	$7,659,600	$11,100,400	$15,212,400
Environmental Mitigation	$705,396	$1,440,598	$2,384,438	$3,815,100
Engineering, Legal, Financial, and Misc.	$3,171,397	$5,207,957	$7,479,110	$10,644,936
Total Capital Cost	$19,028,383	$31,247,741	$44,874,661	$63,869,616
Capital Cost / Unit Capacity	$1,277	$839	$602	$429
Annual Capital Cost	$1,706,846	$2,802,922	$4,025,257	$5,729,105
Operations and Maintenance	$47,431	$80,692	$116,830	$171,129
Water Rights Mitigation	$25,760	$28,800	$33,760	$36,960
Total Annual Cost	$1,780,037	$2,912,414	$4,175,847	$5,937,193
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$577	$944	$1,354	$1,925
Average Conditions	$217	$295	$370	$486

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.1-2b
Concan Project Cost and Data Summary With Purchase of Water Rights

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	1300.5	1321.8	1341.2	1365.3
Surface Area (ac)	710	1,450	2,400	3,840
Capacity (acft)	14,900	37,250	74,500	149,000
25-Year Flood Pool:				
Elevation (ft-msl)	1312.0	1332.7	1351.4	1374.2
Surface Area (ac)	1,030	1,990	2,900	4,450
100-Year Flood Pool:				
Elevation (ft-msl)	1314.3	1335.1	1353.7	1376.5
Surface Area (ac)	1,130	2,110	3,060	4,610
Top of Dam Elevation (ft-msl)	1326.9	1354.5	1373.9	1398.0
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	3,850	3,890	3,890	3,890
Average Conditions	8,740	12,640	14,490	15,950
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.4	0.4	0.4	0.4
Estuarine Inflow Reduction (acft/yr)	1,920	2,300	2,700	3,020
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$10,082,790	$16,547,920	$23,207,380	$33,182,180
Road Relocations	$80,000	$391,667	$703,333	$1,015,000
Land Acquisition	$4,988,800	$7,659,600	$11,100,400	$15,212,400
Environmental Mitigation	$705,396	$1,440,598	$2,384,438	$3,815,100
Engineering, Legal, Financial, and Misc.	$3,171,397	$5,207,957	$7,479,110	$10,644,936
Total Capital Cost	$19,028,383	$31,247,741	$44,874,661	$63,869,616
Capital Cost / Unit Capacity	$1,277	$839	$602	$429
Annual Capital Cost	$1,706,846	$2,802,922	$4,025,257	$5,729,105
Operations and Maintenance	$47,431	$80,692	$116,830	$171,129
Water Rights Mitigation	$30,720	$36,800	$43,200	$48,320
Total Annual Cost	$1,784,997	$2,920,414	$4,185,287	$5,948,553
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$464	$751	$1,076	$1,529
Average Conditions	$204	$231	$289	$373

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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PLANNING STUDY PHASE III

CONCAN PROJECT
EVALUATION SUMMARY

FIGURE 3.1-4

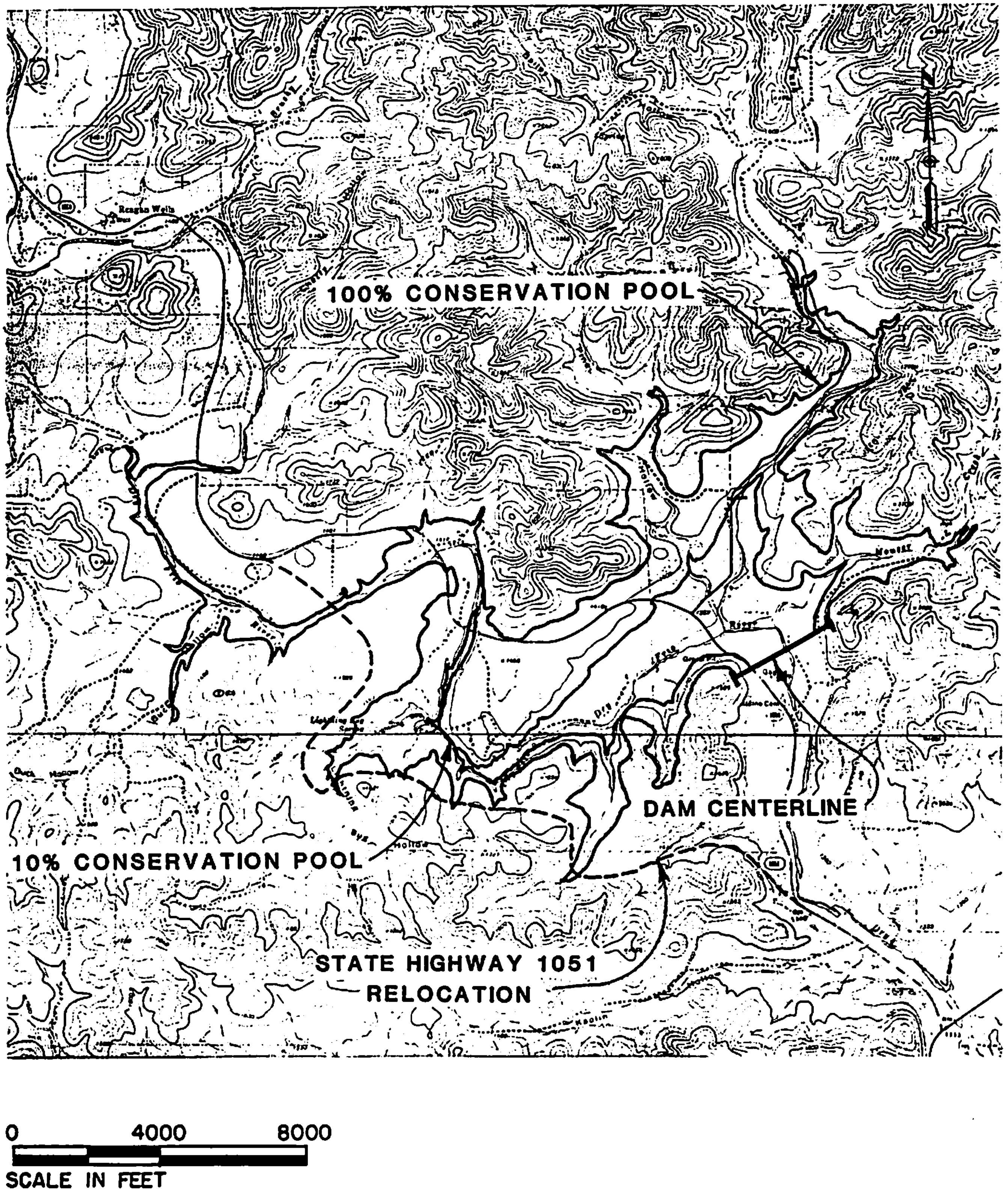
maximum conservation capacity at a minimum cost per unit recharge enhancement of $204 per ac-ft per year assuming limited purchase of water rights.

3.1.3 Upper Dry Frio Project

The Upper Dry Frio Project is located on the Dry Frio River about 5 miles southeast of Reagan Wells near the upstream edge of the Edwards Aquifer recharge zone. The project site was identified in a previous study (Ref. 3) and has a maximum conservation capacity of 60,000 ac-ft and a maximum normal water surface area of 1,800 acres. As indicated in Figure 3.1-5, development of this project would necessitate relocation of several miles of State Highway 1051. Environmental considerations at this site include the purchase and management of wooded mitigation lands, however, there are no recorded sites of archaelogical significance in the project area.

Both the embankment dam and the composite embankment / roller compacted concrete dam types were evaluated for this site with the composite dam proving more economical at the 10% and 25% capacities and the embankment dam being more economical at the 50% and 100% capacities. Field reconnaissance indicated the presence of sufficient construction materials for either dam type.

Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.1-3a and 3.1-3b and Figure 3.1-6 graphically summarizes project evaluation. Due to the extremely high recharge capacity of the Dry Frio River bed, the Upper Dry Frio Project would have no significant impact on the yield of the CC/LCC System because waters originating above the site would not have arrived at Choke Canyon Reservoir during the critical drought under natural conditions. The Upper Dry Frio Project



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PLANNING STUDY PHASE III

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UPPER DRY FRIO PROJECT SITE MAP

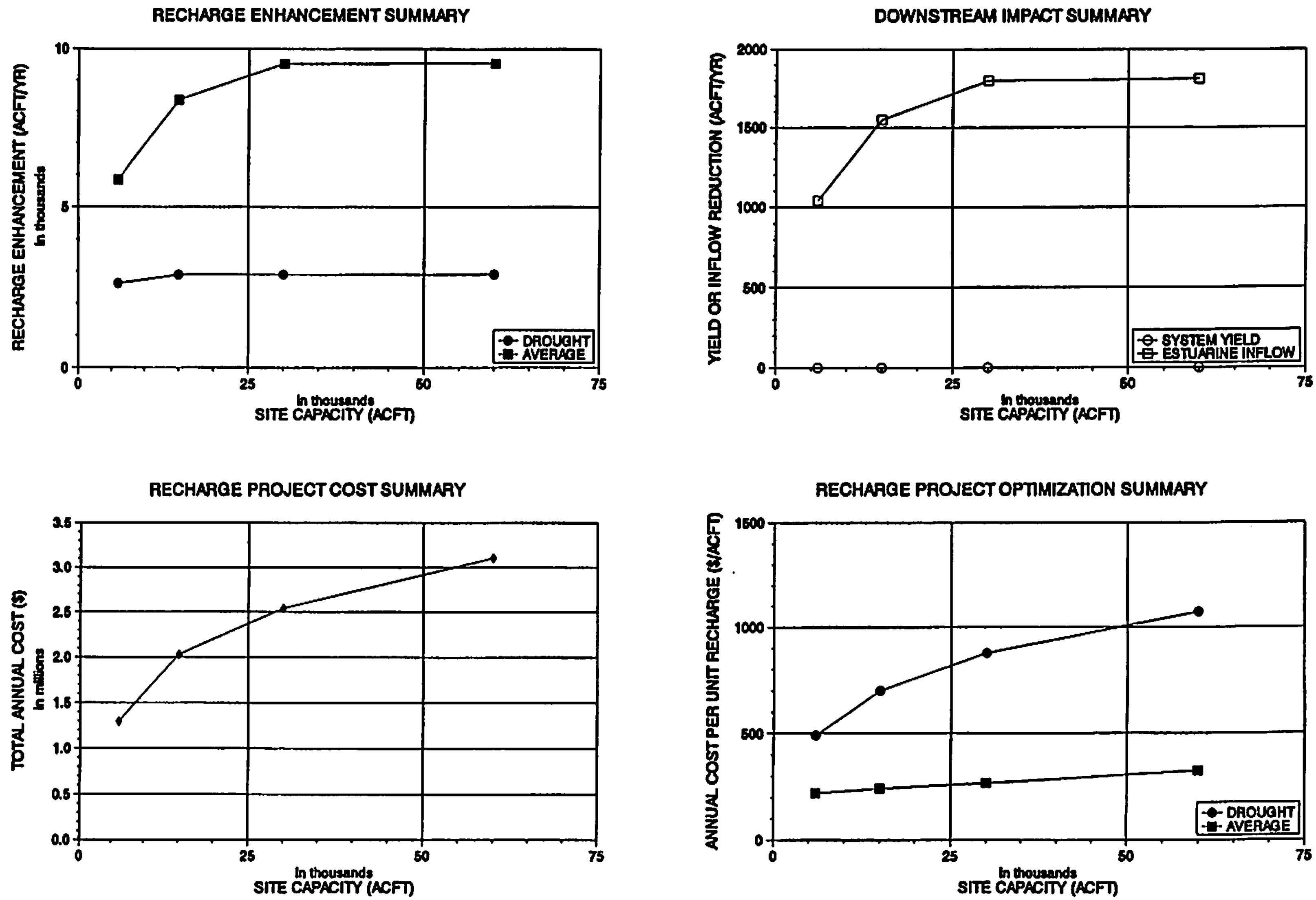
FIGURE 3.1-5

TABLE 3.1-3a Upper Dry Frio Project Cost and Data Summary				
Physical Data	**Percentage of Maximum Project Conservation Capacity**			
	10%	**25%**	**50%**	**100%**
Dam Type	RCC Composite	RCC Composite	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	1387.2	1402.1	1417.4	1438.0
Surface Area (ac)	440	780	1,160	1,800
Capacity (acft)	6,000	15,000	30,000	60,000
25-Year Flood Pool:				
Elevation (ft-msl)	1393.1	1407.8	1436.5	1451.0
Surface Area (ac)	570	910	1,740	2,360
100-Year Flood Pool:				
Elevation (ft-msl)	1394.5	1409.1	1439.2	1453.2
Surface Area (ac)	600	950	1,840	2,460
Top of Dam Elevation (ft-msl)	1405.6	1420.5	1453.6	1468.1
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	2,630	2,900	2,900	2,900
Average Conditions	5,840	8,360	9,400	9,420
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.2	0.2	0.2	0.2
Estuarine Inflow Reduction (acft/yr)	1,040	1,550	1,780	1,780
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$4,272,720	$6,892,390	$8,947,060	$11,786,830
Road Relocations	$3,795,000	$4,927,000	$6,115,667	$7,191,000
Land Acquisition	$3,121,830	$5,649,650	$6,656,560	$7,149,960
Environmental Mitigation	$457,844	$811,633	$1,207,044	$1,873,000
Engineering, Legal, Financial, and Misc.	$2,329,479	$3,656,135	$4,585,266	$5,600,158
Total Capital Cost	$13,976,873	$21,936,808	$27,511,598	$33,600,948
Capital Cost / Unit Capacity	$2,329	$1,462	$917	$560
Annual Capital Cost	$1,253,726	$1,967,732	$2,467,790	$3,014,005
Operations and Maintenance	$21,491	$35,370	$47,388	$65,147
Water Rights Mitigation	$16,640	$24,800	$28,480	$28,480
Total Annual Cost	$1,291,856	$2,027,901	$2,543,659	$3,107,632
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$491	$699	$877	$1,072
Average Conditions	$221	$243	$271	$330
Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.				

TABLE 3.1-3b
Upper Dry Frio Project Cost and Data Summary With Purchase of Water Rights

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	1387.2	1402.1	1417.4	1438.0
Surface Area (ac)	440	780	1,160	1,800
Capacity (acft)	6,000	15,000	30,000	60,000
25-Year Flood Pool:				
Elevation (ft-msl)	1393.1	1407.8	1436.5	1451.0
Surface Area (ac)	570	910	1,740	2,360
100-Year Flood Pool:				
Elevation (ft-msl)	1394.5	1409.1	1439.2	1453.2
Surface Area (ac)	600	950	1,840	2,460
Top of Dam Elevation (ft-msl)	1405.6	1420.5	1453.6	1468.1
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	2,630	2,900	2,900	2,900
Average Conditions	5,840	8,360	9,520	9,540
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.2	0.2	0.2	0.2
Estuarine Inflow Reduction (acft/yr)	1,040	1,550	1,800	1,810
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$4,272,720	$6,892,390	$8,947,060	$11,786,830
Road Relocations	$3,795,000	$4,927,000	$6,115,667	$7,191,000
Land Acquisition	$3,121,830	$5,649,650	$6,656,560	$7,149,960
Environmental Mitigation	$457,844	$811,633	$1,207,044	$1,873,000
Engineering, Legal, Financial, and Misc.	$2,329,479	$3,656,135	$4,585,266	$5,600,158
Total Capital Cost	$13,976,873	$21,936,808	$27,511,598	$33,600,948
Capital Cost / Unit Capacity	$2,329	$1,462	$917	$560
Annual Capital Cost	$1,253,726	$1,967,732	$2,467,790	$3,014,005
Operations and Maintenance	$21,491	$35,370	$47,388	$65,147
Water Rights Mitigation	$16,640	$24,800	$28,800	$28,960
Total Annual Cost	$1,291,856	$2,027,901	$2,543,979	$3,108,112
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$491	$699	$877	$1,072
Average Conditions	$221	$243	$267	$326

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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UPPER DRY FRIO PROJECT EVALUATION SUMMARY

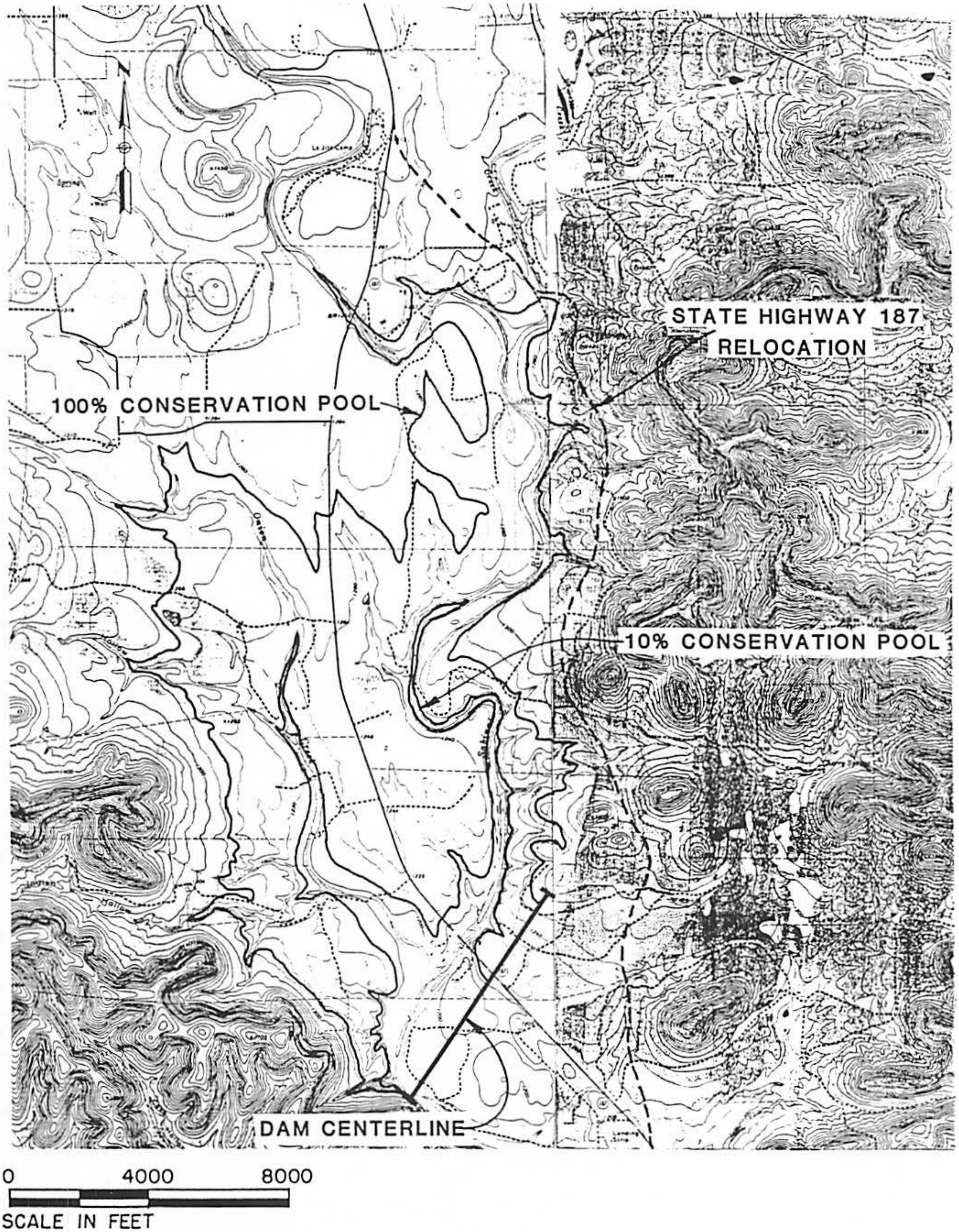
FIGURE 3.1-6

would, however, reduce inflows to the CC/LCC System during years outside of the critical drought period. As indicated in the tables and figures, optimal site development is at about 10% of the maximum conservation capacity at a minimum cost per unit recharge enhancement of $221 per ac-ft per year under either water rights scenario.

3.1.4 Upper Sabinal Project

The Upper Sabinal Project is located on the Sabinal River near the upstream edge of the Edwards Aquifer recharge zone. The project site was identified in a previous study (Ref. 17) and has a maximum conservation capacity of 93,300 ac-ft. Development of this project would necessitate the relocation of several miles of State Highway 187 as indicated in Figure 3.1-7. Environmental considerations at this site include the possible presence of threatened or endangered species, instream flow studies, and purchase and management of wooded mitigation lands. No sites of archaeological significance have been recorded within the maximum conservation pool of the reservoir.

Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.1-4a and 3.1-4b and Figure 3.1-8 graphically summarizes project evaluation. Both the embankment dam and the composite embankment / roller compacted concrete dam types were evaluated for this site with the composite dam proving more economical at the 10%, 25%, and 50% capacities and the embankment dam being more economical at the 100% capacity. As indicated in the tables and figures, optimal site development is at about 10% of the maximum conservation capacity at a minimum cost per unit recharge enhancement of $146 per ac-ft per year assuming purchase of water rights from the owners of the CC/LCC System. When honoring all water rights to extent possible



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UPPER SABINAL PROJECT SITE MAP

FIGURE 3.1-7

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TABLE 3.1-4a
Upper Sabinal Project Cost and Data Summary

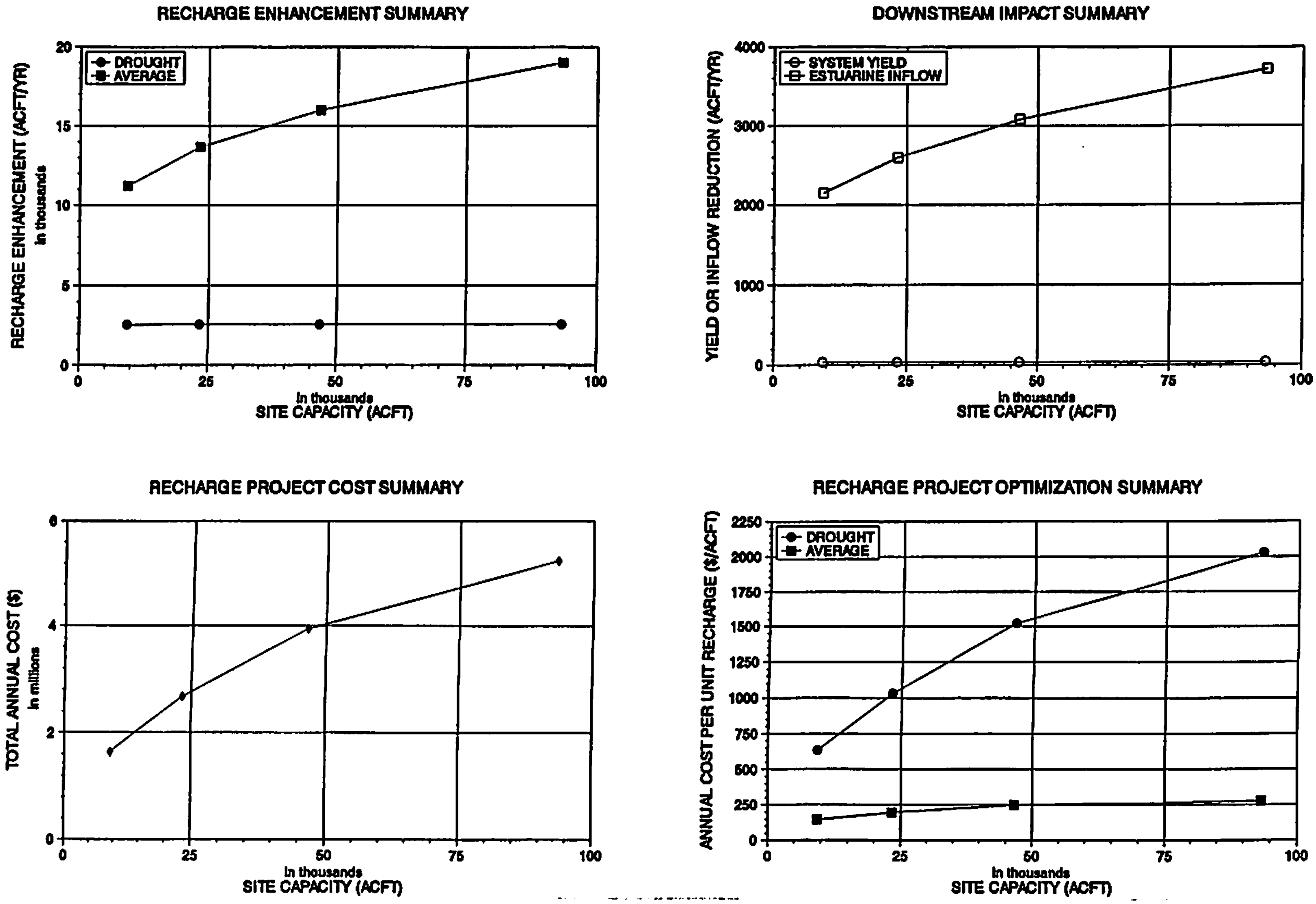
Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	Embankment
Conservation Pool:				
Elevation (ft-msl)	1213.4	1231.1	1247.3	1266.4
Surface Area (ac)	550	1,070	1,850	3,110
Capacity (acft)	9,330	23,325	46,650	93,300
25-Year Flood Pool:				
Elevation (ft-msl)	1222.6	1239.7	1255.1	1279.2
Surface Area (ac)	790	1,420	2,310	4,200
100-Year Flood Pool:				
Elevation (ft-msl)	1224.3	1241.5	1256.9	1281.4
Surface Area (ac)	850	1,520	2,420	4,390
Top of Dam Elevation (ft-msl)	1239.5	1257.2	1273.4	1296.2
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	2,520	2,520	2,520	2,520
Average Conditions	10,080	11,230	12,890	14,670
CC/LCC System Yield Reduction (acft/yr)	30	30	30	30
Median CC/LCC System Storage Reduction (%)	0.4	0.4	0.4	0.4
Estuarine Inflow Reduction (acft/yr)	1,950	2,170	2,510	2,900
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$7,445,380	$13,129,120	$19,890,600	$26,654,510
Road Relocations	$3,587,000	$4,339,500	$5,092,000	$5,470,000
Land Acquisition	$2,943,200	$5,239,200	$8,360,600	$11,660,290
Environmental Mitigation	$542,413	$1,055,240	$1,824,481	$3,067,100
Engineering, Legal, Financial, and Misc.	$2,903,599	$4,752,612	$7,033,536	$9,370,380
Total Capital Cost	$17,421,592	$28,515,672	$42,201,217	$56,222,280
Capital Cost / Unit Capacity	$1,867	$1,223	$905	$603
Annual Capital Cost	$1,562,717	$2,557,856	$3,785,449	$5,043,139
Operations and Maintenance	$35,282	$63,216	$98,062	$137,718
Water Rights Mitigation	$40,830	$44,350	$49,790	$56,030
Total Annual Cost	$1,638,828	$2,665,422	$3,933,302	$5,236,887
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$650	$1,058	$1,561	$2,078
Average Conditions	$163	$237	$305	$357

