REGIONAL WATER MANAGEMENT WITH FULL CONSUMPTIVE USE

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This study was part of an interdisciplinary-interuniversity research project entitled, "Regional Water Management with Full Consumptive Use." The principal investigators were Robert R. Lansford, Agricultural Economist, New Mexico State University; Shaul Ben-David, Economist, University of New Mexico; Fred Roach, Economist, University of New Mexico; Bobby J. Creel, Agricultural Economist, New Mexico State University; and Bruce R. Beattie, Agricultural Economist, Texas A & M University. Other investigators included John W. Adams, Economist, University of Texas at San Antonio; Lonnie L. Jones, Agricultural Economist, Texas A & M University; and Donald Reddell, Agricultural Engineer, Texas A & M University. These investigators were included in the research effort as consultants and made contributions in formulation of the study, the interindustry model, and hydrology. Robert R. Lansford served as the coordinator for all phases of the project.

Although the research team is solely and totally responsible for statements and conclusions in this report, many people helped in the work. Don Book and William Coffman, Graduate Assistants at Texas A & M University, helped with the development of the interindustry model. One of the key elements of this study was the use of a technical advisory committee composed of representatives from state and federal agencies. The willingness of this advisory committee to work with the study group was outstanding. Many of the changes in the study reflected the advice offered by members of the technical advisory committee. Membership of the Advisory Committee was:

Wayne Buckner	Texas Water Development Board
H. P. Burleigh	Formerly Director Texas Water Development Board
W. P. Cunningham	Elephant Butte Irrigation District
Bruce Gaines	West Texas Council of Governments
A. O. Galves	Southern Rio Grande Council of Governments
Thomas G. Gebhard	Formerly Director of Utilities, City of Las Cruces
Jesse Gilmer	Rio Grande Compact Commission, Texas
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James W. Kirby	U. S. Bureau of Reclamation
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Philip Mutz	New Mexico Interstate Stream Commission
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Reza Pazand	Ph.D.	Economics - UNM
Roberta Katson	M.A.	Economics - UNM
W. S. Coffman	M.A.	Agricultural Economics - TAMU
Don Book	Ph.D.	Statistics - TAMU

The development of the economic structure of El Paso and Hudspeth counties of Texas in an input-output (interindustry) framework utilized in this study is also reported in a separate report entitled, *An Interindustry Model of El Paso and Hudspeth Counties, Texas*, by W. S. Coffman, B. R. Beattie, L. L. Jones, and J. W. Adams through the Texas Water Resources Institute as Technical Report Number 69, in April 1976.

Special thanks go to Professor John W. Clark and Dr. Jack Runkles for their support in the search for funding for the project; to Dr. Garrey Carruthers for his continuing support and encouragement; to the reviewers of the manuscript; and to Linda Burks for efficiently and expertly typing the many manuscripts. Needless to say, errors remaining, either in logic or numerical content of this analysis, are attributable to the authors.

REGIONAL WATER MANAGEMENT WITH FULL CONSUMPTIVE USE--AN EXECUTIVE SUMMARY*

The stretch of the Rio Grande from Elephant Butte, New Mexico to Fort Quitman, Texas probably comes as close to consumptively using all of the surface water of the river as any major river basin in the United States. The only surface waters that escape the region at Fort Quitman are occasional flood waters from thunderstorms. In this reach of the river, production of water is negligible and comes primarily from thunderstorm runoff. The surface water for the region is stored at Elephant Butte Reservoir and released as demanded. The primary purpose of this study was to evaluate the social and economic impacts of alternative water-use policies for the stretch of the Rio Grande from Elephant Butte to Fort Quitman.

This study presents alternative long-run production and water utilization patterns in the Rio Grande Region from Elephant Butte to Fort Quitman. A socio-economic model utilizing an interregional input-output model for the four county (Dona Ana, Sierra, El Paso and Hudspeth) region provided the data base for the regional economic structure. This data base was