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

Table 3.1-4b
Upper Sabinal Project Cost and Data Summary With Purchase of Water Rights

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	Embankment
Conservation Pool:				
Elevation (ft-msl)	1213.4	1231.1	1247.3	1266.4
Surface Area (ac)	550	1,070	1,850	3,110
Capacity (acft)	9,330	23,325	46,650	93,300
25-Year Flood Pool:				
Elevation (ft-msl)	1222.6	1239.7	1255.1	1279.2
Surface Area (ac)	790	1,420	2,310	4,200
100-Year Flood Pool:				
Elevation (ft-msl)	1224.3	1241.5	1256.9	1281.4
Surface Area (ac)	850	1,520	2,420	4,390
Top of Dam Elevation (ft-msl)	1239.5	1257.2	1273.4	1296.2
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	2,590	2,590	2,590	2,590
Average Conditions	11,240	13,690	16,010	19,000
CC/LCC System Yield Reduction (acft/yr)	30	30	30	30
Median CC/LCC System Storage Reduction (%)	0.6	0.6	0.6	0.6
Estuarine Inflow Reduction (acft/yr)	2,150	2,600	3,080	3,720
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$7,445,380	$13,129,120	$19,890,600	$26,654,510
Road Relocations	$3,587,000	$4,339,500	$5,092,000	$5,470,000
Land Acquisition	$2,943,200	$5,239,200	$8,360,600	$11,660,290
Environmental Mitigation	$542,413	$1,055,240	$1,824,481	$3,067,100
Engineering, Legal, Financial, and Misc.	$2,903,599	$4,752,612	$7,033,536	$9,370,380
Total Capital Cost	$17,421,592	$28,515,672	$42,201,217	$56,222,280
Capital Cost / Unit Capacity	$1,867	$1,223	$905	$603
Annual Capital Cost	$1,562,717	$2,557,856	$3,785,449	$5,043,139
Operations and Maintenance	$35,282	$63,216	$98,062	$137,718
Water Rights Mitigation	$44,030	$51,230	$58,910	$69,150
Total Annual Cost	$1,642,028	$2,672,302	$3,942,422	$5,250,007
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$634	$1,032	$1,522	$2,027
Average Conditions	$146	$195	$246	$276

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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UPPER SABINAL PROJECT EVALUATION SUMMARY

FIGURE 3.1-8

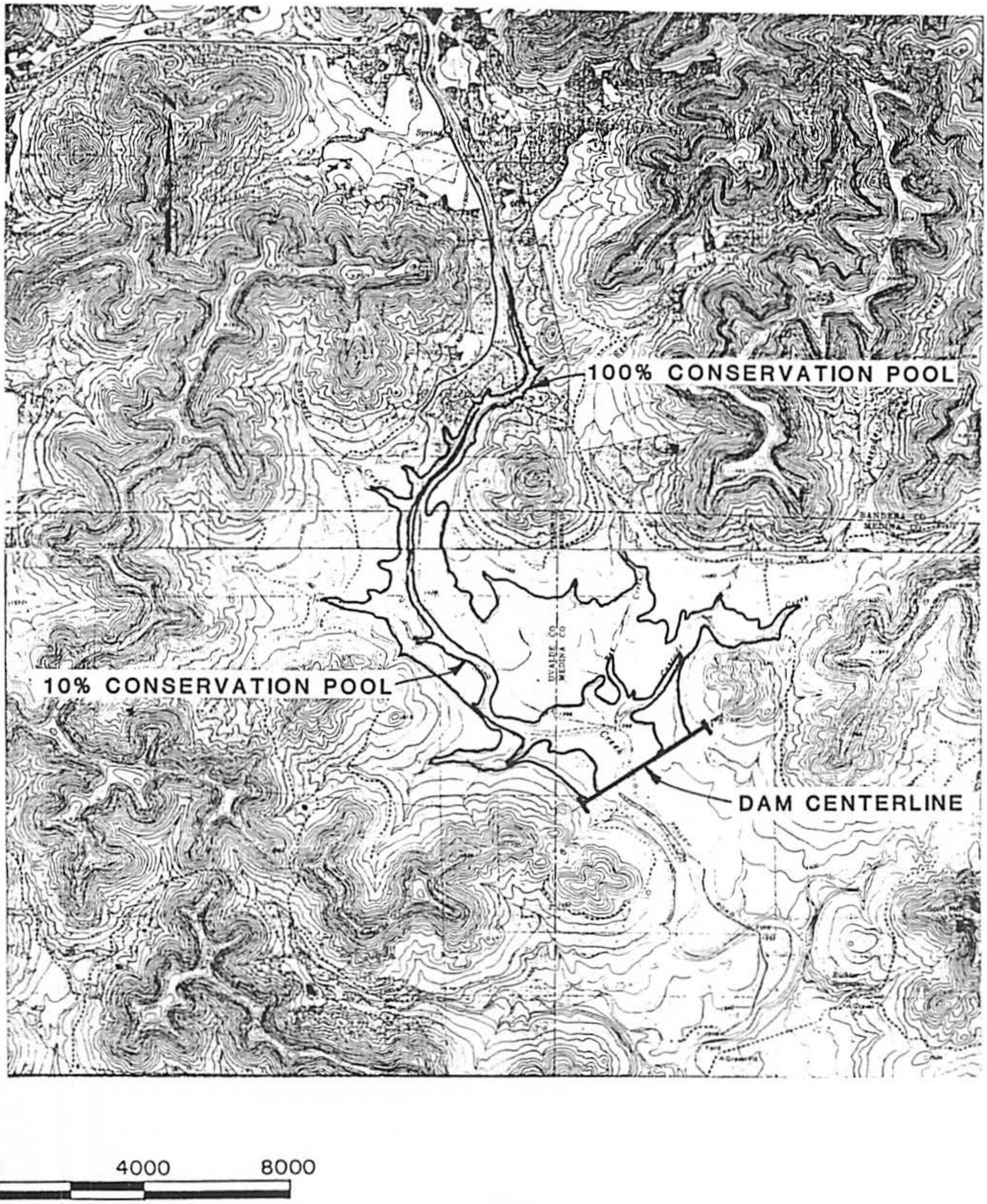
(first water rights scenario), the unit cost of recharge enhancement at the 10% capacity becomes $163 per ac-ft per year making the Upper Sabinal Project the most economical of all Type 1 projects evaluated.

3.1.5 Upper Seco Project

The Upper Seco Project is located on Seco Creek about 1.5 miles south of the intersection of the Uvalde, Medina, and Bandera County lines. The project site was identified in a previous study (Ref. 17) and has a maximum conservation capacity of 23,000 ac-ft. As indicated in Figure 3.1-9, the project is located in a somewhat remote area necessitating only minimal relocation of private roads. Environmental considerations at this site include the possible presence of threatened or endangered species, instream flow studies, and purchase and management of wooded mitigation lands. No sites of archaeological significance have been recorded within the maximum conservation pool of the reservoir.

Both the embankment dam and the composite embankment / roller compacted concrete dam types were evaluated for this site with the composite dam proving more economical at the 10% and 25% capacities and the embankment dam being more economical at the 50% and 100% capacities. Field reconnaissance indicated the presence of sufficient construction materials for either dam type including extensive sand and gravel terrace deposits along the left bank and cobbles and boulders in the streambed.

Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.1-5a and 3.1-5b and Figure 3.1-10 graphically summarizes project evaluation. Due to limited runoff from the watershed upstream and the existing Seco Creek



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PLANNING STUDY PHASE III

UPPER SECO PROJECT
SITE MAP

FIGURE 3.1-9

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TABLE 3.1-5a
Upper Seco Project Cost and Data Summary

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	1401.9	1412.7	1425.0	1441.1
Surface Area (ac)	190	380	600	900
Capacity (acft)	2,300	5,750	11,500	23,000
25-Year Flood Pool:				
Elevation (ft-msl)	1407.9	1418.7	1437.9	1448.6
Surface Area (ac)	300	490	840	1,080
100-Year Flood Pool:				
Elevation (ft-msl)	1409.3	1420.1	1440.9	1450.4
Surface Area (ac)	320	510	900	1,130
Top of Dam Elevation (ft-msl)	1420.8	1436.1	1455.2	1465.9
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	290	290	290	290
Average Conditions	1,280	2,280	3,410	3,820
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.1	0.1	0.1	0.1
Estuarine Inflow Reduction (acft/yr)	250	440	690	780
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$3,511,590	$5,329,740	$6,515,860	$8,534,190
Road Relocations	$0	$25,000	$50,000	$75,000
Land Acquisition	$1,307,520	$1,880,420	$3,024,430	$4,055,140
Environmental Mitigation	$201,041	$402,082	$634,867	$952,300
Engineering, Legal, Financial, and Misc.	$1,004,030	$1,527,448	$2,045,031	$2,723,326
Total Capital Cost	$6,024,181	$9,164,691	$12,270,188	$16,339,956
Capital Cost / Unit Capacity	$2,619	$1,594	$1,067	$710
Annual Capital Cost	$540,369	$822,073	$1,100,636	$1,465,694
Operations and Maintenance	$15,946	$25,119	$32,063	$43,137
Water Rights Mitigation	$4,000	$7,040	$11,040	$12,480
Total Annual Cost	$560,315	$854,232	$1,143,739	$1,521,311
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$1,932	$2,946	$3,944	$5,246
Average Conditions	$438	$375	$335	$398

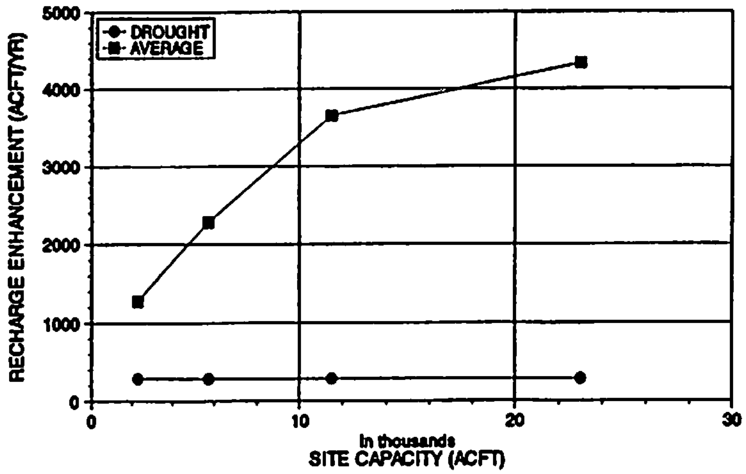
Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.1-5b
Upper Seco Project Cost and Data Summary With Purchase of Water Rights

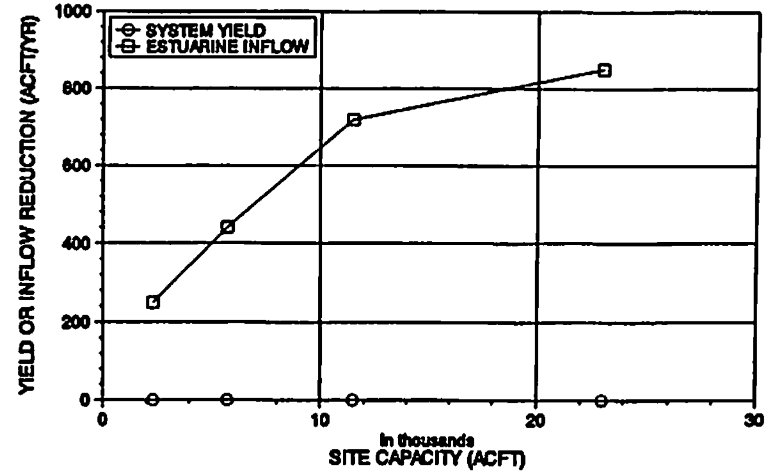
Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	1401.9	1412.7	1425.0	1441.1
Surface Area (ac)	190	380	600	900
Capacity (acft)	2,300	5,750	11,500	23,000
25-Year Flood Pool:				
Elevation (ft-msl)	1407.9	1418.7	1437.9	1448.6
Surface Area (ac)	300	490	840	1,080
100-Year Flood Pool:				
Elevation (ft-msl)	1409.3	1420.1	1440.9	1450.4
Surface Area (ac)	320	510	900	1,130
Top of Dam Elevation (ft-msl)	1420.8	1436.1	1455.2	1465.9
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	290	290	290	290
Average Conditions	1,280	2,280	3,660	4,330
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.1	0.1	0.1	0.1
Estuarine Inflow Reduction (acft/yr)	250	440	720	850
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$3,511,590	$5,329,740	$6,515,860	$8,534,190
Road Relocations	$0	$25,000	$50,000	$75,000
Land Acquisition	$1,307,520	$1,880,420	$3,024,430	$4,055,140
Environmental Mitigation	$201,041	$402,082	$634,867	$952,300
Engineering, Legal, Financial, and Misc.	$1,004,030	$1,527,448	$2,045,031	$2,723,326
Total Capital Cost	$6,024,181	$9,164,691	$12,270,188	$16,339,956
Capital Cost / Unit Capacity	$2,619	$1,594	$1,067	$710
Annual Capital Cost	$540,369	$822,073	$1,100,636	$1,465,694
Operations and Maintenance	$15,946	$25,119	$32,063	$43,137
Water Rights Mitigation	$4,000	$7,040	$11,520	$13,600
Total Annual Cost	$560,315	$854,232	$1,144,219	$1,522,431
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$1,932	$2,946	$3,946	$5,250
Average Conditions	$438	$375	$313	$352

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

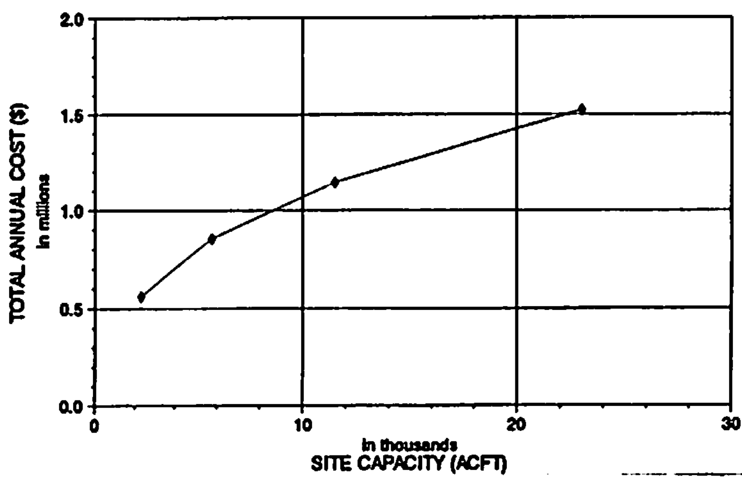
RECHARGE ENHANCEMENT SUMMARY



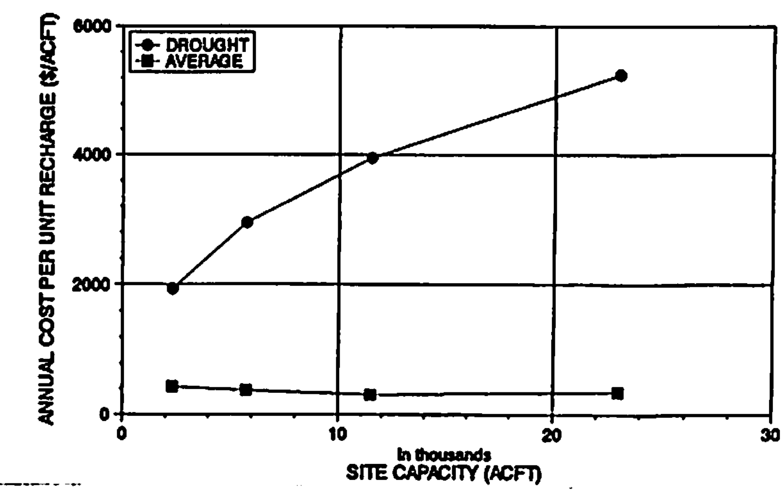
DOWNSTREAM IMPACT SUMMARY



RECHARGE PROJECT COST SUMMARY



RECHARGE PROJECT OPTIMIZATION SUMMARY



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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**UPPER SECO PROJECT
EVALUATION SUMMARY**

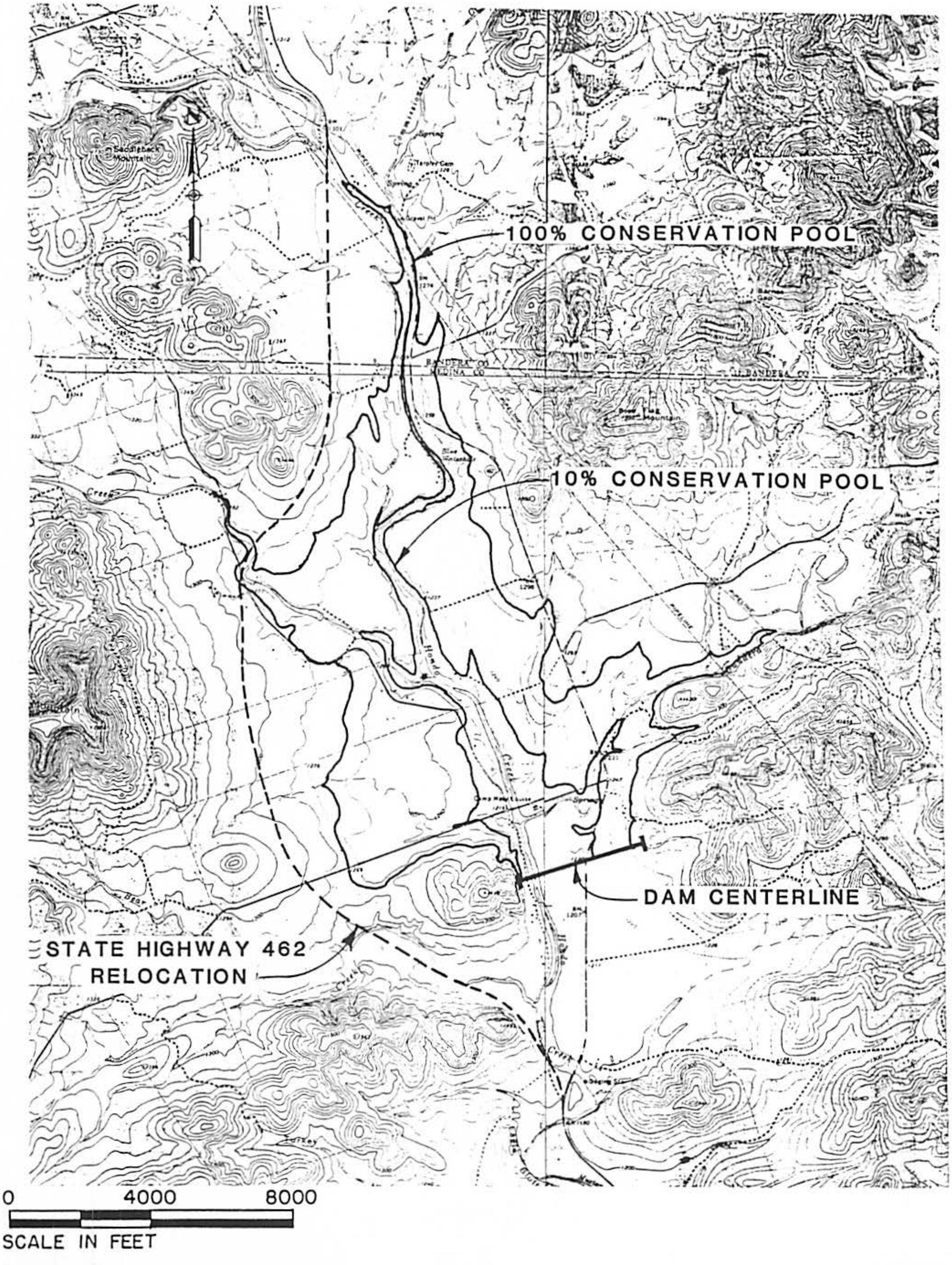
FIGURE 3.1-10

recharge project located downstream of the site, recharge enhancement due to this project would be the least of any Type 1 project evaluated. As indicated in the tables and figures, optimal site development based on average conditions is at about 50% of the maximum conservation capacity at a minimum cost per unit recharge enhancement of $313 per ac-ft per year assuming purchase of water rights from the owners of the CC/LCC System. When honoring all water rights to extent possible (first water rights scenario), the unit cost of recharge enhancement at the 50% capacity becomes $335 per ac-ft per year making the Upper Seco Project the least economical of all Type 1 projects evaluated.

3.1.6 Upper Hondo Project

The Upper Hondo Project is located on Hondo Creek in Medina County about 3 miles south of the Bandera County line near Camp Mary Louise. It is a Type 1 project identified in a previous study by the U.S. Army Corps of Engineers (Ref. 17) and has a maximum conservation capacity of 47,000 ac-ft. As indicated in Figure 3.1-11, development of this project would necessitate the relocation of several miles of State Highway 462 and the acquisition of improved streamfront property including Camp Mary Louise. Environmental considerations at this site include the possible presence of threatened or endangered species, instream flow studies, purchase and management of wooded mitigation lands, and the existance of dinosaur tracks in Hondo Creek downstream of the project. No sites of archaeological significance have been recorded within the maximum conservation pool of the reservoir.

Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.1-6a and 3.1-6b and Figure 3.1-12 graphically summarizes project



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PLANNING STUDY PHASE III

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UPPER HONDO PROJECT SITE MAP

FIGURE 3.1-11

TABLE 3.1-6a
Upper Hondo Project Cost and Data Summary

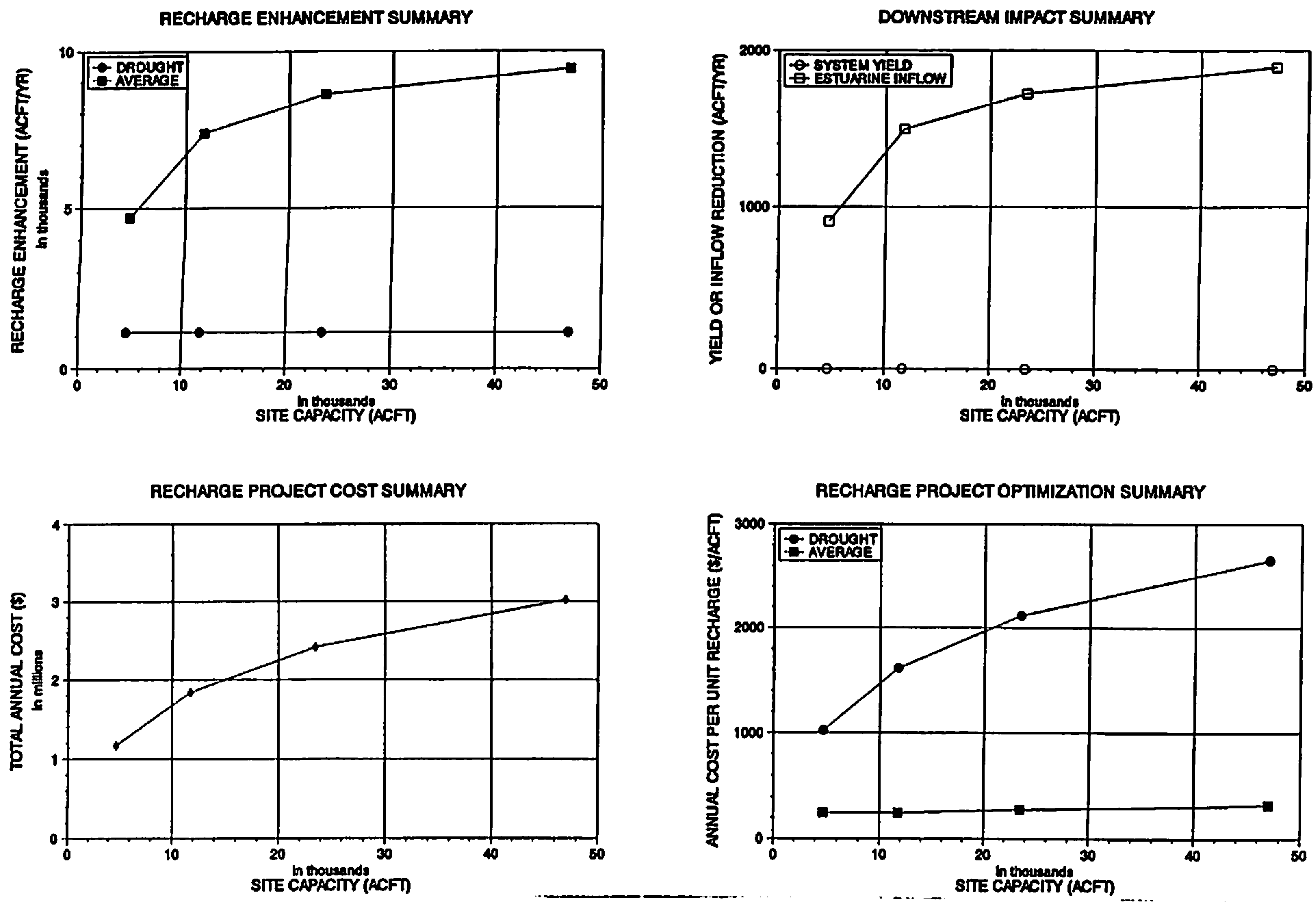
Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	Embankment
Conservation Pool:				
Elevation (ft-msl)	1226.3	1241.1	1251.1	1266.6
Surface Area (ac)	350	770	1,260	2,000
Capacity (acft)	4,700	11,750	23,500	47,000
25-Year Flood Pool:				
Elevation (ft-msl)	1234.5	1247.7	1257.6	1275.1
Surface Area (ac)	570	1,100	1,580	2,480
100-Year Flood Pool:				
Elevation (ft-msl)	1236.1	1249.4	1259.4	1276.8
Surface Area (ac)	610	1,180	1,660	2,570
Top of Dam Elevation (ft-msl)	1247.9	1262.7	1272.7	1290.2
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	1,140	1,140	1,140	1,140
Average Conditions	4,700	7,030	7,680	8,360
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.1	0.1	0.1	0.1
Estuarine Inflow Reduction (acft/yr)	910	1,400	1,550	1,700
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$4,014,600	$6,752,700	$9,212,480	$10,652,840
Road Relocations	$3,380,000	$4,717,667	$6,055,333	$7,393,000
Land Acquisition	$2,776,830	$4,304,440	$5,160,840	$7,138,460
Environmental Mitigation	$352,695	$775,929	$1,269,702	$2,015,400
Engineering, Legal, Financial, and Misc.	$2,104,825	$3,310,147	$4,339,671	$5,439,940
Total Capital Cost	$12,628,950	$19,860,883	$26,038,026	$32,639,640
Capital Cost / Unit Capacity	$2,687	$1,690	$1,108	$694
Annual Capital Cost	$1,132,817	$1,781,521	$2,335,611	$2,927,776
Operations and Maintenance	$19,558	$34,711	$49,450	$62,611
Water Rights Mitigation	$14,560	$22,400	$24,800	$27,200
Total Annual Cost	$1,166,935	$1,838,632	$2,409,861	$3,017,587
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$1,024	$1,613	$2,114	$2,647
Average Conditions	$248	$262	$314	$361

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.1-6b
Upper Hondo Project Cost and Data Summary With Purchase of Water Rights

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	Embankment
Conservation Pool:				
Elevation (ft-msl)	1226.3	1241.1	1251.1	1266.6
Surface Area (ac)	350	770	1,260	2,000
Capacity (acft)	4,700	11,750	23,500	47,000
25-Year Flood Pool:				
Elevation (ft-msl)	1234.5	1247.7	1257.6	1275.1
Surface Area (ac)	570	1,100	1,580	2,480
100-Year Flood Pool:				
Elevation (ft-msl)	1236.1	1249.4	1259.4	1276.8
Surface Area (ac)	610	1,180	1,660	2,570
Top of Dam Elevation (ft-msl)	1247.9	1262.7	1272.7	1290.2
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	1,140	1,140	1,140	1,140
Average Conditions	4,700	7,370	8,610	9,420
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.1	0.2	0.2	0.2
Estuarine Inflow Reduction (acft/yr)	910	1,490	1,720	1,890
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$4,014,600	$6,752,700	$9,212,480	$10,652,840
Road Relocations	$3,380,000	$4,717,667	$6,055,333	$7,393,000
Land Acquisition	$2,776,830	$4,304,440	$5,160,840	$7,138,460
Environmental Mitigation	$352,695	$775,929	$1,269,702	$2,015,400
Engineering, Legal, Financial, and Misc.	$2,104,825	$3,310,147	$4,339,671	$5,439,940
Total Capital Cost	$12,628,950	$19,860,883	$26,038,026	$32,639,640
Capital Cost / Unit Capacity	$2,687	$1,690	$1,108	$694
Annual Capital Cost	$1,132,817	$1,781,521	$2,335,611	$2,927,776
Operations and Maintenance	$19,558	$34,711	$49,450	$62,611
Water Rights Mitigation	$14,560	$23,840	$27,520	$30,240
Total Annual Cost	$1,166,935	$1,840,072	$2,412,581	$3,020,627
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$1,024	$1,614	$2,116	$2,650
Average Conditions	$248	$250	$280	$321

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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UPPER HONDO PROJECT
EVALUATION SUMMARY

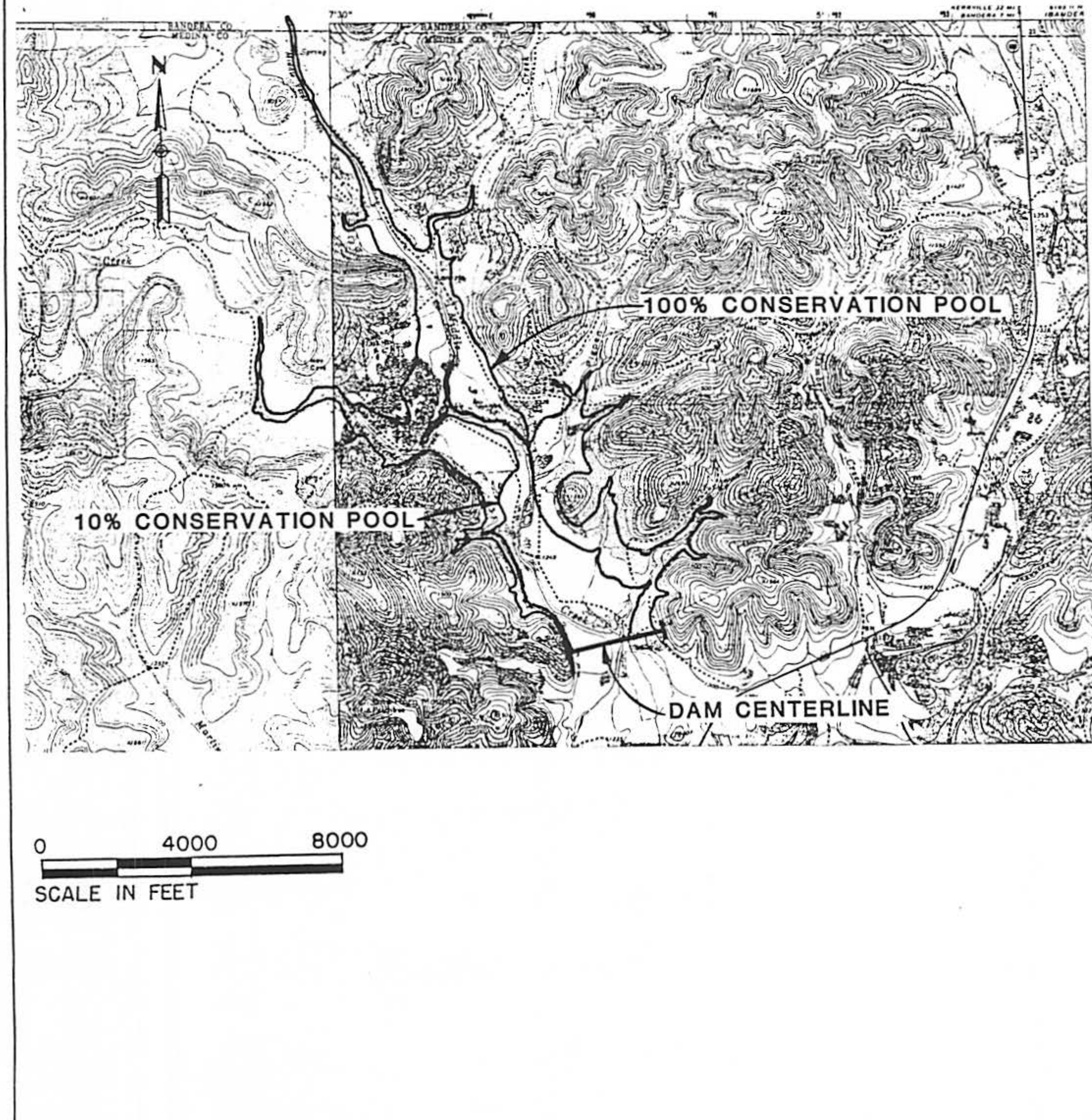
FIGURE 3.1-12

evaluation. Both the embankment dam and the composite embankment / roller compacted concrete dam types were evaluated for this site with the composite dam proving more economical at the 10%, 25%, and 50% capacities and the embankment dam being more economical at the 100% capacity. As indicated in the tables and figures, optimal site development is at about 10% of the maximum conservation capacity at a minimum cost per unit recharge enhancement of $248 per ac-ft per year subject to either of the water rights scenarios considered.

3.1.7 Upper Verde Project

The Upper Verde Project is located on Middle Verde Creek near the upstream edge of the Edwards Aquifer recharge zone. Maximum conservation storage capacity and surface area are 23,000 ac-ft and 880 acres, respectively. As indicated in Figure 3.1-13, no major highway relocations would be necessitated by the project, however, some relocation of private roads would be required. Environmental considerations at this site include the possible presence of threatened or endangered species, instream flow studies, and purchase and management of wooded mitigation lands. No sites of archaeological significance have been recorded within the maximum conservation pool of the reservoir.

Both the embankment dam and the composite embankment / roller compacted concrete dam types were evaluated for this site with the composite dam proving more economical at the 10%, 25%, and 50% capacities and the embankment dam being more economical at the 100% capacity. Although minor flooding was in progress when the site was visited, extensive gravel deposits are likely as gravel has apparently been mined recently immediately upstream of the dam site.



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PLANNING STUDY PHASE III**

**UPPER VERDE PROJECT
SITE MAP**

FIGURE 3.1-13

Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.1-7a and 3.1-7b and Figure 3.1-14 graphically summarizes project evaluation. As indicated in the tables and figures, optimal site development is at about 25% of the maximum conservation capacity at a minimum cost per unit recharge enhancement of $185 per ac-ft per year assuming purchase of water rights from the owners of the CC/LCC System. When honoring all water rights to extent possible (first water rights scenario), the unit cost of recharge enhancement at the 25% capacity becomes $210 per ac-ft per year making the Upper Verde Project the second most economical of all Type 1 projects evaluated.

3.2 Type 2 Mainstem Recharge Enhancement Projects

3.2.1 Indian Creek Project

The Indian Creek Project is located on the Nueces River approximately two miles downstream of the West Nueces River confluence and immediately downstream of the Indian Creek confluence. The project site was identified in a previous study (Ref. 6) and has the second largest maximum conservation capacity (165,000 ac-ft) and largest surface area (7,650 ac) of any of the projects considered in this study. As indicated in Figure 3.2-1, development of this project at 100% capacity would necessitate a minor relocation of State Highway 55.

Although the Indian Creek Project is located near the downstream edge of the Edwards Aquifer recharge zone as is typical of Type 2 projects, it also bears certain similarity to the Type 1 projects as flows may be stored in the reservoir for extended periods due to the relatively low direct percolation rate. Recharge enhancement was calculated

TABLE 3.1-7a
Upper Verde Project Cost and Data Summary

Physical Data	Percentage of Maximum Project conservation Capacity			
	10%	20%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	Embankment
Conservation Pool:				
Elevation (ft-msl)	1260.4	1270.6	1283.9	1300.9
Surface Area (ac)	230	350	540	880
Capacity (acft)	2,300	5,750	11,500	23,000
25-Year Flood Pool:				
Elevation (ft-msl)	1266.7	1277.0	1289.7	1312.9
Surface Area (ac)	310	430	660	1,170
100-Year Flood Pool:				
Elevation (ft-msl)	1268.1	1278.3	1291.0	1315.0
Surface Area (ac)	320	450	680	1,220
Top of Dam Elevation (ft-msl)	1280.4	1290.6	1303.9	1331.3
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	1,210	1,390	1,390	1,390
Average Conditions	2,950	3,990	4,280	4,600
CC/LCC System Yield Reduction (acft/yr)	120	120	120	120
Median CC/LCC System Storage Reduction (%)	0.1	0.1	0.1	0.1
Estuarine Inflow Reduction (acft/yr)	490	730	800	880
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$2,928,450	$4,367,670	$6,698,280	$7,546,180
Road Relocations	$125,000	$145,833	$166,667	$85,000
Land Acquisition	$1,931,420	$2,243,620	$3,211,230	$5,048,750
Environmental Mitigation	$244,767	$372,472	$574,670	$936,500
Engineering, Legal, Financial, and Misc.	$1,045,927	$1,425,919	$2,130,169	$2,723,286
Total Capital Cost	$6,275,564	$8,555,514	$12,781,017	$16,339,716
Capital Cost / Unit Capacity	$2,729	$1,488	$1,111	$710
Annual Capital Cost	$562,918	$767,430	$1,146,457	$1,465,673
Operations and Maintenance	$14,014	$20,971	$32,193	$38,985
Water Rights Mitigation	$46,360	$50,200	$51,320	$52,600
Total Annual Cost	$623,292	$838,600	$1,229,970	$1,557,257
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$515	$603	$885	$1,120
Average Conditions	$211	$210	$287	$339

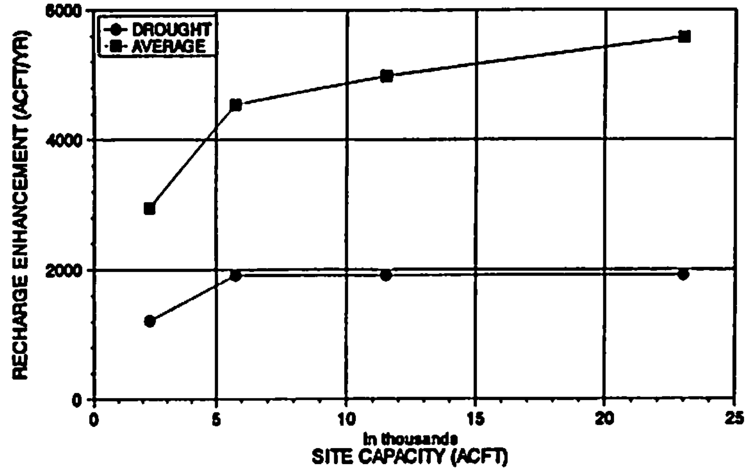
Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.1-7b
Upper Verde Project Cost and Data Summary With Purchase of Water Rights

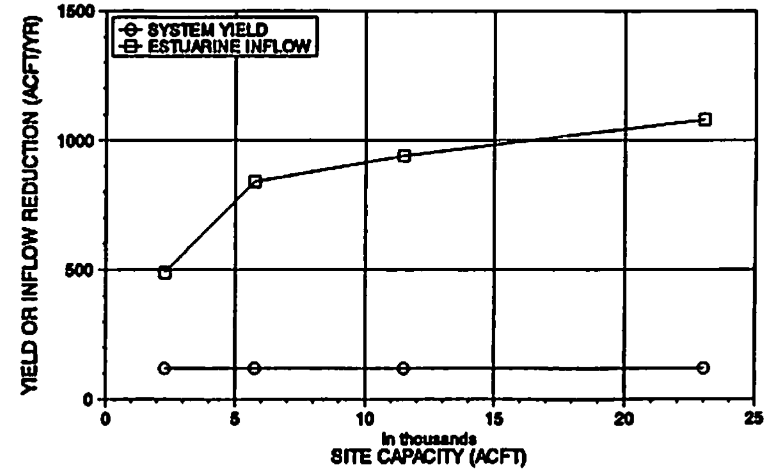
Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	Embankment
Conservation Pool:				
Elevation (ft-msl)	1260.4	1270.6	1283.9	1300.9
Surface Area (ac)	230	350	540	880
Capacity (acft)	2,300	5,750	11,500	23,000
25-Year Flood Pool:				
Elevation (ft-msl)	1266.7	1277.0	1289.7	1312.9
Surface Area (ac)	310	430	660	1,170
100-Year Flood Pool:				
Elevation (ft-msl)	1268.1	1278.3	1291.0	1315.0
Surface Area (ac)	320	450	680	1,220
Top of Dam Elevation (ft-msl)	1280.4	1290.6	1303.9	1331.3
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	1,210	1,910	1,910	1,910
Average Conditions	2,950	4,540	4,980	5,580
CC/LCC System Yield Reduction (acft/yr)	120	120	120	120
Median CC/LCC System Storage Reduction (%)	0.1	0.1	0.1	0.1
Estuarine Inflow Reduction (acft/yr)	490	840	940	1,080
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$2,928,450	$4,367,670	$6,698,280	$7,546,180
Road Relocations	$125,000	$145,833	$166,667	$85,000
Land Acquisition	$1,931,420	$2,243,620	$3,211,230	$5,048,750
Environmental Mitigation	$244,767	$372,472	$574,670	$936,500
Engineering, Legal, Financial, and Misc.	$1,045,927	$1,425,919	$2,130,169	$2,723,286
Total Capital Cost	$6,275,564	$8,555,514	$12,781,017	$16,339,716
Capital Cost / Unit Capacity	$2,729	$1,488	$1,111	$710
Annual Capital Cost	$562,918	$767,430	$1,146,457	$1,465,673
Operations and Maintenance	$14,014	$20,971	$32,193	$38,985
Water Rights Mitigation	$46,360	$51,960	$53,560	$55,800
Total Annual Cost	$623,292	$840,360	$1,232,210	$1,560,457
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$515	$440	$645	$817
Average Conditions	$211	$185	$247	$280

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

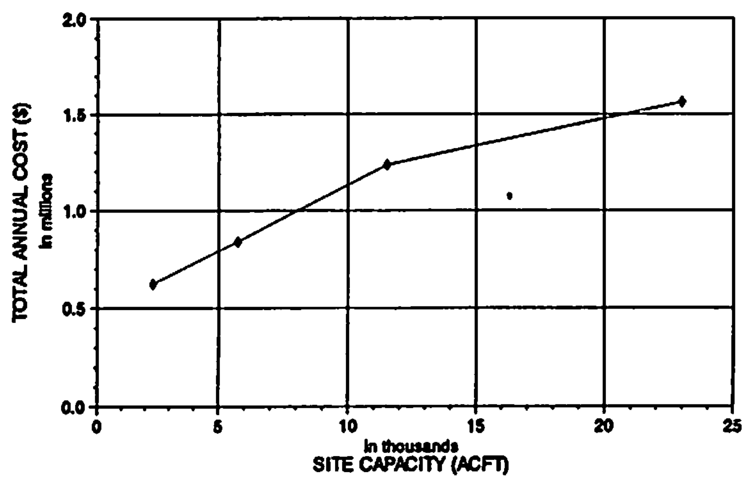
RECHARGE ENHANCEMENT SUMMARY



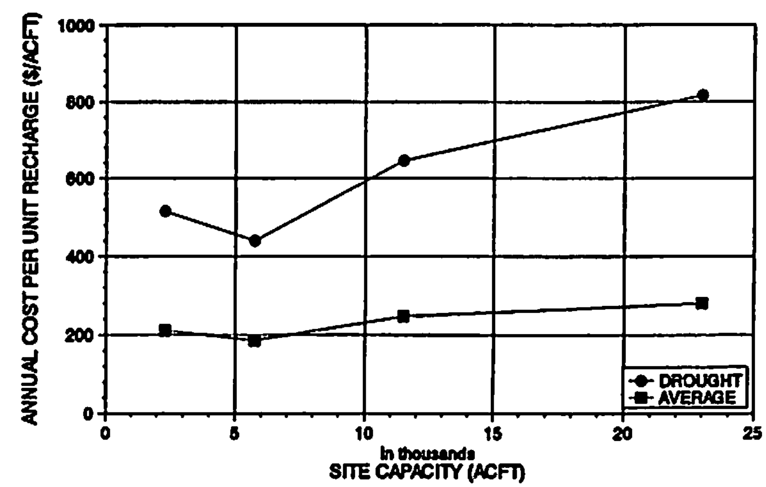
DOWNSTREAM IMPACT SUMMARY



RECHARGE PROJECT COST SUMMARY



RECHARGE PROJECT OPTIMIZATION SUMMARY



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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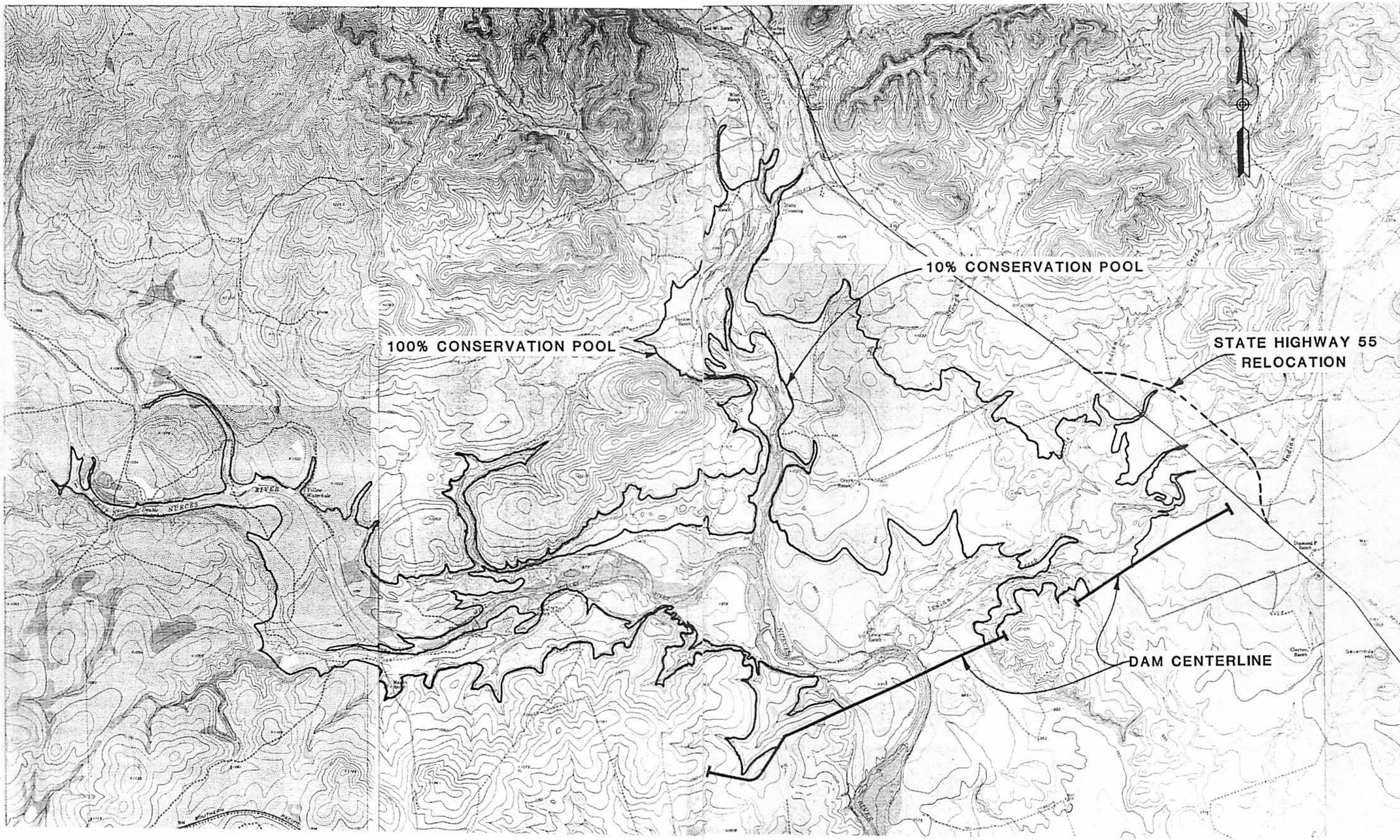
UPPER VERDE PROJECT EVALUATION SUMMARY

FIGURE 3.1-14



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PLANNING STUDY PHASE III

INDIAN CREEK PROJECT
SITE MAP

FIGURE 3.2-1

assuming a direct percolation capacity of 2,000 ac-ft per month and the diversion of up to 2,000 ac-ft per month to the Dry Frio River for subsequent natural recharge. Calculated recharge enhancement for this project was greater than that for any other Type 2 project evaluated. Cost estimates for the Indian Creek Project include the capital costs of a small diversion dam, pump station, and raw water pipeline to the Dry Frio River as well as annual power costs for operation of the pump station.

Environmental considerations at this site include the possibility of threatened or endangered species and the proximity of identified sites of archaeological significance. As the reservoir area will be subject to inundation for extended periods, purchase and management of wooded mitigation lands would be required.

The composite embankment / roller compacted concrete dam type was selected for this site due to the flood potential associated with the large upstream drainage area and the availability of construction materials. A peak flood flow near this site of 616,000 cubic feet per second (63% of the Probable Maximum Flood) was observed in 1935. Abundant gravel to cobble deposits were noted in the river bed during the field reconnaissance.

Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.2-1a and 3.2-1b and Figure 3.2-2 graphically summarizes project evaluation. As indicated in the tables and figures, optimal site development is at about 25% of the maximum conservation capacity at a minimum cost per unit recharge enhancement of $213 per ac-ft per year assuming purchase of water rights from the owners of the CC/LCC System. Preliminary analyses indicate that implementation of the Indian Creek Project will have no significant adverse impact on the braided reach of the Nueces River. Studies conducted by the U.S. Geological Survey (Ref. 18) and frequency analysis of

TABLE 3.2-1a
Indian Creek Project Cost and Data Summary

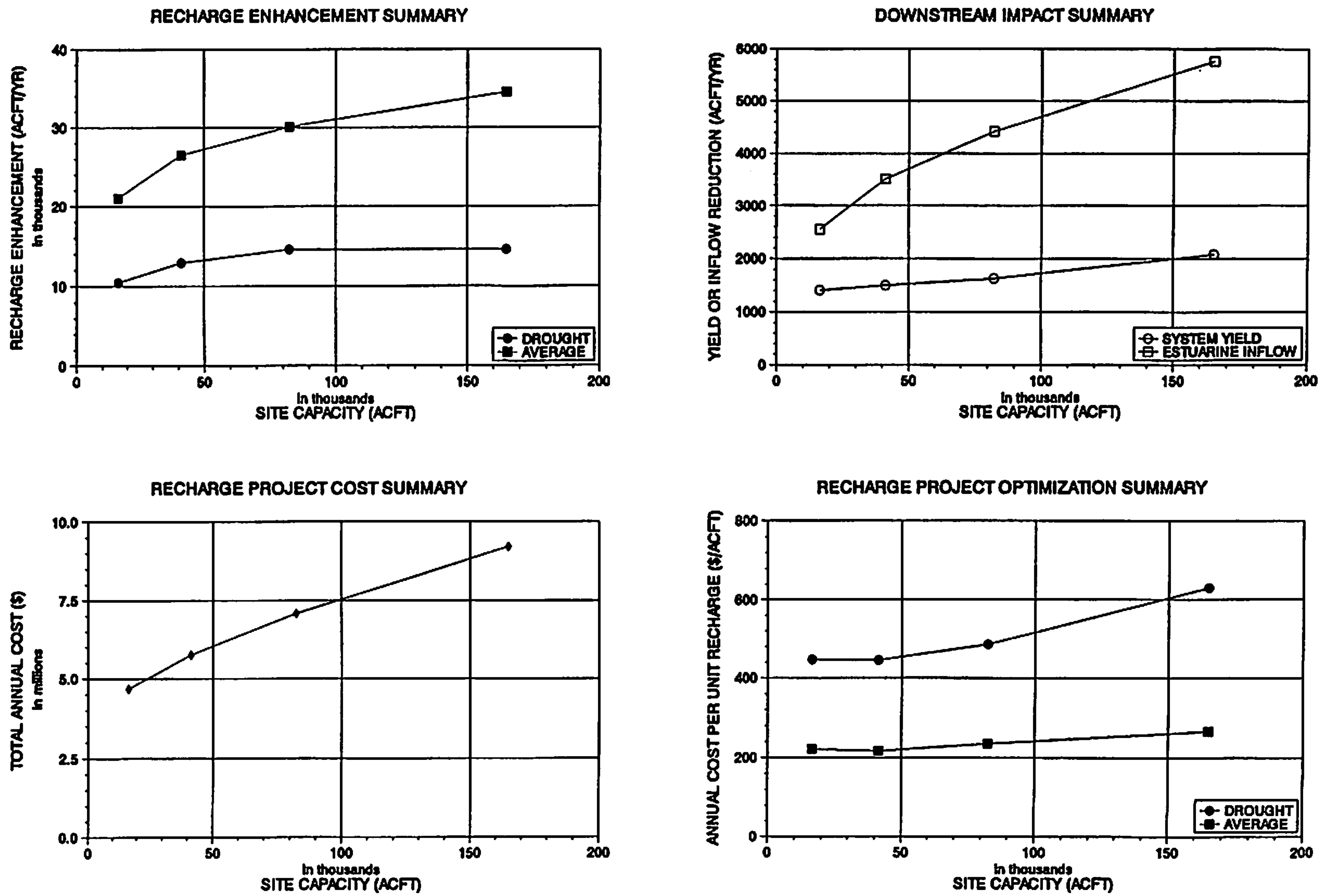
Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	975.1	987.9	999.0	1012.5
Surface Area (ac)	1,260	2,770	4,760	7,650
Capacity (acft)	16,500	41,250	82,500	165,000
25-Year Flood Pool:				
Elevation (ft-msl)	984.3	996.9	1007.9	1021.2
Surface Area (ac)	2,190	4,340	6,610	9,620
100-Year Flood Pool:				
Elevation (ft-msl)	986.1	998.8	1009.9	1023.1
Surface Area (ac)	2,460	4,710	7,060	10,100
Top of Dam Elevation (ft-msl)	999.1	1011.9	1023.0	1036.5
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	3,850	3,840	3,840	3,830
Average Conditions	10,680	14,650	18,040	22,180
CC/LCC System Yield Reduction (acft/yr)	10	10	10	10
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	1,630	2,330	3,030	4,120
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$24,813,930	$31,039,830	$38,486,000	$50,837,120
Road Relocations	$0	$0	$0	$3,148,000
Land Acquisition	$2,488,700	$4,256,100	$6,660,900	$9,985,500
Environmental Mitigation	$701,105	$1,541,319	$2,648,620	$4,256,710
Engineering, Legal, Financial, and Misc.	$5,600,747	$7,367,450	$9,559,104	$13,645,466
Total Capital Cost	$33,604,482	$44,204,698	$57,354,623	$81,872,796
Capital Cost / Unit Capacity	$2,037	$1,072	$695	$496
Annual Capital Cost	$3,014,322	$3,965,161	$5,144,710	$7,343,990
Operations and Maintenance	$1,192,550	$1,221,401	$1,256,388	$1,313,348
Water Rights Mitigation	$29,290	$40,490	$51,690	$69,130
Total Annual Cost	$4,236,162	$5,227,053	$6,452,788	$8,726,468
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$1,100	$1,361	$1,680	$2,278
Average Conditions	$397	$357	$358	$393

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.2-1b
Indian Creek Project Cost and Data Summary With Purchase of Water Rights

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	975.1	987.9	999.0	1012.5
Surface Area (ac)	1,260	2,770	4,760	7,650
Capacity (acft)	16,500	41,250	82,500	165,000
25-Year Flood Pool:				
Elevation (ft-msl)	984.3	996.9	1007.9	1021.2
Surface Area (ac)	2,190	4,340	6,610	9,620
100-Year Flood Pool:				
Elevation (ft-msl)	986.1	998.8	1009.9	1023.1
Surface Area (ac)	2,460	4,710	7,060	10,100
Top of Dam Elevation (ft-msl)	999.1	1011.9	1023.0	1036.5
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	10,460	12,920	14,600	14,600
Average Conditions	21,050	26,500	30,130	34,500
CC/LCC System Yield Reduction (acft/yr)	1,410	1,500	1,630	2,080
Median CC/LCC System Storage Reduction (%)	-0.2	-0.1	-0.2	-0.3
Estuarine Inflow Reduction (acft/yr)	2,550	3,510	4,420	5,760
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$24,813,930	$31,039,830	$38,486,000	$50,837,120
Road Relocations	$0	$0	$0	$3,148,000
Land Acquisition	$2,488,700	$4,256,100	$6,660,900	$9,985,500
Environmental Mitigation	$368,365	$809,818	$1,391,600	$2,236,500
Engineering, Legal, Financial, and Misc.	$5,534,199	$7,221,150	$9,307,700	$13,241,424
Total Capital Cost	$33,205,194	$43,326,897	$55,846,200	$79,448,544
Capital Cost / Unit Capacity	$2,012	$1,050	$677	$482
Annual Capital Cost	$2,978,506	$3,886,423	$5,009,404	$7,126,534
Operations and Maintenance	$1,192,550	$1,221,401	$1,256,388	$1,313,348
Water Rights Mitigation	$493,410	$537,660	$593,950	$759,840
Total Annual Cost	$4,664,466	$5,645,484	$6,859,743	$9,199,723
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$446	$437	$470	$630
Average Conditions	$222	$213	$228	$267

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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INDIAN CREEK PROJECT EVALUATION SUMMARY

FIGURE 3.2-2

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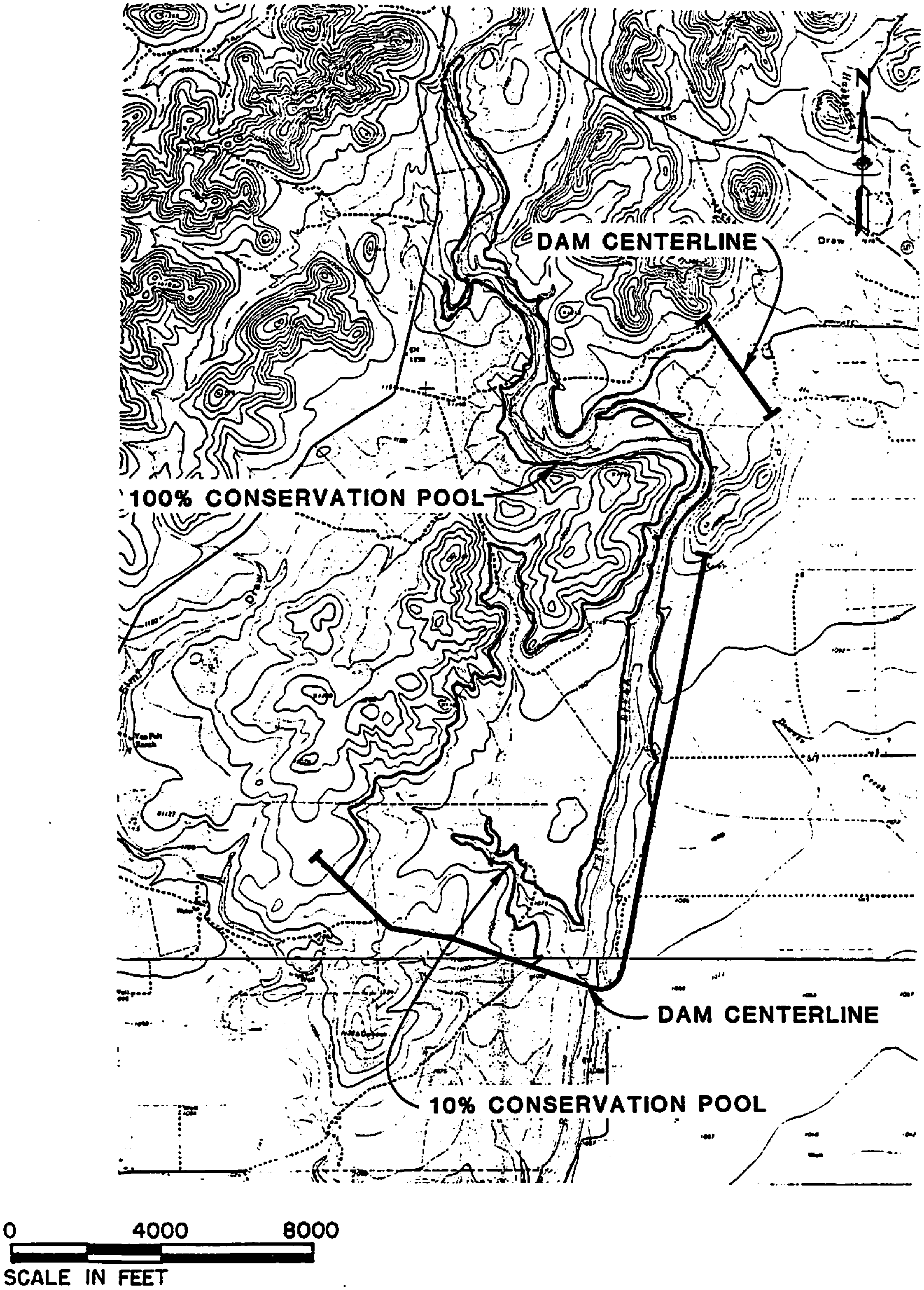
flows from the Nueces River Basin Model indicate that the frequency of overbank inundation would be reduced by less than 1% while the frequency of zero flow would be unaffected by project implementation and operation.

3.2.2 Lower Frio Project

The Lower Frio Project is located on the Frio River approximately 7 miles north of Knippa in Uvalde County. It is a Type 2 recharge enhancement project with a maximum conservation capacity of 50,000 ac-ft and surface area of 1,760 acres. As is apparent in Figure 3.2-3, the project is located in a relatively remote area and no significant relocations would be necessitated by project development. Environmental considerations associated with the development of this project are believed to be limited to basic environmental reports and investigations of cultural resources and values.

The composite embankment / roller compacted concrete dam type was selected for this site due to the flood potential associated with the large upstream drainage area and the availability of construction materials. Abundant gravel deposits were noted both in the channel and on terraces along the right bank during the field reconnaissance.

Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.2-2a and 3.2-2b and Figure 3.2-4 graphically summarizes project evaluation. Due to the high recharge capacity of the Frio River bed, the Lower Frio Project would have no significant impact on the yield of the CC/LCC System because waters originating above the site would not have arrived at Choke Canyon Reservoir during the critical drought under natural conditions. The project would, however, reduce inflows to the CC/LCC System during years outside of the critical drought period. As indicated in the



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PLANNING STUDY PHASE III

LOWER FRIO PROJECT
SITE MAP

FIGURE 3.2-3

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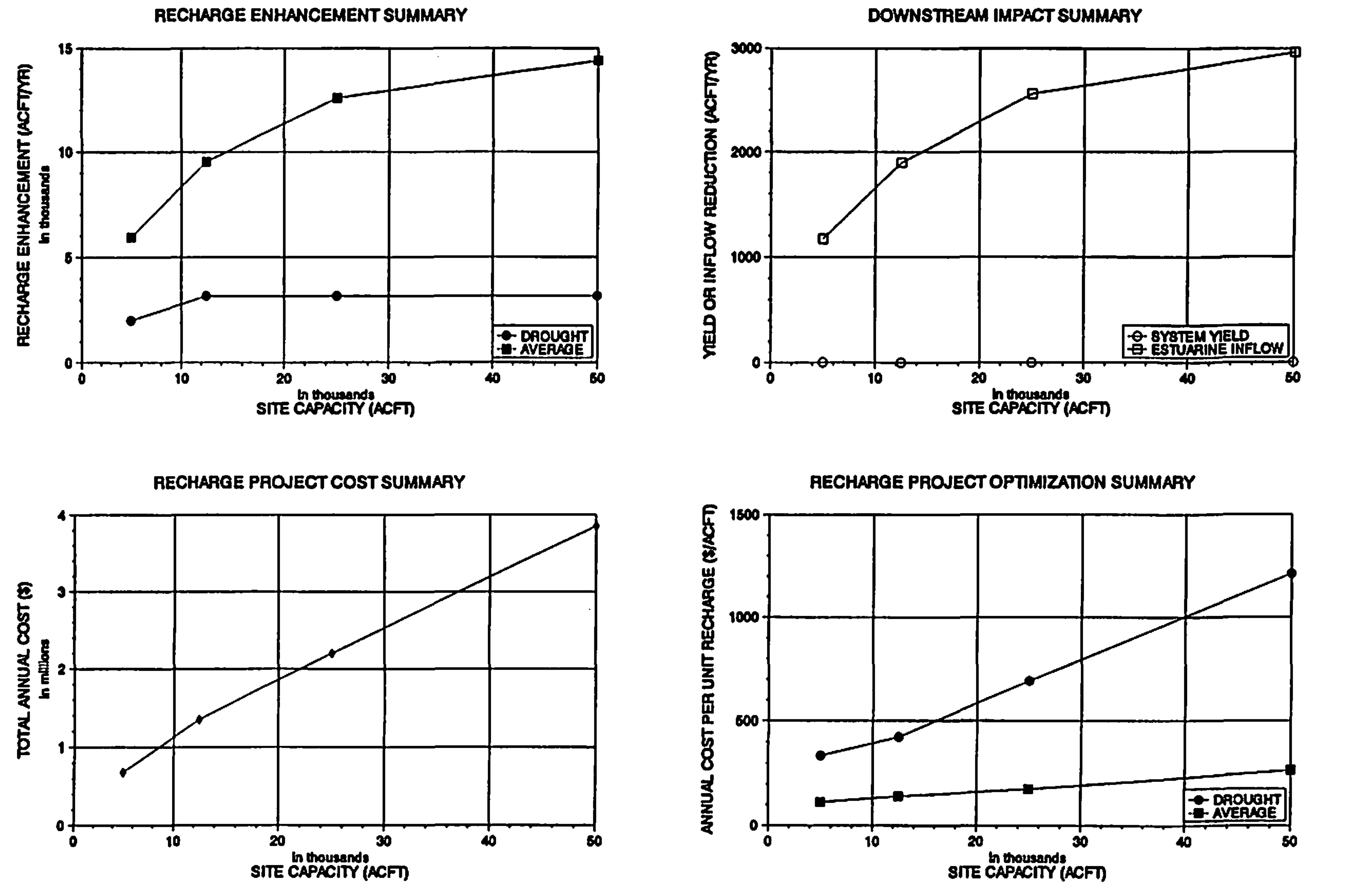
TABLE 3.2-2a Lower Frio Project Cost and Data Summary				
Physical Data	**Percentage of Maximum Project Conservation Capacity**			
	10%	**25%**	**50%**	**100%**
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	1082.1	1094.9	1106.7	1123.2
Surface Area (ac)	340	820	1,280	1,760
Capacity (acft)	5,000	12,500	25,000	50,000
25-Year Flood Pool:				
Elevation (ft-msl)	1087.9	1100.8	1112.6	1129.0
Surface Area (ac)	540	1,080	1,470	1,960
100-Year Flood Pool:				
Elevation (ft-msl)	1089.1	1101.9	1113.6	1130.2
Surface Area (ac)	580	1,120	1,500	2,000
Top of Dam Elevation (ft-msl)	1099.9	1112.7	1124.5	1141.0
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	5	7	7	7
Average Conditions	2,470	4,100	5,400	6,640
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	540	900	1,190	1,460
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$5,465,930	$10,838,710	$18,060,070	$32,385,260
Road Relocations	$0	$0	$0	$0
Land Acquisition	$452,000	$934,000	$1,241,000	$1,638,000
Environmental Mitigation	$22,197	$53,533	$83,564	$114,900
Engineering, Legal, Financial, and Misc.	$1,188,025	$2,365,249	$3,876,927	$6,827,632
Total Capital Cost	$7,128,152	$14,191,492	$23,261,560	$40,965,792
Capital Cost / Unit Capacity	$1,426	$1,135	$930	$819
Annual Capital Cost	$639,395	$1,272,977	$2,086,562	$3,674,632
Operations and Maintenance	$21,864	$43,355	$72,240	$129,541
Water Rights Mitigation	$8,640	$14,400	$19,040	$23,360
Total Annual Cost	$669,899	$1,330,732	$2,177,842	$3,827,533
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$133,980	$190,105	$311,120	$546,790
Average Conditions	$271	$325	$403	$576

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.2-2b
Lower Frio Project Cost and Data Summary With Purchase of Water Rights

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	1082.1	1094.9	1106.7	1123.2
Surface Area (ac)	340	820	1,280	1,760
Capacity (acft)	5,000	12,500	25,000	50,000
25-Year Flood Pool:				
Elevation (ft-msl)	1087.9	1100.8	1112.6	1129.0
Surface Area (ac)	540	1,080	1,470	1,960
100-Year Flood Pool:				
Elevation (ft-msl)	1089.1	1101.9	1113.6	1130.2
Surface Area (ac)	580	1,120	1,500	2,000
Top of Dam Elevation (ft-msl)	1099.9	1112.7	1124.5	1141.0
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	2,020	3,180	3,180	3,180
Average Conditions	5,940	9,530	12,570	14,400
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.3	0.3	0.3	0.3
Estuarine Inflow Reduction (acft/yr)	1,170	1,900	2,560	2,960
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$5,465,930	$10,838,710	$18,060,070	$32,385,260
Road Relocations	$0	$0	$0	$0
Land Acquisition	$452,000	$934,000	$1,241,000	$1,638,000
Environmental Mitigation	$22,197	$53,533	$83,564	$114,900
Engineering, Legal, Financial, and Misc.	$1,188,025	$2,365,249	$3,876,927	$6,827,632
Total Capital Cost	$7,128,152	$14,191,492	$23,261,560	$40,965,792
Capital Cost / Unit Capacity	$1,426	$1,135	$930	$819
Annual Capital Cost	$639,395	$1,272,977	$2,086,562	$3,674,632
Operations and Maintenance	$21,864	$43,355	$72,240	$129,541
Water Rights Mitigation	$18,720	$30,400	$40,960	$47,360
Total Annual Cost	$679,979	$1,346,732	$2,199,762	$3,851,533
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$337	$424	$692	$1,211
Average Conditions	$114	$141	$175	$267

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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LOWER FRIO PROJECT EVALUATION SUMMARY

FIGURE 3.2-4

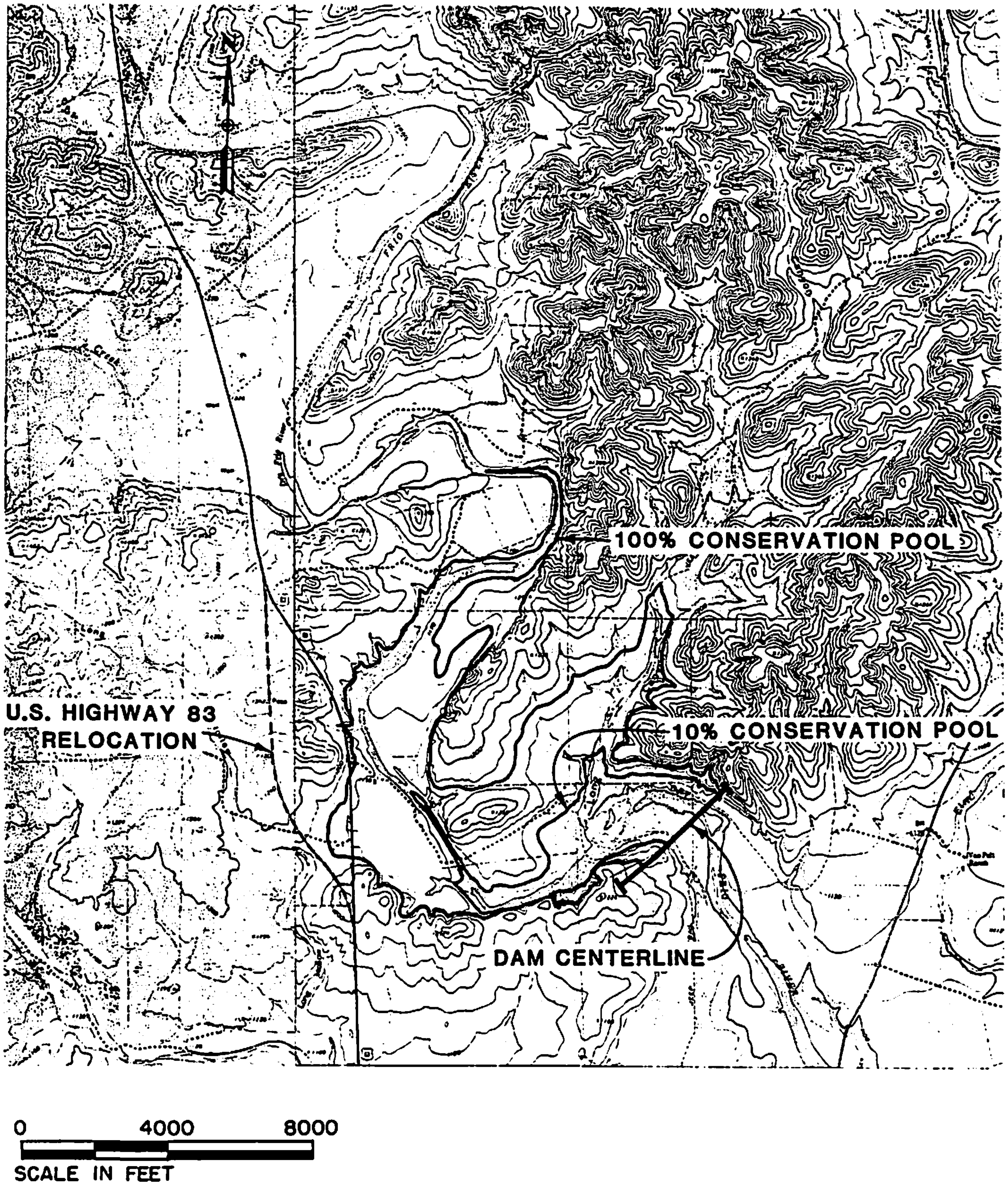
tables and figures, optimal site development is at about 10% of the maximum conservation capacity at a minimum cost per unit recharge enhancement of $114 per ac-ft per year assuming purchase of water rights from the owners of the CC/LCC System. This is a relatively low unit cost of recharge enhancement compared to many of the projects evaluated. Hence, it may be advantageous to construct the Lower Frio Project to a capacity in excess of the "optimum" because additional recharge enhancement may be obtained more economically at this site than by developing another project.

3.2.3 Lower Dry Frio Project

The Lower Dry Frio Project is located on the Dry Frio River approximately 7 miles northwest of Knippa in Uvalde County. It is a Type 2 recharge enhancement project with a maximum conservation capacity of 30,000 ac-ft and surface area of 1,190 acres. As is apparent in Figure 3.2-5, development of this project at capacities in excess of the 25% capacity would necessitate relocation of less than 2 miles of U.S. Highway 83. Environmental considerations associated with the development of this project are believed to be limited to basic environmental reports and investigations of cultural resources and values with the possible exception of a threatened / endangered species survey.

Both the embankment dam and the composite embankment / roller compacted concrete dam types were evaluated for this site with the composite dam proving more economical at the 10%, 25%, and 50% capacities and the embankment dam being more economical at the 100% capacity. Field reconnaissance indicated the presence of sufficient construction materials for either dam type.

Project cost and data summaries subject to the two water rights scenarios are



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LOWER DRY FRIO PROJECT
SITE MAP

FIGURE 3.2-5

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included as Tables 3.2-3a and 3.2-3b and Figure 3.2-6 graphically summarizes project evaluation. Due to the high recharge capacity of the Dry Frio River bed, the Lower Dry Frio Project would have no significant impact on the yield of the CC/LCC System because waters originating above the site would not have arrived at Choke Canyon Reservoir during the critical drought under natural conditions. The project would, however, reduce inflows to the CC/LCC System during years outside of the critical drought period. As indicated in the tables and figures, optimal site development is at about 25% of the maximum conservation capacity at a minimum cost per unit recharge enhancement of $216 per ac-ft per year assuming purchase of water rights from the owners of the CC/LCC System.

3.2.4 Lower Sabinal Project

The Lower Sabinal Project is located on the Sabinal River approximately 5 miles north of Sabinal in Uvalde County. It is a Type 2 recharge enhancement project with a maximum conservation capacity of 35,000 ac-ft and surface area of 1,430 acres. As indicated in Figure 3.2-7, development of this project would necessitate only minor relocation of private roads. Environmental considerations associated with the development of this project are believed to be limited to basic environmental reports and investigations of cultural resources and values with the possible exception of a threatened / endangered species survey.

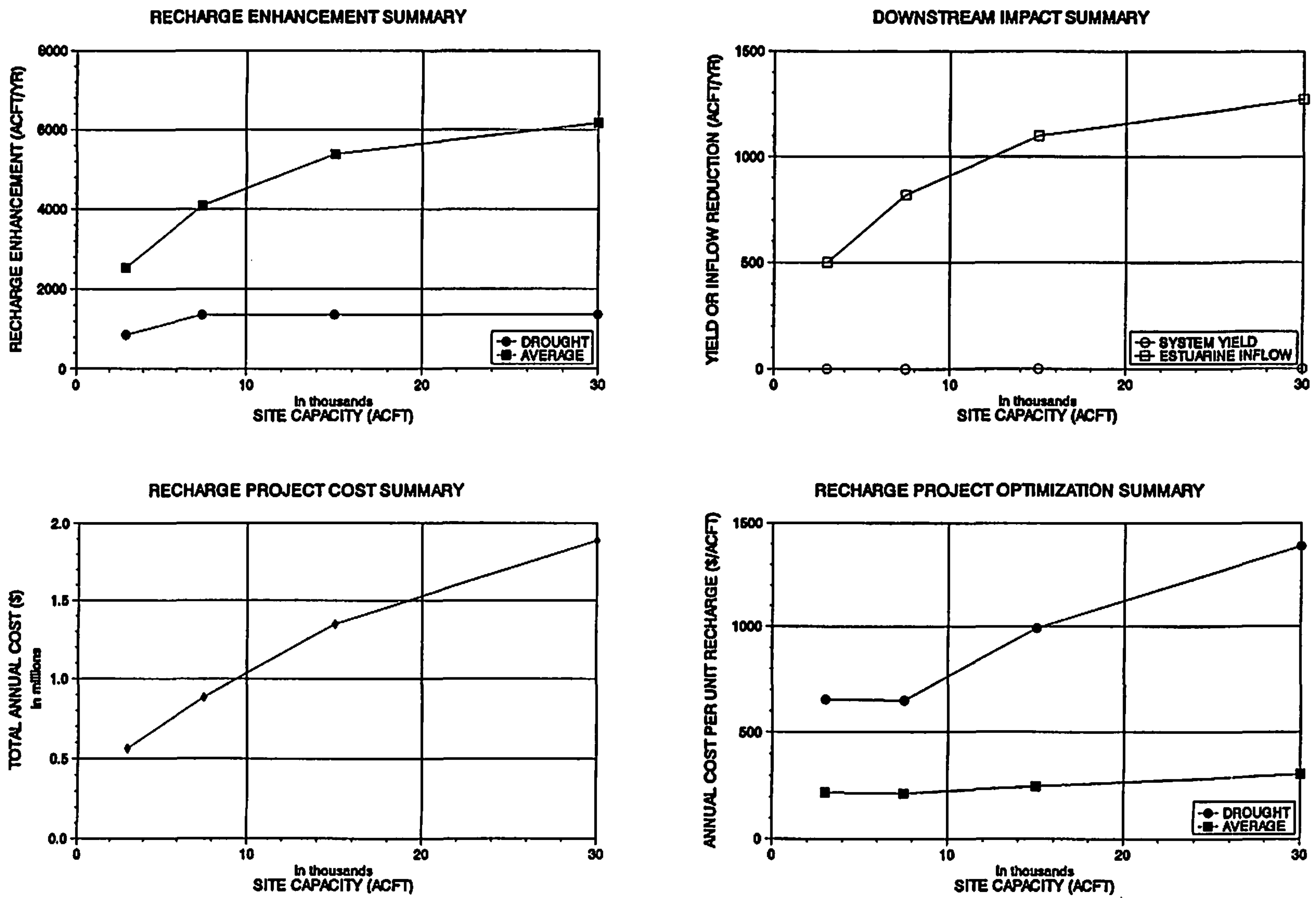
The composite enbankment / roller compacted concrete dam type was selected for this site due to topographic constraints and the availability of construction materials. Massive sand and gravel deposits were noted both in the channel and along the left bank during the field reconnaissance.

TABLE 3.2-3a Lower Dry Frio Project Cost and Data Summary				
Physical Data	**Percentage of Maximum Project Conservation Capacity**			
	10%	**25%**	**50%**	**100%**
Dam Type	RCC Composite	RCC Composite	RCC Composite	Embankment
Conservation Pool:				
Elevation (ft-msl)	1128.1	1142.1	1155.0	1171.0
Surface Area (ac)	230	420	740	1,190
Capacity (acft)	3,000	7,500	15,000	30,000
25-Year Flood Pool:				
Elevation (ft-msl)	1135.3	1149.4	1162.0	1191.5
Surface Area (ac)	310	590	930	1,974
100-Year Flood Pool:				
Elevation (ft-msl)	1136.8	1150.9	1163.6	1194.2
Surface Area (ac)	330	630	970	2,077
Top of Dam Elevation (ft-msl)	1150.2	1164.2	1177.1	1205.2
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	2	3	3	3
Average Conditions	1,060	1,760	2,310	2,850
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	240	390	510	630
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$4,605,890	$7,150,300	$10,176,780	$13,358,500
Road Relocations	$0	$0	$830,000	$1,660,000
Land Acquisition	$358,000	$642,000	$914,000	$1,730,700
Environmental Mitigation	$16,235	$29,647	$52,235	$84,000
Engineering, Legal, Financial, and Misc.	$996,025	$1,564,389	$2,394,603	$3,366,640
Total Capital Cost	$5,976,150	$9,386,336	$14,367,618	$20,199,840
Capital Cost / Unit Capacity	$1,992	$1,252	$958	$673
Annual Capital Cost	$536,061	$841,954	$1,288,775	$1,811,926
Operations and Maintenance	$18,424	$28,601	$40,707	$53,434
Water Rights Mitigation	$3,840	$6,240	$8,160	$10,080
Total Annual Cost	$558,324	$876,796	$1,337,642	$1,875,440
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$279,162	$292,265	$445,881	$625,147
Average Conditions	$527	$498	$579	$658

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.2-3b Lower Dry Frio Project Cost and Data Summary With Purchase of Water Rights				
	Percentage of Maximum Project Conservation Capacity			
Physical Data	**10%**	**25%**	**50%**	**100%**
Dam Type	RCC Composite	RCC Composite	RCC Composite	Embankment
Conservation Pool:				
Elevation (ft-msl)	1128.1	1142.1	1155.0	1171.0
Surface Area (ac)	230	420	740	1,190
Capacity (acft)	3,000	7,500	15,000	30,000
25-Year Flood Pool:				
Elevation (ft-msl)	1135.3	1149.4	1162.0	1191.5
Surface Area (ac)	310	590	930	1,974
100-Year Flood Pool:				
Elevation (ft-msl)	1136.8	1150.9	1163.6	1194.2
Surface Area (ac)	330	630	970	2,077
Top of Dam Elevation (ft-msl)	1150.2	1164.2	1177.1	1205.2
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	860	1,360	1,360	1,360
Average Conditions	2,540	4,090	5,390	6,170
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.1	0.1	0.1	0.1
Estuarine Inflow Reduction (acft/yr)	500	820	1,100	1,270
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$4,605,890	$7,150,300	$10,176,780	$13,358,500
Road Relocations	$0	$0	$830,000	$1,660,000
Land Acquisition	$358,000	$642,000	$914,000	$1,730,700
Environmental Mitigation	$16,235	$29,647	$52,235	$84,000
Engineering, Legal, Financial, and Misc.	$996,025	$1,564,389	$2,394,603	$3,366,640
Total Capital Cost	$5,976,150	$9,386,336	$14,367,618	$20,199,840
Capital Cost / Unit Capacity	$1,992	$1,252	$958	$673
Annual Capital Cost	$536,061	$841,954	$1,288,775	$1,811,926
Operations and Maintenance	$18,424	$28,601	$40,707	$53,434
Water Rights Mitigation	$8,000	$13,120	$17,600	$20,320
Total Annual Cost	$562,484	$883,676	$1,347,082	$1,885,680
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$654	$650	$991	$1,387
Average Conditions	$221	$216	$250	$306

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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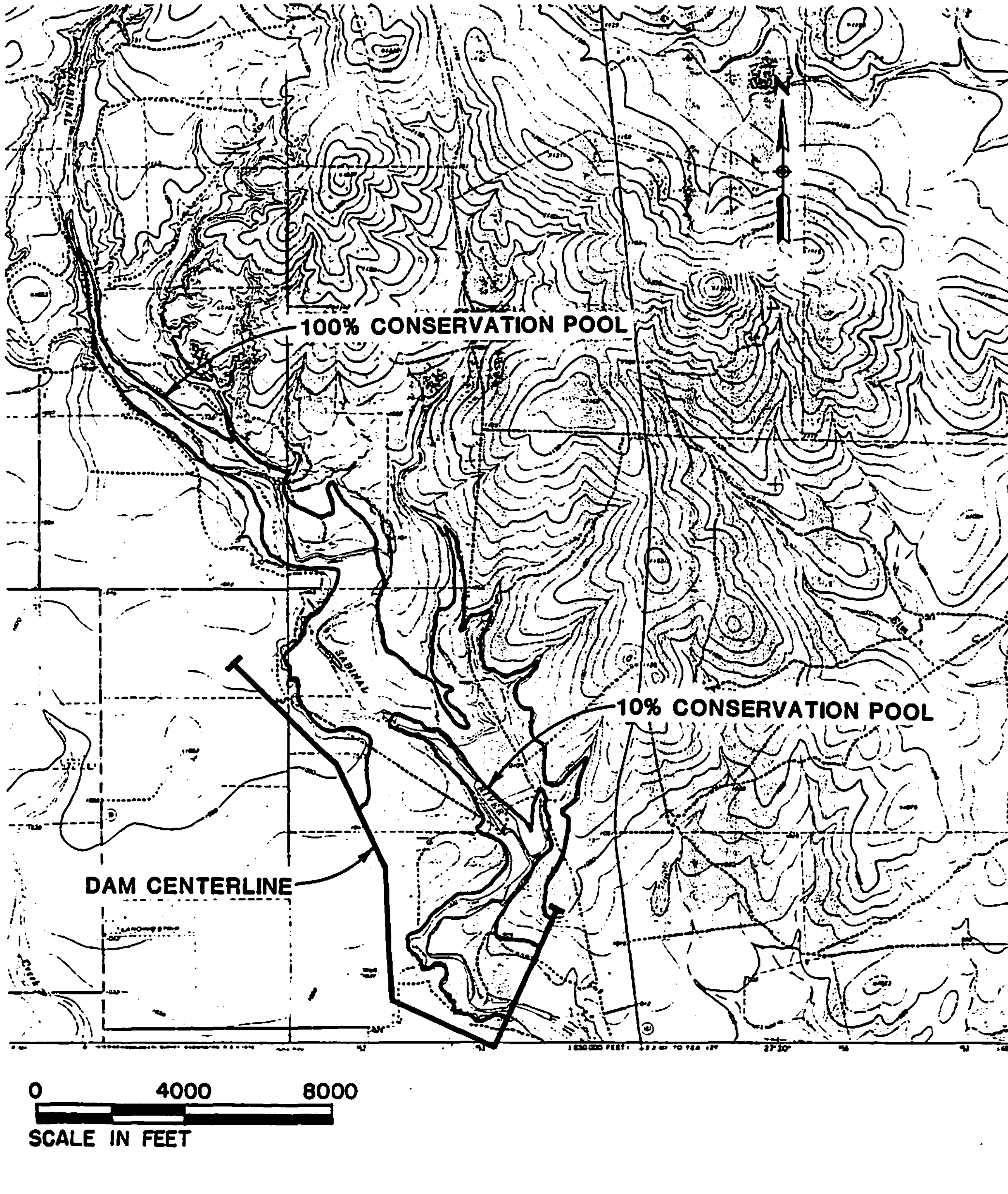
PLANNING STUDY PHASE III

LOWER DRY FRIO PROJECT
EVALUATION SUMMARY

FIGURE 3.2-6



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LOWER SABINAL PROJECT SITE MAP

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FIGURE 3.2-7

Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.2-4a and 3.2-4b and Figure 3.2-8 graphically summarizes project evaluation. As indicated in the tables and figures, optimal site development is at about 10% of the maximum conservation capacity at a minimum cost per unit recharge enhancement of $66 per ac-ft per year assuming purchase of water rights from the owners of the CC/LCC System. This is by far the lowest unit cost of recharge enhancement for any of the projects evaluated. Hence, it may be advantageous to construct the Lower Sabinal Project to a capacity in excess of the "optimum" because additional recharge enhancement may be obtained more economically at this site than by developing another project.

3.2.5 Lower Seco Project

The Lower Seco Project is located on Seco Creek approximately 10 miles north of D'Hanis in Medina County. It is a Type 2 recharge enhancement project with a maximum conservation capacity of 28,000 ac-ft and surface area of 1,630 acres. As indicated in Figure 3.2-9, development of this project would necessitate only relocation of some private roads. Environmental considerations associated with the development of this project are believed to be limited to basic environmental reports and investigations of cultural resources and values with the possible exception of a threatened / endangered species survey.

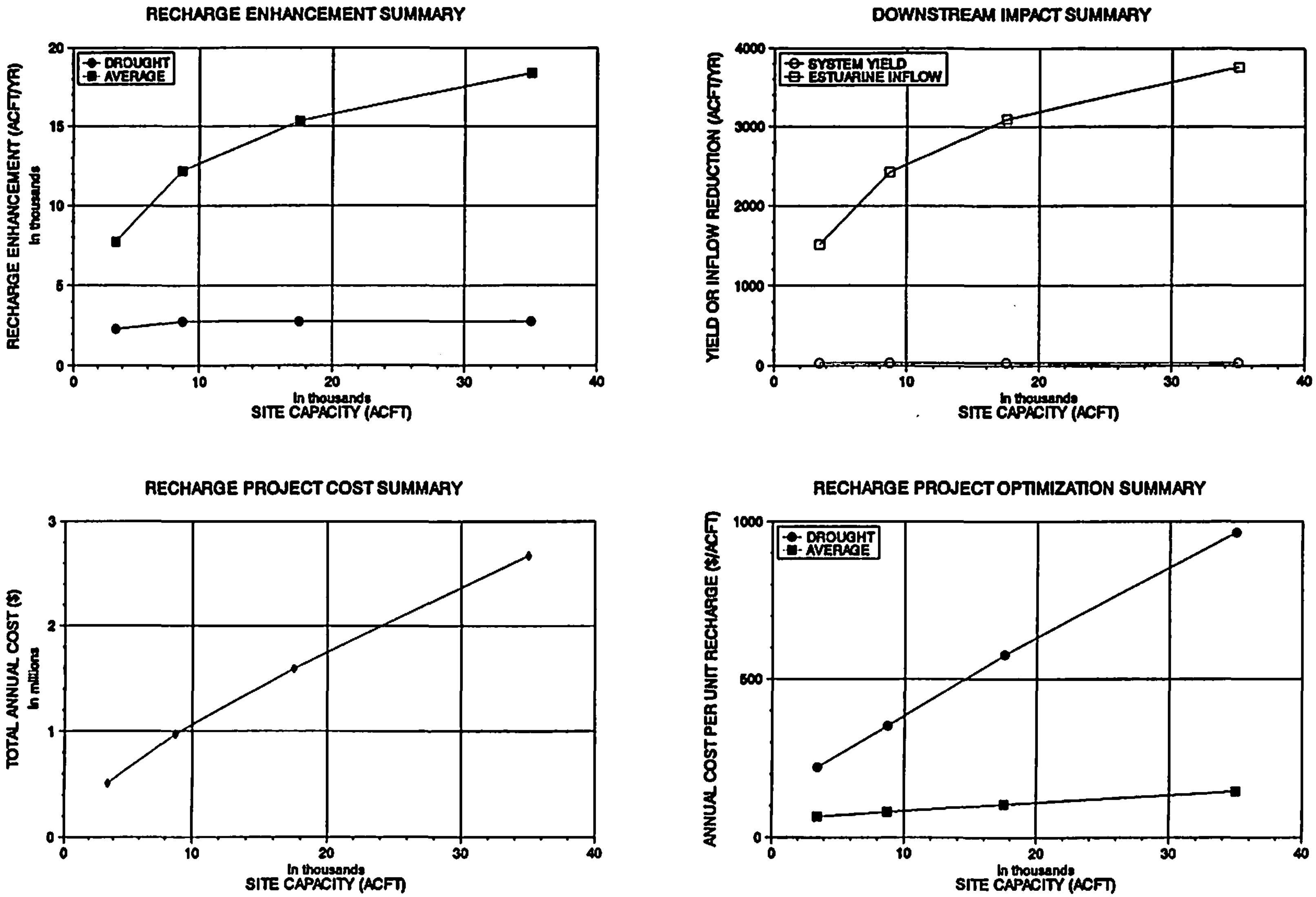
Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.2-5a and 3.2-5b and Figure 3.2-10 graphically summarizes project evaluation. The composite enbankment / roller compacted concrete dam type was selected for this site due to topographic constraints and the availability of construction materials. As indicated in the tables and figures, optimal site development is at about 10% of the

TABLE 3.2-4a
Lower Sabinal Project Cost and Data Summary

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	1005.1	1018.1	1030.1	1044.7
Surface Area (ac)	280	550	960	1,430
Capacity (acft)	3,500	8,750	17,500	35,000
25-Year Flood Pool:				
Elevation (ft-msl)	1011.0	1023.9	1035.9	1050.5
Surface Area (ac)	380	740	1,140	1,710
100-Year Flood Pool:				
Elevation (ft-msl)	1012.1	1025.1	1037.1	1051.5
Surface Area (ac)	410	780	1,180	1,750
Top of Dam Elevation (ft-msl)	1023.8	1036.8	1048.8	1063.4
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	8	10	10	10
Average Conditions	2,290	4,200	5,860	7,480
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	500	930	1,290	1,650
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$3,922,400	$7,621,000	$12,701,820	$21,739,840
Road Relocations	$0	$13,333	$26,667	$40,000
Land Acquisition	$319,000	$612,000	$982,000	$1,488,000
Environmental Mitigation	$20,716	$40,692	$71,027	$105,800
Engineering, Legal, Financial, and Misc.	$852,423	$1,657,405	$2,756,303	$4,674,728
Total Capital Cost	$5,114,539	$9,944,431	$16,537,816	$28,048,368
Capital Cost / Unit Capacity	$1,461	$1,137	$945	$801
Annual Capital Cost	$458,774	$892,015	$1,483,442	$2,515,939
Operations and Maintenance	$15,690	$30,484	$50,807	$86,959
Water Rights Mitigation	$8,000	$14,880	$20,640	$26,400
Total Annual Cost	$482,464	$937,379	$1,554,889	$2,629,298
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$60,308	$93,738	$155,489	$262,930
Average Conditions	$211	$223	$265	$352

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.2-4b Lower Sabinal Project Cost and Data Summary With Purchase of Water Rights				
	Percentage of Maximum Project Conservation Capacity			
Physical Data	**10%**	**25%**	**50%**	**100%**
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	1005.1	1018.1	1030.1	1044.7
Surface Area (ac)	280	550	960	1,430
Capacity (acft)	3,500	8,750	17,500	35,000
25-Year Flood Pool:				
Elevation (ft-msl)	1011.0	1023.9	1035.9	1050.5
Surface Area (ac)	380	740	1,140	1,710
100-Year Flood Pool:				
Elevation (ft-msl)	1012.1	1025.1	1037.1	1051.5
Surface Area (ac)	410	780	1,180	1,750
Top of Dam Elevation (ft-msl)	1023.8	1036.8	1048.8	1063.4
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	2,300	2,770	2,770	2,770
Average Conditions	7,720	12,190	15,350	18,400
CC/LCC System Yield Reduction (acft/yr)	30	30	30	30
Median CC/LCC System Storage Reduction (%)	0.4	0.6	0.7	0.7
Estuarine Inflow Reduction (acft/yr)	1,510	2,430	3,090	3,760
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$3,922,400	$7,621,000	$12,701,820	$21,739,840
Road Relocations	$0	$13,333	$26,667	$40,000
Land Acquisition	$319,000	$612,000	$982,000	$1,488,000
Environmental Mitigation	$20,716	$40,692	$71,027	$105,800
Engineering, Legal, Financial, and Misc.	$852,423	$1,657,405	$2,756,303	$4,674,728
Total Capital Cost	$5,114,539	$9,944,431	$16,537,816	$28,048,368
Capital Cost / Unit Capacity	$1,461	$1,137	$945	$801
Annual Capital Cost	$458,774	$892,015	$1,483,442	$2,515,939
Operations and Maintenance	$15,690	$30,484	$50,807	$86,959
Water Rights Mitigation	$33,790	$48,510	$59,070	$69,790
Total Annual Cost	$508,254	$971,009	$1,593,319	$2,672,688
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$221	$351	$575	$965
Average Conditions	$66	$80	$104	$145
Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.				



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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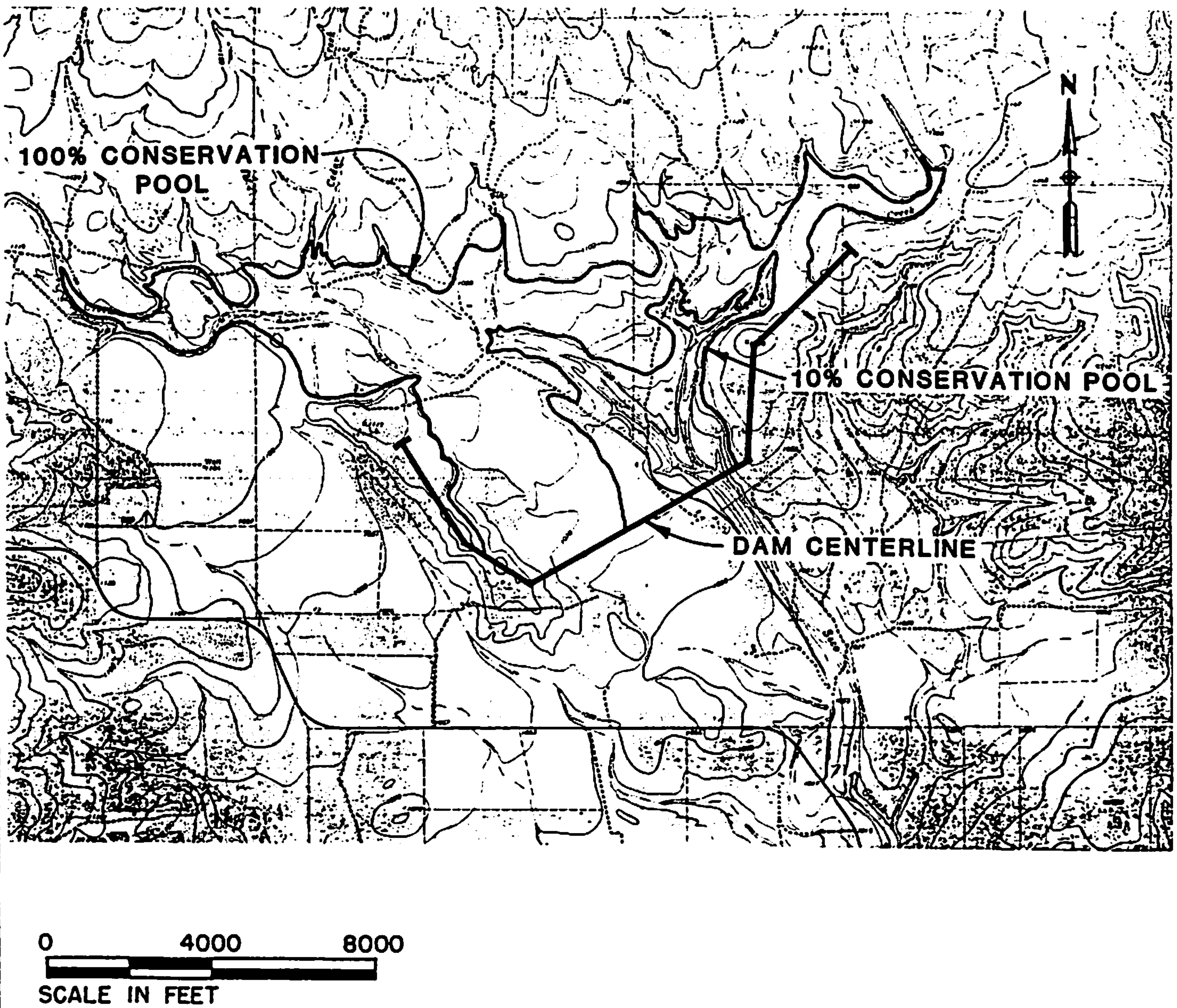
LOWER SABINAL PROJECT EVALUATION SUMMARY

FIGURE 3.2-8



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PLANNING STUDY PHASE III

LOWER SECO PROJECT
SITE MAP

FIGURE 3.2-9

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TABLE 3.2-5a
Lower Seco Project Cost and Data Summary

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	1060.2	1070.3	1078.8	1089.7
Surface Area (ac)	220	620	990	1,630
Capacity (acft)	2,800	7,000	14,000	28,000
25-Year Flood Pool:				
Elevation (ft-msl)	1066.1	1076.0	1084.3	1094.9
Surface Area (ac)	480	870	1,300	1,890
100-Year Flood Pool:				
Elevation (ft-msl)	1067.2	1077.1	1085.5	1096.1
Surface Area (ac)	500	920	1,370	1,950
Top of Dam Elevation (ft-msl)	1077.9	1088.0	1096.5	1107.4
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	0	0	0	0
Average Conditions	1,050	1,540	2,240	2,830
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	230	340	490	620
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$4,857,210	$8,038,650	$11,569,120	$17,665,930
Road Relocations	$0	$58,333	$116,667	$175,000
Land Acquisition	$444,000	$771,000	$1,325,000	$1,792,000
Environmental Mitigation	$14,307	$40,319	$64,380	$106,000
Engineering, Legal, Financial, and Misc.	$1,063,103	$1,781,660	$2,615,033	$3,947,786
Total Capital Cost	$6,378,620	$10,689,963	$15,690,200	$23,686,716
Capital Cost / Unit Capacity	$2,278	$1,527	$1,121	$846
Annual Capital Cost	$572,162	$958,890	$1,407,411	$2,124,698
Operations and Maintenance	$19,429	$32,155	$46,276	$70,664
Water Rights Mitigation	$3,680	$5,440	$7,840	$9,920
Total Annual Cost	$595,271	$996,484	$1,461,527	$2,205,282
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	n/a	n/a	n/a	n/a
Average Conditions	$567	$647	$652	$779

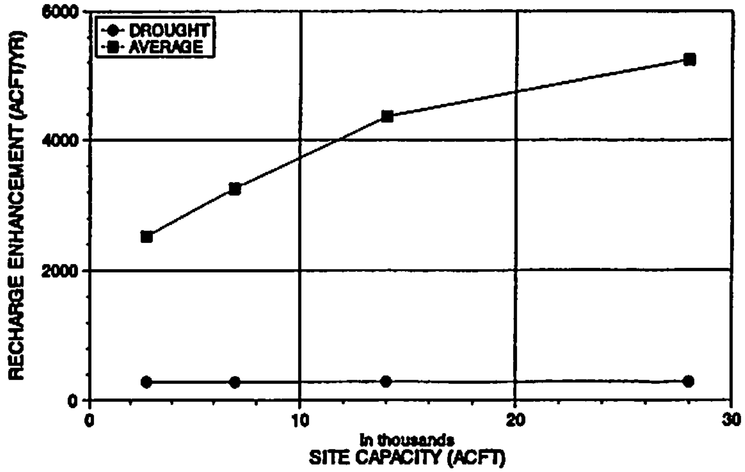
Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.2-5b
Lower Seco Project Cost and Data Summary With Purchase of Water Rights

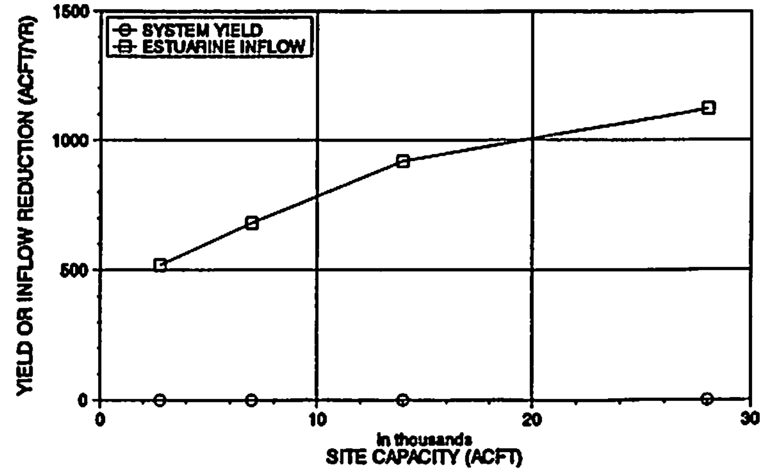
Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	1060.2	1070.3	1078.8	1089.7
Surface Area (ac)	220	620	990	1,630
Capacity (acft)	2,800	7,000	14,000	28,000
25-Year Flood Pool:				
Elevation (ft-msl)	1066.1	1076.0	1084.3	1094.9
Surface Area (ac)	480	870	1,300	1,890
100-Year Flood Pool:				
Elevation (ft-msl)	1067.2	1077.1	1085.5	1096.1
Surface Area (ac)	500	920	1,370	1,950
Top of Dam Elevation (ft-msl)	1077.9	1088.0	1096.5	1107.4
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	290	290	290	290
Average Conditions	2,520	3,260	4,360	5,240
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.1	0.1	0.1	0.1
Estuarine Inflow Reduction (acft/yr)	520	680	920	1,120
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$4,857,210	$8,038,650	$11,569,120	$17,665,930
Road Relocations	$0	$58,333	$116,667	$175,000
Land Acquisition	$444,000	$771,000	$1,325,000	$1,792,000
Environmental Mitigation	$14,307	$40,319	$64,380	$106,000
Engineering, Legal, Financial, and Misc.	$1,063,103	$1,781,660	$2,615,033	$3,947,786
Total Capital Cost	$6,378,620	$10,689,963	$15,690,200	$23,686,716
Capital Cost / Unit Capacity	$2,278	$1,527	$1,121	$846
Annual Capital Cost	$572,162	$958,890	$1,407,411	$2,124,698
Operations and Maintenance	$19,429	$32,155	$46,276	$70,664
Water Rights Mitigation	$8,320	$10,880	$14,720	$17,920
Total Annual Cost	$599,911	$1,001,924	$1,468,407	$2,213,282
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$2,069	$3,455	$5,063	$7,632
Average Conditions	$238	$307	$337	$422

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

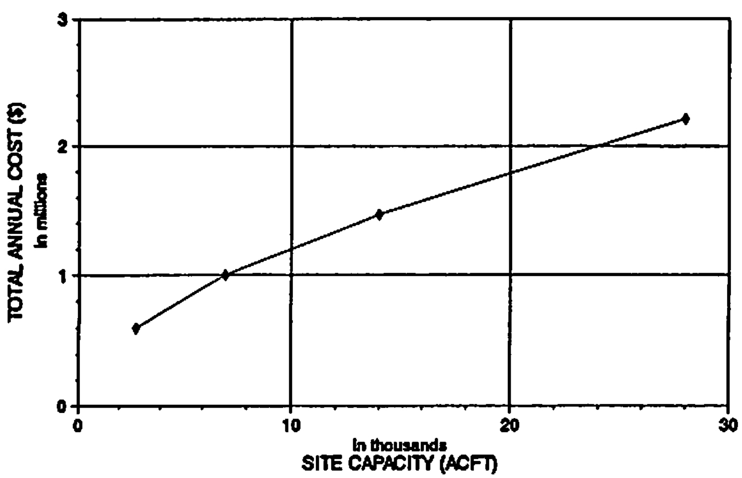
RECHARGE ENHANCEMENT SUMMARY



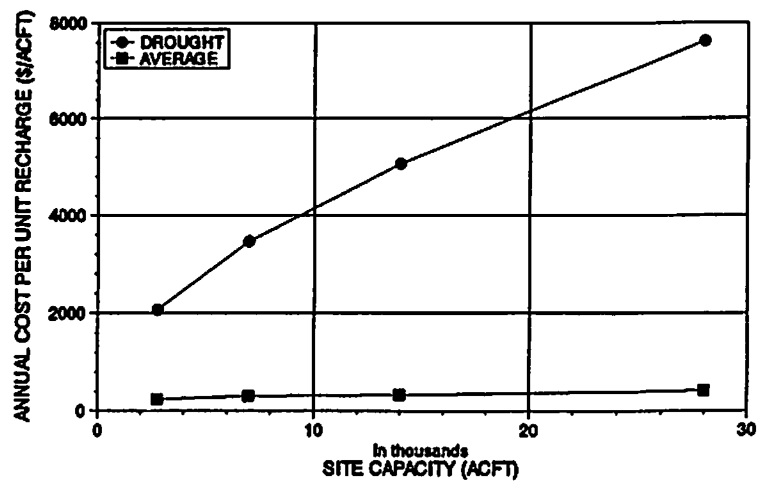
DOWNSTREAM IMPACT SUMMARY



RECHARGE PROJECT COST SUMMARY



RECHARGE PROJECT OPTIMIZATION SUMMARY



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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PLANNING STUDY PHASE III

LOWER SECO PROJECT
EVALUATION SUMMARY

FIGURE 3.2-10

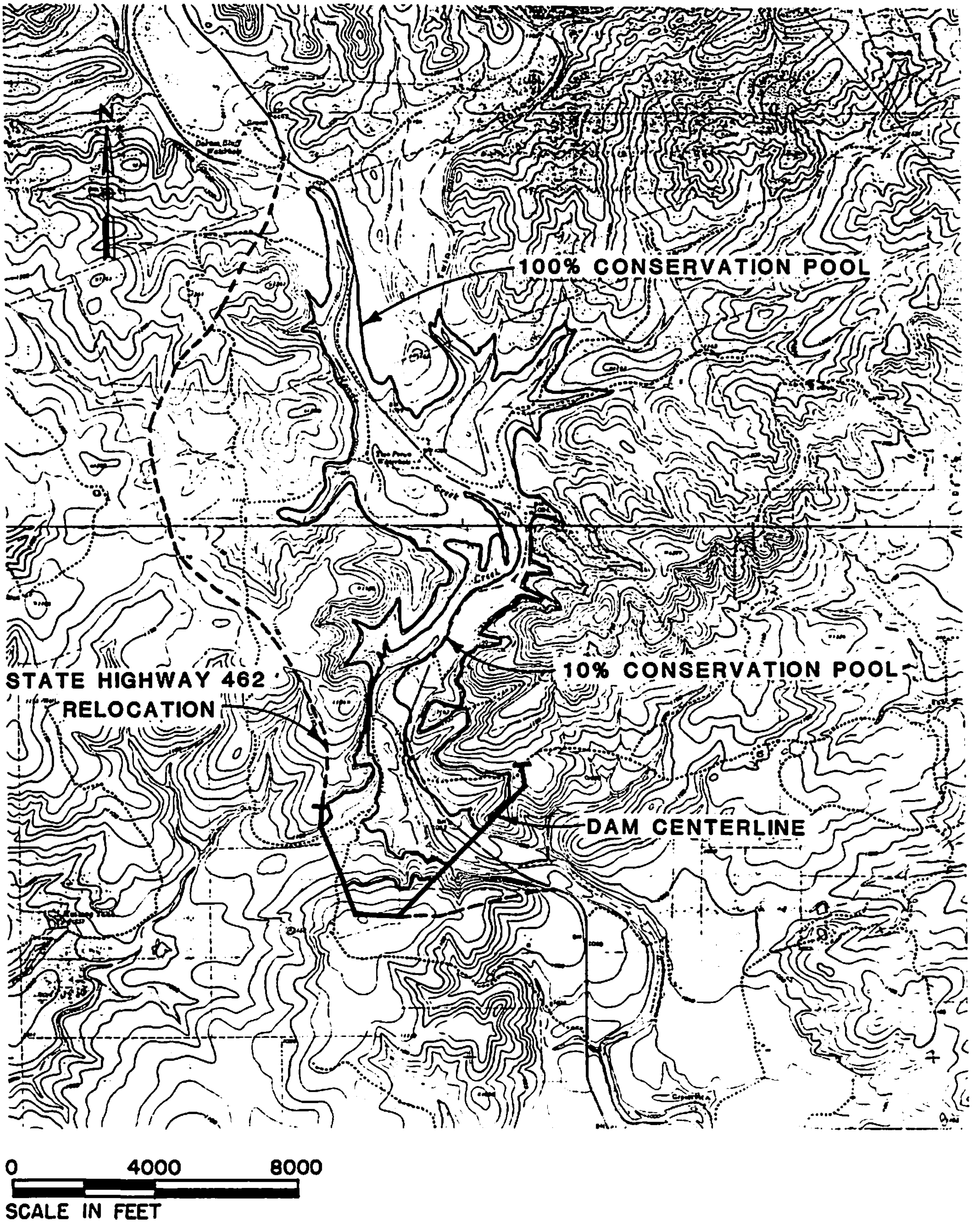
maximum conservation capacity at a minimum cost per unit recharge enhancement of $238 per ac-ft per year assuming purchase of water rights from the owners of the CC/LCC System making the Lower Seco Project the least economical of all Type 2 Mainstem projects evaluated.

3.2.6 Lower Hondo Project

The Lower Hondo Project is located on Hondo Creek approximately 10 miles north by northwest of Hondo in Medina County. It is a Type 2 recharge enhancement project with a maximum conservation capacity of 28,000 ac-ft and surface area of 1,260 acres. As indicated in Figure 3.2-11, development of this project would necessitate relocation of State Highway 462. Environmental considerations associated with the development of this project are believed to be limited to basic environmental reports and investigations of cultural resources and values.

Both the embankment dam and the composite embankment / roller compacted concrete dam types were evaluated for this site with the composite dam proving more economical at all capacities. Field reconnaissance indicated the presence of sufficient construction materials including abundant sands and gravels for either dam type.

Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.2-6a and 3.2-6b and Figure 3.2-12 graphically summarizes project evaluation. As indicated in the tables and figures, optimal site development is at about 10% of the maximum conservation capacity at a minimum cost per unit recharge enhancement of $150 per ac-ft per year assuming purchase of water rights from the owners of the CC/LCC System.



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PLANNING STUDY PHASE III

LOWER HONDO PROJECT
SITE MAP

FIGURE 3.2-11

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TABLE 3.2-6a
Lower Hondo Project Cost and Data Summary

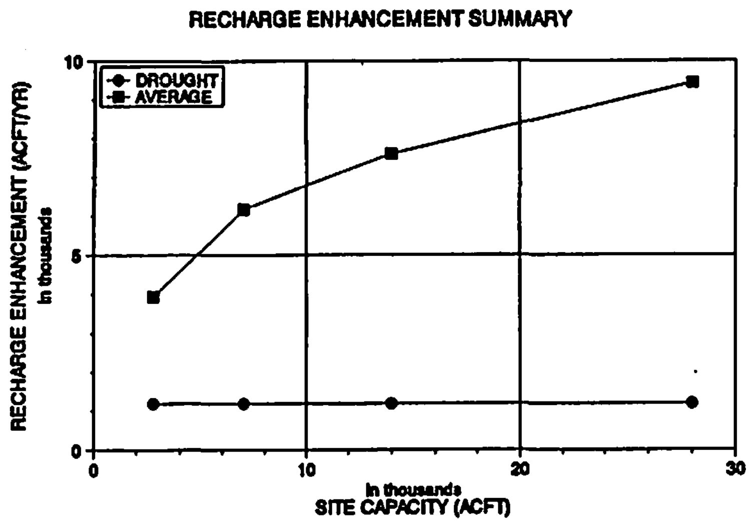
Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	1064.4	1077.6	1087.6	1102.4
Surface Area (ac)	230	490	770	1,260
Capacity (acft)	2,800	7,000	14,000	28,000
25-Year Flood Pool:				
Elevation (ft-msl)	1071.1	1084.1	1094.0	1108.0
Surface Area (ac)	360	660	960	1,550
100-Year Flood Pool:				
Elevation (ft-msl)	1072.4	1085.4	1095.3	1109.5
Surface Area (ac)	390	700	1,000	1,620
Top of Dam Elevation (ft-msl)	1085.8	1099.0	1109.0	1123.8
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	3	3	3	3
Average Conditions	1,280	2,290	3,220	4,230
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	280	510	710	930
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$3,600,630	$6,201,580	$8,733,540	$13,767,960
Road Relocations	$1,187,500	$2,810,667	$4,433,833	$6,057,000
Land Acquisition	$403,000	$748,000	$1,038,000	$1,625,000
Environmental Mitigation	$15,406	$32,822	$51,578	$84,400
Engineering, Legal, Financial, and Misc.	$1,041,307	$1,958,614	$2,851,390	$4,306,872
Total Capital Cost	$6,247,844	$11,751,683	$17,108,341	$25,841,232
Capital Cost / Unit Capacity	$2,231	$1,679	$1,222	$923
Annual Capital Cost	$560,432	$1,054,126	$1,534,618	$2,317,959
Operations and Maintenance	$14,403	$24,806	$34,934	$55,072
Water Rights Mitigation	$4,480	$8,160	$11,360	$14,880
Total Annual Cost	$579,314	$1,087,092	$1,580,912	$2,387,910
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$193,105	$362,364	$526,971	$795,970
Average Conditions	$453	$475	$491	$565

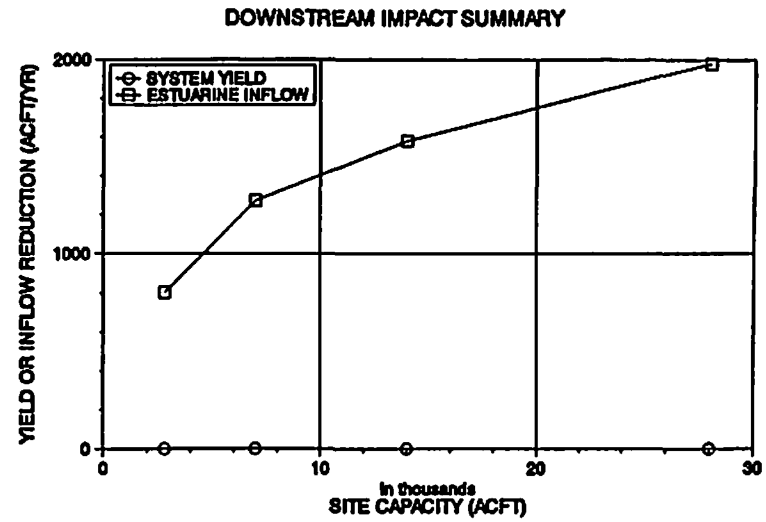
Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

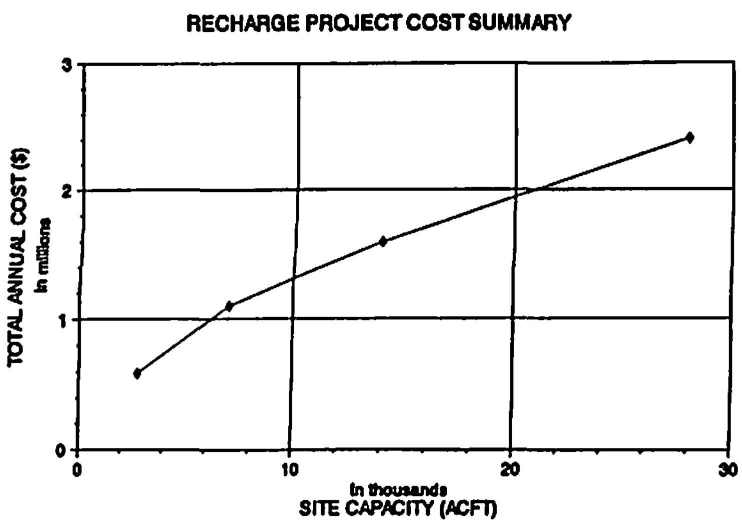
TABLE 3.2-6b
Lower Hondo Project Cost and Data Summary With Purchase of Water Rights

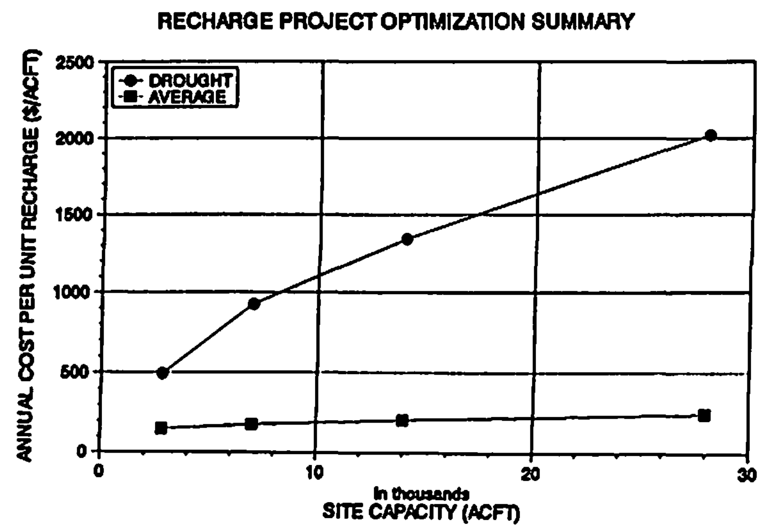
Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	RCC Composite
Conservation Pool:				
Elevation (ft-msl)	1064.4	1077.6	1087.6	1102.4
Surface Area (ac)	230	490	770	1,260
Capacity (acft)	2,800	7,000	14,000	28,000
25-Year Flood Pool:				
Elevation (ft-msl)	1071.1	1084.1	1094.0	1108.0
Surface Area (ac)	360	660	960	1,550
100-Year Flood Pool:				
Elevation (ft-msl)	1072.4	1085.4	1095.3	1109.5
Surface Area (ac)	390	700	1,000	1,620
Top of Dam Elevation (ft-msl)	1085.8	1099.0	1109.0	1123.8
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	1,190	1,190	1,190	1,190
Average Conditions	3,930	6,170	7,601	9,420
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.1	0.1	0.2	0.2
Estuarine Inflow Reduction (acft/yr)	800	1,270	1,580	1,980
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$3,600,630	$6,201,580	$8,733,540	$13,767,960
Road Relocations	$1,187,500	$2,810,667	$4,433,833	$6,057,000
Land Acquisition	$403,000	$748,000	$1,038,000	$1,625,000
Environmental Mitigation	$15,406	$32,822	$51,578	$84,400
Engineering, Legal, Financial, and Misc.	$1,041,307	$1,958,614	$2,851,390	$4,306,872
Total Capital Cost	$6,247,844	$11,751,683	$17,108,341	$25,841,232
Capital Cost / Unit Capacity	$2,231	$1,679	$1,222	$923
Annual Capital Cost	$560,432	$1,054,126	$1,534,618	$2,317,959
Operations and Maintenance	$14,403	$24,806	$34,934	$55,072
Water Rights Mitigation	$12,800	$20,320	$25,280	$31,680
Total Annual Cost	$587,634	$1,099,252	$1,594,832	$2,404,710
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$494	$924	$1,340	$2,021
Average Conditions	$150	$178	$210	$255

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.









NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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**LOWER HONDO PROJECT
EVALUATION SUMMARY**

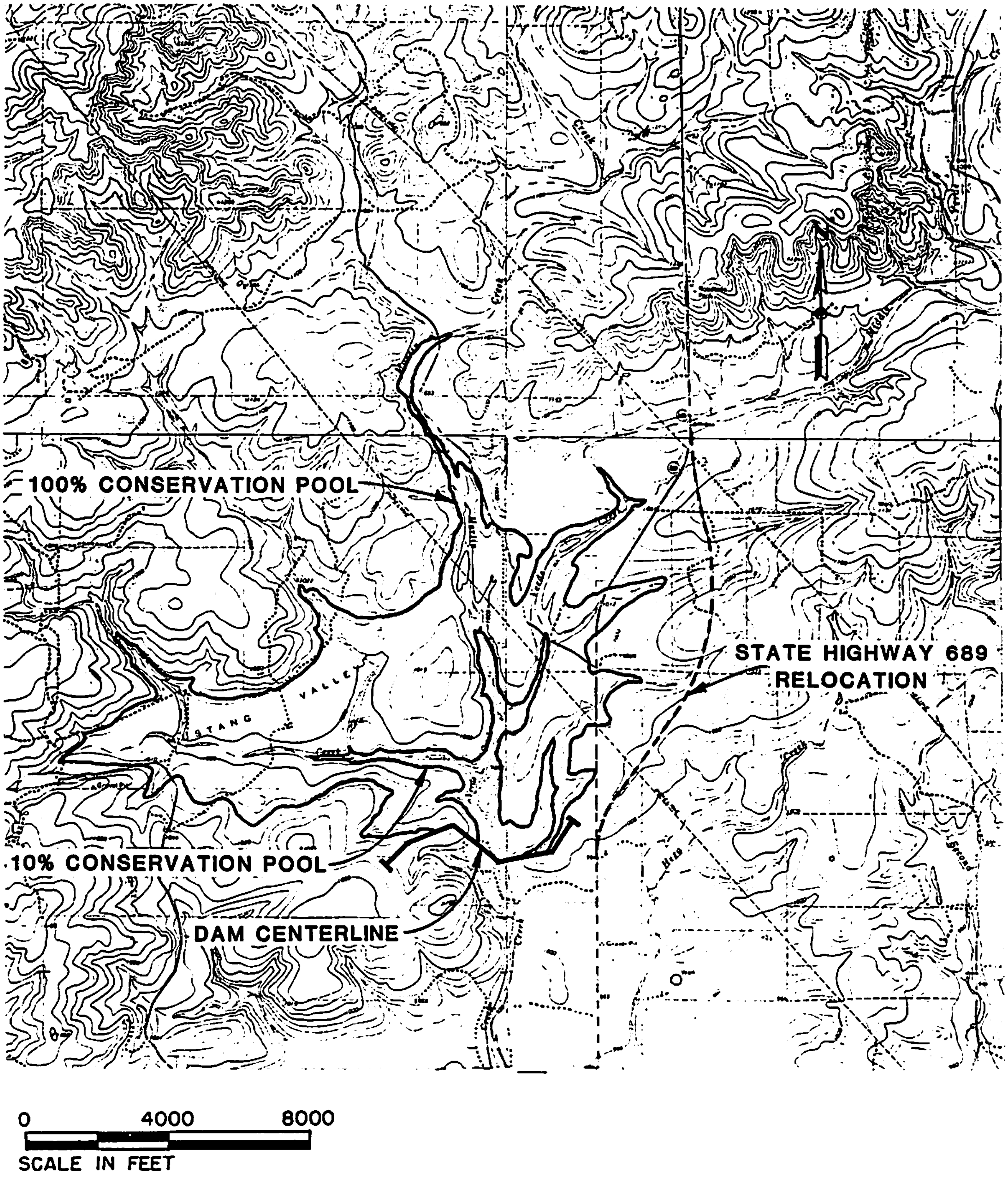
FIGURE 3.2-12

3.2.7 Lower Verde Project

The Lower Verde Project is located on Verde Creek approximately 9 miles north of Hondo in Medina County. It is a Type 2 recharge enhancement project with a maximum conservation capacity of 24,000 ac-ft and surface area of 1,730 acres. As indicated in Figure 3.2-13, development of this project at maximum capacity would necessitate relocation of about 2 miles of State Highway 689. Environmental considerations associated with the development of this project are believed to be limited to basic environmental reports and investigations of cultural resources and values.

Both the embankment dam and the composite embankment / roller compacted concrete dam types were evaluated for this site with the composite dam proving more economical at the 10%, 25%, and 50% capacities and the embankment dam being more economical at the 100% capacity. Field reconnaissance indicated a highly fractured limestone creek bed with visible evidence of faulting as well as the presence of sufficient construction materials for either dam type.

Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.2-7a and 3.2-7b and Figure 3.2-14 graphically summarizes project evaluation. As indicated in the tables and figures, optimal site development is at about 10% of the maximum conservation capacity at a minimum cost per unit recharge enhancement of $134 per ac-ft per year assuming purchase of water rights from the owners of the CC/LCC System. This is a relatively low unit cost of recharge enhancement compared to many of the projects evaluated. Hence, it may be advantageous to construct the Lower Verde Project to a capacity in excess of the "optimum" because additional recharge



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LOWER VERDE PROJECT
SITE MAP

FIGURE 3.2-13

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TABLE 3.2-7a
Lower Verde Project Cost and Data Summary

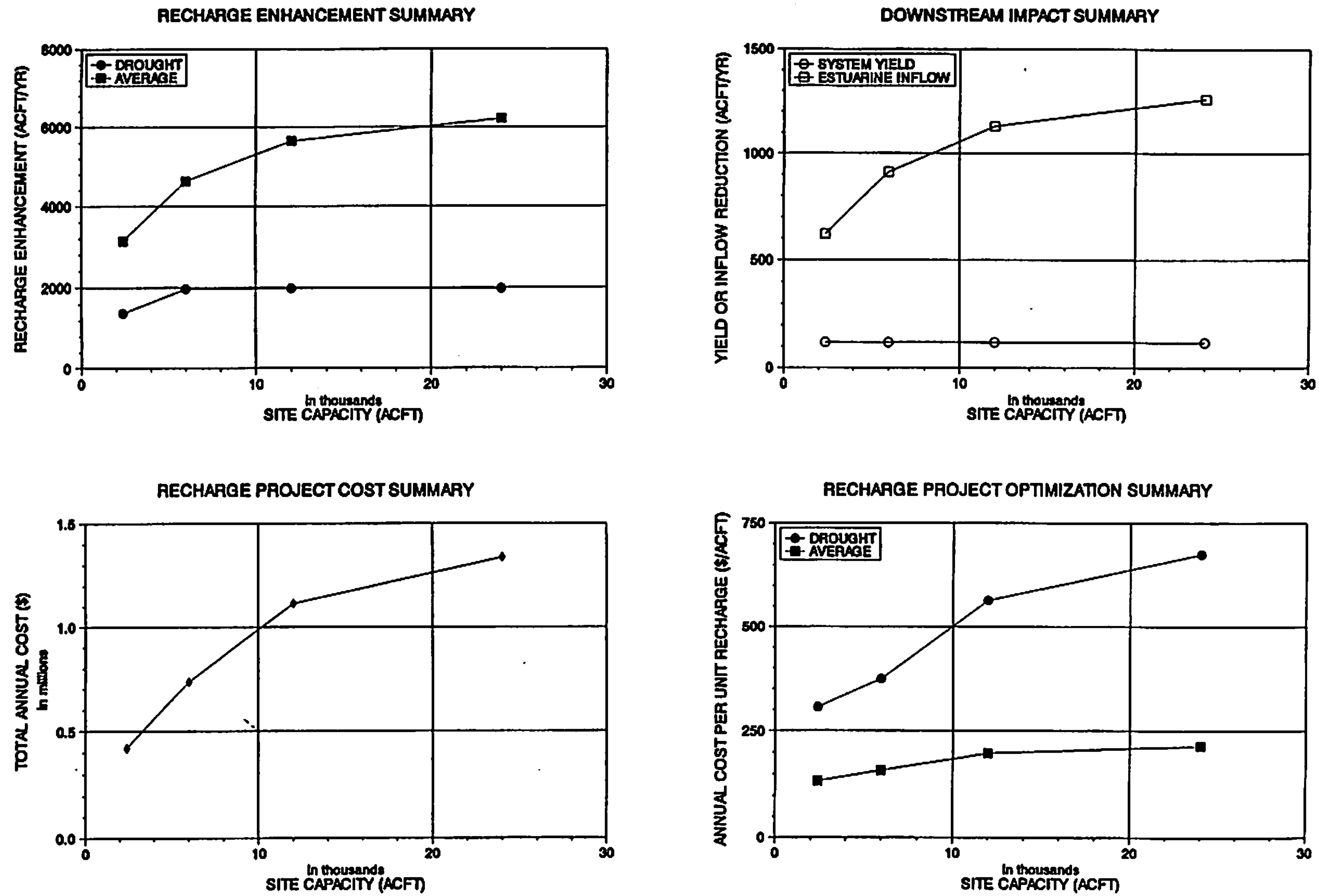
Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	Embankment
Conservation Pool:				
Elevation (ft-msl)	985.6	995.6	1003.7	1012.8
Surface Area (ac)	230	500	980	1,730
Capacity (acft)	2,400	6,000	12,000	24,000
25-Year Flood Pool:				
Elevation (ft-msl)	992.6	1002.3	1010.1	1024.2
Surface Area (ac)	400	860	1,550	2,480
100-Year Flood Pool:				
Elevation (ft-msl)	993.9	1003.6	1011.2	1025.9
Surface Area (ac)	450	980	1,620	2,590
Top of Dam Elevation (ft-msl)	1006.2	1016.2	1024.3	1038.0
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	0	0	0	0
Average Conditions	920	1,660	2,290	2,800
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	210	370	510	620
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$2,857,990	$4,397,120	$6,038,490	$6,210,490
Road Relocations	$0	$846,667	$1,693,333	$2,540,000
Land Acquisition	$495,000	$898,000	$1,825,000	$2,788,800
Environmental Mitigation	$14,810	$32,197	$63,105	$111,400
Engineering, Legal, Financial, and Misc.	$673,560	$1,234,797	$1,923,986	$2,330,138
Total Capital Cost	$4,041,360	$7,408,780	$11,543,914	$13,980,828
Capital Cost / Unit Capacity	$1,684	$1,235	$962	$583
Annual Capital Cost	$362,510	$664,568	$1,035,489	$1,254,080
Operations and Maintenance	$11,432	$17,588	$24,154	$24,842
Water Rights Mitigation	$3,360	$5,920	$8,160	$9,920
Total Annual Cost	$377,302	$688,076	$1,067,803	$1,288,842
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	n/a	n/a	n/a	n/a
Average Conditions	$410	$415	$466	$460

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.2-7b
Lower Verde Project Cost and Data Summary With Purchase of Water Rights

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	RCC Composite	RCC Composite	RCC Composite	Embankment
Conservation Pool:				
Elevation (ft-msl)	985.6	995.6	1003.7	1012.8
Surface Area (ac)	230	500	980	1,730
Capacity (acft)	2,400	6,000	12,000	24,000
25-Year Flood Pool:				
Elevation (ft-msl)	992.6	1002.3	1010.1	1024.2
Surface Area (ac)	400	860	1,550	2,480
100-Year Flood Pool:				
Elevation (ft-msl)	993.9	1003.6	1011.2	1025.9
Surface Area (ac)	450	980	1,620	2,590
Top of Dam Elevation (ft-msl)	1006.2	1016.2	1024.3	1038.0
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	1,380	1,970	1,980	1,980
Average Conditions	3,150	4,630	5,640	6,220
CC/LCC System Yield Reduction (acft/yr)	120	120	120	120
Median CC/LCC System Storage Reduction (%)	0.1	0.1	0.2	0.2
Estuarine Inflow Reduction (acft/yr)	620	910	1,130	1,260
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$2,857,990	$4,397,120	$6,038,490	$6,210,490
Road Relocations	$0	$846,667	$1,693,333	$2,540,000
Land Acquisition	$495,000	$898,000	$1,825,000	$2,788,800
Environmental Mitigation	$14,810	$32,197	$63,105	$111,400
Engineering, Legal, Financial, and Misc.	$673,560	$1,234,797	$1,923,986	$2,330,138
Total Capital Cost	$4,041,360	$7,408,780	$11,543,914	$13,980,828
Capital Cost / Unit Capacity	$1,684	$1,235	$962	$583
Annual Capital Cost	$362,510	$664,568	$1,035,489	$1,254,080
Operations and Maintenance	$11,432	$17,588	$24,154	$24,842
Water Rights Mitigation	$48,440	$53,080	$56,600	$58,680
Total Annual Cost	$422,382	$735,236	$1,116,243	$1,337,602
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$306	$373	$564	$676
Average Conditions	$134	$159	$198	$215

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.



NOTE: FIGURES ASSUME PURCHASE OF WATER RIGHTS.

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LOWER VERDE PROJECT EVALUATION SUMMARY

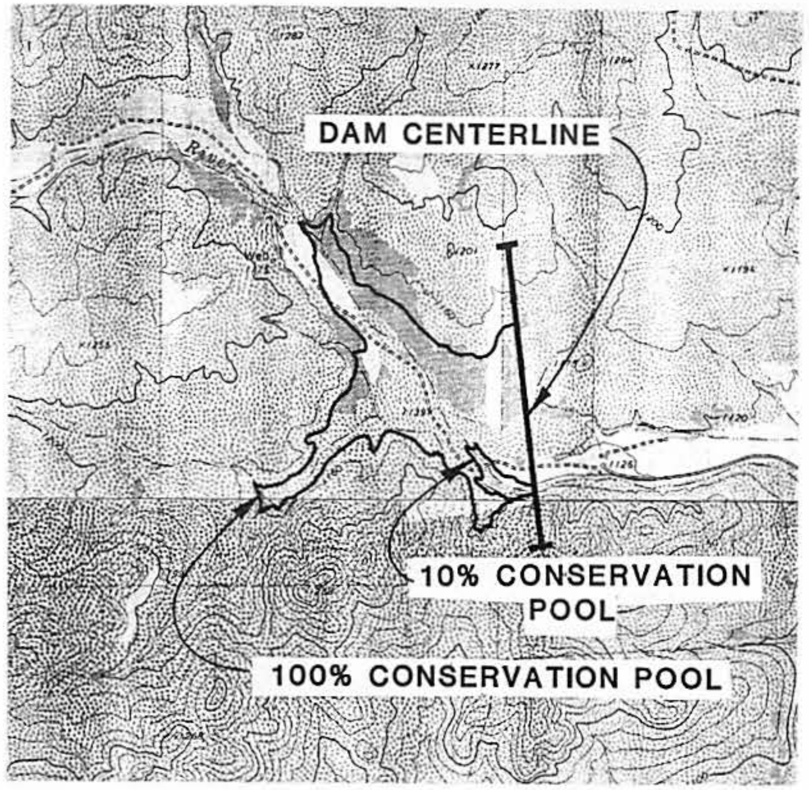
FIGURE 3.2-14

enhancement may be obtained more economically at this site than by developing another project.

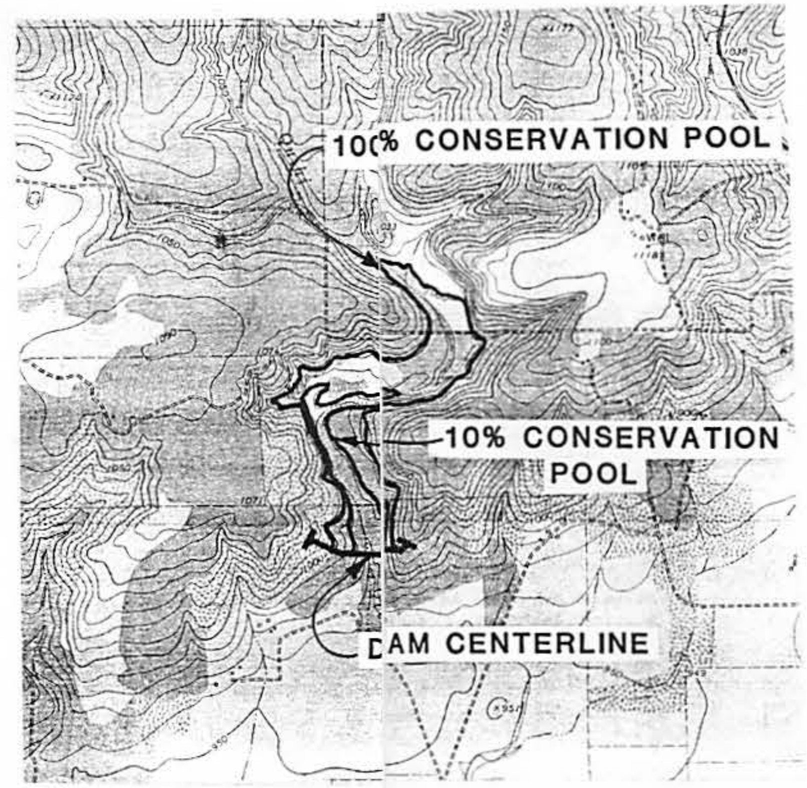
3.3 Type 2 Tributary Recharge Enhancement Projects

A total of five Type 2 tributary recharge enhancement projects including the Leona River, Blanco, Little Blanco, Elm Creek, and Quihi Creek Projects were evaluated in the performance of this study. The general locations of these sites are shown in Figure 2.1-2 while site maps are presented in Figure 3.3-1. Maxium conservation capacities (and surface areas) for these projects ranged from 1,570 ac-ft (120 acres) at Quihi Creek to 6,940 ac-ft (370 acres) at Elm Creek. As indicated in Figure 3.3-1, none of these projects would necessitate highway relocations, however, some private road relocations would be required at the Leona River and Little Blanco sites. Environmental considerations associated with the development of these projects are believed to be limited to basic environmental reports and investigations of cultural resources and values except at the Blanco, Little Blanco, and Elm Creek sites where threatened/endangered species surveys may be required.

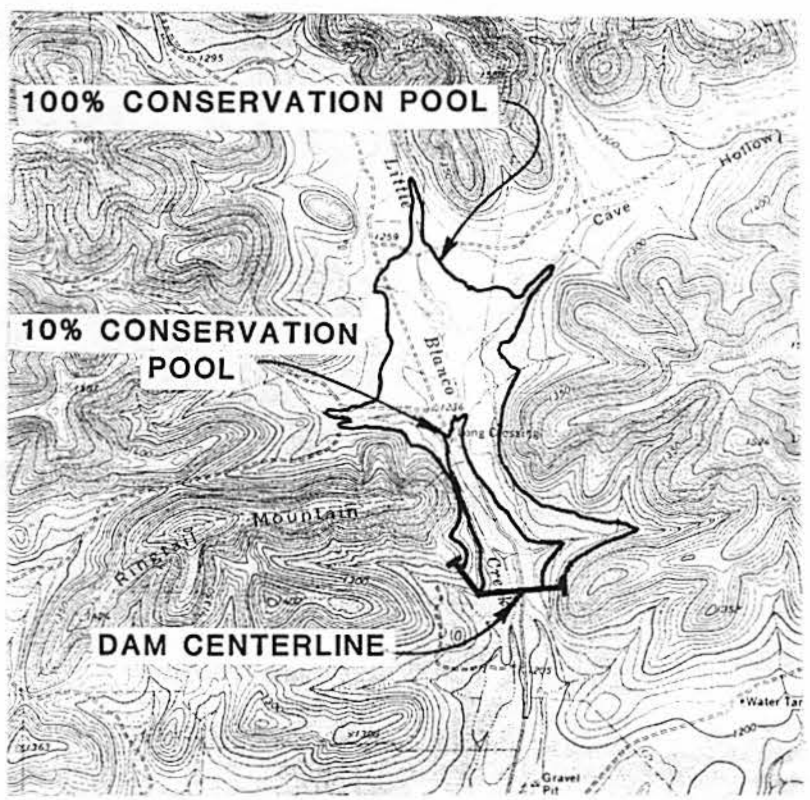
Project cost and data summaries subject to the two water rights scenarios are included as Tables 3.3-1a and 3.3-1b through Tables 3.3-5a and 3.3-5b. Embankment dams were assumed to be the most economical for all Type 2 tributary sites at all percentages of maximum conservation capacity and estimated construction costs were comparable with those for the existing Parker Creek dam (after adjustment for inflation). As indicated in the tables, optimal development of each site under average climatic conditions is at the maximum conservation capacity assuming purchase of water rights from the owners of the CC/LCC System. The minimum cost per unit recharge enhancement amongst these



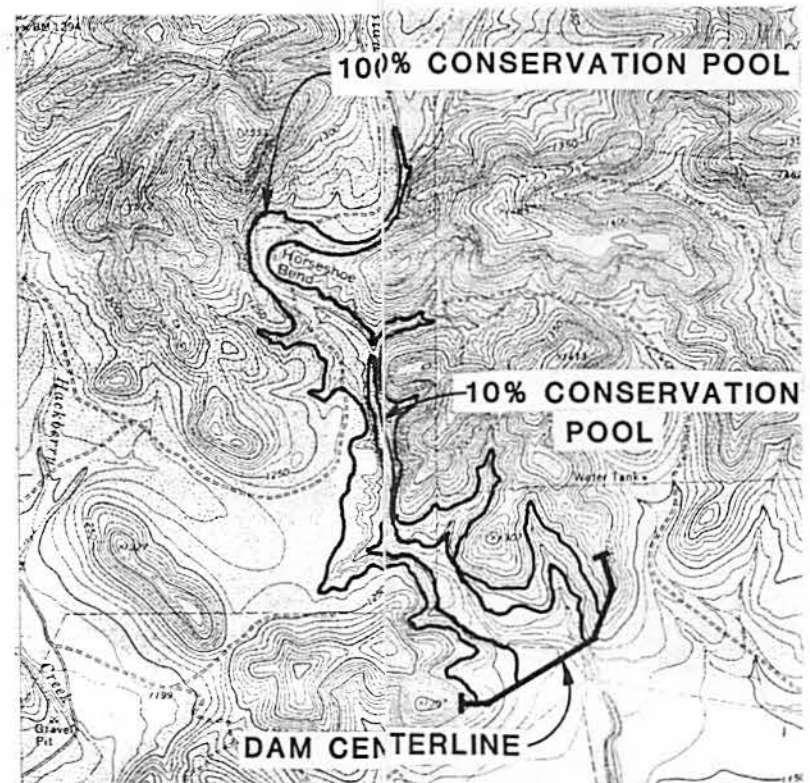
LEONA RIVER PROJECT



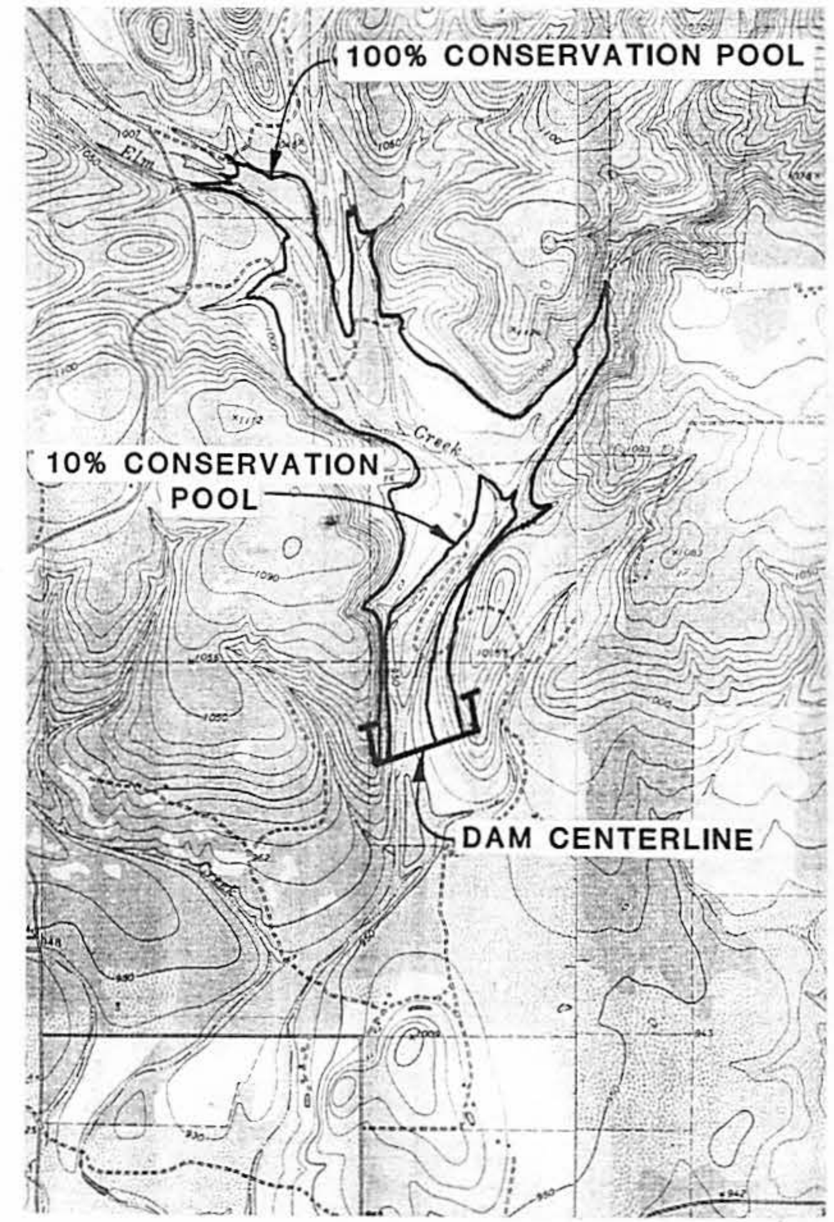
QUIHI CREEK PROJECT



LITTLE BLANCO PROJECT



BLANCO PROJECT



ELM CREEK PROJECT

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TYPE 2 TRIBUTARY PROJECTS
SITE MAPS

FIGURE 3.3-1

TABLE 3.3-1a
Leona River Project Cost and Data Summary

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	Embankment	Embankment	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	1132.2	1139.0	1145.3	1153.3
Surface Area (ac)	50	90	140	220
Capacity (acft)	293	733	1,465	2,930
25-Year Flood Pool:				
Elevation (ft-msl)	1152.0	1152.0	1152.0	1152.0
Surface Area (ac)	190	190	190	190
100-Year Flood Pool:				
Elevation (ft-msl)	1153.0	1153.0	1153.0	1153.0
Surface Area (ac)	200	200	200	200
Top of Dam Elevation (ft-msl)	1161.6	1161.6	1161.6	1161.6
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	0	0	0	0
Average Conditions	10	30	50	80
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	0	10	10	20
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$1,985,990	$1,985,990	$1,985,990	$1,985,990
Road Relocations	$105,000	$105,000	$105,000	$105,000
Land Acquisition	$157,400	$157,400	$157,400	$157,400
Environmental Mitigation	$8,977	$16,159	$25,136	$39,500
Engineering, Legal, Financial, and Misc.	$451,473	$452,910	$454,705	$457,578
Total Capital Cost	$2,708,841	$2,717,459	$2,728,232	$2,745,468
Capital Cost / Unit Capacity	$9,245	$3,707	$1,862	$937
Annual Capital Cost	$242,983	$243,756	$244,722	$246,268
Operations and Maintenance	$7,944	$7,944	$7,944	$7,944
Water Rights Mitigation	$0	$160	$160	$320
Total Annual Cost	$250,927	$251,860	$252,826	$254,532
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	n/a	n/a	n/a	n/a
Average Conditions	$25,093	$8,395	$5,057	$3,182

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.3-1b
Leona River Project Cost and Data Summary With Purchase of Water Rights

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	Embankment	Embankment	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	1132.2	1139.0	1145.3	1153.3
Surface Area (ac)	50	90	140	220
Capacity (acft)	293	733	1,465	2,930
25-Year Flood Pool:				
Elevation (ft-msl)	1152.0	1152.0	1152.0	1152.0
Surface Area (ac)	190	190	190	190
100-Year Flood Pool:				
Elevation (ft-msl)	1153.0	1153.0	1153.0	1153.0
Surface Area (ac)	200	200	200	200
Top of Dam Elevation (ft-msl)	1161.6	1161.6	1161.6	1161.6
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	30	60	60	60
Average Conditions	60	120	190	280
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.1	0.1
Estuarine Inflow Reduction (acft/yr)	10	30	40	60
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$1,985,990	$1,985,990	$1,985,990	$1,985,990
Road Relocations	$105,000	$105,000	$105,000	$105,000
Land Acquisition	$157,400	$157,400	$157,400	$157,400
Environmental Mitigation	$8,977	$16,159	$25,136	$39,500
Engineering, Legal, Financial, and Misc.	$451,473	$452,910	$454,705	$457,578
Total Capital Cost	$2,708,841	$2,717,459	$2,728,232	$2,745,468
Capital Cost / Unit Capacity	$9,245	$3,707	$1,862	$937
Annual Capital Cost	$242,983	$243,756	$244,722	$246,268
Operations and Maintenance	$7,944	$7,944	$7,944	$7,944
Water Rights Mitigation	$160	$480	$640	$960
Total Annual Cost	$251,087	$252,180	$253,306	$255,172
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$8,370	$4,203	$4,222	$4,253
Average Conditions	$4,185	$2,102	$1,333	$911

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.3-2a
Blanco Project Cost and Data Summary

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	Embankment	Embankment	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	1190.2	1201.8	1214.1	1230.4
Surface Area (ac)	60	100	160	260
Capacity (acft)	660	1,640	3,290	6,580
25-Year Flood Pool:				
Elevation (ft-msl)	1231.8	1231.8	1231.8	1231.8
Surface Area (ac)	270	1	1	1
100-Year Flood Pool:				
Elevation (ft-msl)	1233.4	1233.4	1233.4	1233.4
Surface Area (ac)	290	290	290	290
Top of Dam Elevation (ft-msl)	1245.0	1245.0	1245.0	1245.0
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	0	0	0	0
Average Conditions	20	60	90	100
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.1	0.1	0.1
Estuarine Inflow Reduction (acft/yr)	10	10	20	20
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$4,107,000	$4,107,000	$4,107,000	$4,107,000
Road Relocations	$0	$0	$0	$0
Land Acquisition	$223,500	$223,500	$223,500	$223,500
Environmental Mitigation	$8,308	$13,846	$22,154	$36,000
Engineering, Legal, Financial, and Misc.	$867,762	$868,869	$870,531	$873,300
Total Capital Cost	$5,206,569	$5,213,215	$5,223,185	$5,239,800
Capital Cost / Unit Capacity	$7,889	$3,179	$1,588	$796
Annual Capital Cost	$467,029	$467,625	$468,520	$470,010
Operations and Maintenance	$16,428	$16,428	$16,428	$16,428
Water Rights Mitigation	$160	$160	$320	$320
Total Annual Cost	$483,617	$484,213	$485,268	$486,758
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	n/a	n/a	n/a	n/a
Average Conditions	$24,181	$8,070	$5,392	$4,868

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.3-2b
Blanco Project Cost and Data Summary With Purchase of Water Rights

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	Embankment	Embankment	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	1190.2	1201.8	1214.1	1230.4
Surface Area (ac)	60	100	160	260
Capacity (acft)	660	1,640	3,290	6,580
25-Year Flood Pool:				
Elevation (ft-msl)	1231.8	1231.8	1231.8	1231.8
Surface Area (ac)	270	1	1	1
100-Year Flood Pool:				
Elevation (ft-msl)	1233.4	1233.4	1233.4	1233.4
Surface Area (ac)	290	290	290	290
Top of Dam Elevation (ft-msl)	1245.0	1245.0	1245.0	1245.0
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	70	110	110	110
Average Conditions	120	240	360	370
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.1	0.1	0.1
Estuarine Inflow Reduction (acft/yr)	30	50	70	80
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$4,107,000	$4,107,000	$4,107,000	$4,107,000
Road Relocations	$0	$0	$0	$0
Land Acquisition	$223,500	$223,500	$223,500	$223,500
Environmental Mitigation	$8,308	$13,846	$22,154	$36,000
Engineering, Legal, Financial, and Misc.	$867,762	$868,869	$870,531	$873,300
Total Capital Cost	$5,206,569	$5,213,215	$5,223,185	$5,239,800
Capital Cost / Unit Capacity	$7,889	$3,179	$1,588	$796
Annual Capital Cost	$467,029	$467,625	$468,520	$470,010
Operations and Maintenance	$16,428	$16,428	$16,428	$16,428
Water Rights Mitigation	$480	$800	$1,120	$1,280
Total Annual Cost	$483,937	$484,853	$486,068	$487,718
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$6,913	$4,408	$4,419	$4,434
Average Conditions	$4,033	$2,020	$1,350	$1,318

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.3-3a
Little Blanco Project Cost and Data Summary

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	Embankment	Embankment	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	1225.3	1233.8	1241.7	1250.8
Surface Area (ac)	30	70	120	210
Capacity (acft)	293	733	1,465	2,930
25-Year Flood Pool:				
Elevation (ft-msl)	1250.8	1250.8	1250.8	1250.8
Surface Area (ac)	220	220	220	220
100-Year Flood Pool:				
Elevation (ft-msl)	1252.0	1252.0	1252.0	1252.0
Surface Area (ac)	230	230	230	230
Top of Dam Elevation (ft-msl)	1263.2	1263.2	1263.2	1263.2
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	0	0	0	0
Average Conditions	20	50	90	140
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	10	10	20	30
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$1,970,110	$1,970,110	$1,970,110	$1,970,110
Road Relocations	$132,500	$132,500	$132,500	$132,500
Land Acquisition	$177,500	$177,500	$177,500	$177,500
Environmental Mitigation	$4,857	$11,333	$19,429	$34,000
Engineering, Legal, Financial, and Misc.	$456,993	$458,289	$459,908	$462,822
Total Capital Cost	$2,741,961	$2,749,732	$2,759,446	$2,776,932
Capital Cost / Unit Capacity	$9,358	$3,751	$1,884	$948
Annual Capital Cost	$245,954	$246,651	$247,522	$249,091
Operations and Maintenance	$7,880	$7,880	$7,880	$7,880
Water Rights Mitigation	$160	$160	$320	$480
Total Annual Cost	$253,994	$254,691	$255,723	$257,451
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	n/a	n/a	n/a	n/a
Average Conditions	$12,700	$5,094	$2,841	$1,839

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.3-3b Little Blanco Project Cost and Data Summary With Purchase of Water Rights				
	Percentage of Maximum Project Conservation Capacity			
Physical Data	**10%**	**25%**	**50%**	**100%**
Dam Type	Embankment	Embankment	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	1225.3	1233.8	1241.7	1250.8
Surface Area (ac)	30	70	120	210
Capacity (acft)	293	733	1,465	2,930
25-Year Flood Pool:				
Elevation (ft-msl)	1250.8	1250.8	1250.8	1250.8
Surface Area (ac)	220	220	220	220
100-Year Flood Pool:				
Elevation (ft-msl)	1252.0	1252.0	1252.0	1252.0
Surface Area (ac)	230	230	230	230
Top of Dam Elevation (ft-msl)	1263.2	1263.2	1263.2	1263.2
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	70	100	100	100
Average Conditions	70	150	250	390
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	10	30	50	80
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$1,970,110	$1,970,110	$1,970,110	$1,970,110
Road Relocations	$132,500	$132,500	$132,500	$132,500
Land Acquisition	$177,500	$177,500	$177,500	$177,500
Environmental Mitigation	$4,857	$11,333	$19,429	$34,000
Engineering, Legal, Financial, and Misc.	$456,993	$458,289	$459,908	$462,822
Total Capital Cost	$2,741,961	$2,749,732	$2,759,446	$2,776,932
Capital Cost / Unit Capacity	$9,358	$3,751	$1,884	$948
Annual Capital Cost	$245,954	$246,651	$247,522	$249,091
Operations and Maintenance	$7,880	$7,880	$7,880	$7,880
Water Rights Mitigation	$160	$480	$800	$1,280
Total Annual Cost	$253,994	$255,011	$256,203	$258,251
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$3,628	$2,550	$2,562	$2,583
Average Conditions	$3,628	$1,700	$1,025	$662

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.3-4a
Elm Creek Project Cost and Data Summary

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	Embankment	Embankment	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	966.2	975.9	985.2	996.7
Surface Area (ac)	70	140	240	370
Capacity (acft)	694	1,735	3,470	6,940
25-Year Flood Pool:				
Elevation (ft-msl)	999.0	999.0	999.0	999.0
Surface Area (ac)	400	400	400	400
100-Year Flood Pool:				
Elevation (ft-msl)	1000.7	1000.7	1000.7	1000.7
Surface Area (ac)	430	430	430	430
Top of Dam Elevation (ft-msl)	1011.9	1011.9	1011.9	1011.9
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	0	0	0	0
Average Conditions	110	220	350	370
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	20	50	80	80
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$2,345,680	$2,345,680	$2,345,680	$2,345,680
Road Relocations	$0	$0	$0	$0
Land Acquisition	$385,400	$385,400	$385,400	$385,400
Environmental Mitigation	$7,927	$15,854	$27,178	$41,900
Engineering, Legal, Financial, and Misc.	$547,801	$549,387	$551,652	$554,596
Total Capital Cost	$3,286,808	$3,296,321	$3,309,910	$3,327,576
Capital Cost / Unit Capacity	$4,736	$1,900	$954	$479
Annual Capital Cost	$294,827	$295,680	$296,899	$298,484
Operations and Maintenance	$9,383	$9,383	$9,383	$9,383
Water Rights Mitigation	$320	$800	$1,280	$1,280
Total Annual Cost	$304,529	$305,863	$307,562	$309,146
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	n/a	n/a	n/a	n/a
Average Conditions	$2,768	$1,390	$879	$836

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.3-4b
Elm Creek Project Cost and Data Summary With Purchase of Water Rights

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	Embankment	Embankment	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	966.2	975.9	985.2	996.7
Surface Area (ac)	70	140	240	370
Capacity (acft)	694	1,735	3,470	6,940
25-Year Flood Pool:				
Elevation (ft-msl)	999.0	999.0	999.0	999.0
Surface Area (ac)	400	400	400	400
100-Year Flood Pool:				
Elevation (ft-msl)	1000.7	1000.7	1000.7	1000.7
Surface Area (ac)	430	430	430	430
Top of Dam Elevation (ft-msl)	1011.9	1011.9	1011.9	1011.9
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	110	120	120	120
Average Conditions	280	480	650	670
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	60	100	140	140
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$2,345,680	$2,345,680	$2,345,680	$2,345,680
Road Relocations	$0	$0	$0	$0
Land Acquisition	$385,400	$385,400	$385,400	$385,400
Environmental Mitigation	$7,927	$15,854	$27,178	$41,900
Engineering, Legal, Financial, and Misc.	$547,801	$549,387	$551,652	$554,596
Total Capital Cost	$3,286,808	$3,296,321	$3,309,910	$3,327,576
Capital Cost / Unit Capacity	$4,736	$1,900	$954	$479
Annual Capital Cost	$294,827	$295,680	$296,899	$298,484
Operations and Maintenance	$9,383	$9,383	$9,383	$9,383
Water Rights Mitigation	$960	$1,600	$2,240	$2,240
Total Annual Cost	$305,169	$306,663	$308,522	$310,106
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$2,774	$2,556	$2,571	$2,584
Average Conditions	$1,090	$639	$475	$463

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.3-5a
Quihi Creek Project Cost and Data Summary

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	Embankment	Embankment	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	981.7	987.4	993.2	1001.0
Surface Area (ac)	30	50	80	120
Capacity (acft)	157	393	785	1,570
25-Year Flood Pool:				
Elevation (ft-msl)	1001.0	1001.0	1001.0	1001.0
Surface Area (ac)	120	120	120	120
100-Year Flood Pool:				
Elevation (ft-msl)	1002.2	1002.2	1002.2	1002.2
Surface Area (ac)	125	125	125	125
Top of Dam Elevation (ft-msl)	1011.0	1011.0	1011.0	1011.0
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	0	0	0	0
Average Conditions	20	50	80	80
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	10	10	20	20
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$961,750	$961,750	$961,750	$961,750
Road Relocations	$0	$0	$0	$0
Land Acquisition	$97,700	$97,700	$97,700	$97,700
Environmental Mitigation	$7,750	$12,917	$20,667	$31,000
Engineering, Legal, Financial, and Misc.	$213,440	$214,473	$216,023	$218,090
Total Capital Cost	$1,280,640	$1,286,840	$1,296,140	$1,308,540
Capital Cost / Unit Capacity	$8,157	$3,274	$1,651	$833
Annual Capital Cost	$114,873	$115,430	$116,264	$117,376
Operations and Maintenance	$3,847	$3,847	$3,847	$3,847
Water Rights Mitigation	$160	$160	$320	$320
Total Annual Cost	$118,880	$119,437	$120,431	$121,543
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	n/a	n/a	n/a	n/a
Average Conditions	$5,944	$2,389	$1,505	$1,519

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

TABLE 3.3-5b
Quihi Creek Project Cost and Data Summary With Purchase of Water Rights

Physical Data	Percentage of Maximum Project Conservation Capacity			
	10%	25%	50%	100%
Dam Type	Embankment	Embankment	Embankment	Embankment
Conservation Pool:				
Elevation (ft-msl)	981.7	987.4	993.2	1001.0
Surface Area (ac)	30	50	80	120
Capacity (acft)	157	393	785	1,570
25-Year Flood Pool:				
Elevation (ft-msl)	1001.0	1001.0	1001.0	1001.0
Surface Area (ac)	120	120	120	120
100-Year Flood Pool:				
Elevation (ft-msl)	1002.2	1002.2	1002.2	1002.2
Surface Area (ac)	125	125	125	125
Top of Dam Elevation (ft-msl)	1011.0	1011.0	1011.0	1011.0
Hydrologic Data				
Recharge Enhancement (acft/yr):				
Drought Conditions	20	30	30	30
Average Conditions	60	100	140	150
CC/LCC System Yield Reduction (acft/yr)	0	0	0	0
Median CC/LCC System Storage Reduction (%)	0.0	0.0	0.0	0.0
Estuarine Inflow Reduction (acft/yr)	10	20	30	30
Summary of Project Costs				
Dam, Spillway, and Appurtenant Works	$961,750	$961,750	$961,750	$961,750
Road Relocations	$0	$0	$0	$0
Land Acquisition	$97,700	$97,700	$97,700	$97,700
Environmental Mitigation	$7,750	$12,917	$20,667	$31,000
Engineering, Legal, Financial, and Misc.	$213,440	$214,473	$216,023	$218,090
Total Capital Cost	$1,280,640	$1,286,840	$1,296,140	$1,308,540
Capital Cost / Unit Capacity	$8,157	$3,274	$1,651	$833
Annual Capital Cost	$114,873	$115,430	$116,264	$117,376
Operations and Maintenance	$3,847	$3,847	$3,847	$3,847
Water Rights Mitigation	$160	$320	$480	$480
Total Annual Cost	$118,880	$119,597	$120,591	$121,703
Annual Cost / Unit Recharge Enhancement:				
Drought Conditions	$5,944	$3,987	$4,020	$4,057
Average Conditions	$1,981	$1,196	$861	$811

Refer to Appendix B for summary and Section 2 for explanation of assumptions on which project cost and data are based.

projects, however, was $463 per ac-ft per year which is almost twice the unit cost of the least economical Type 2 mainstem site.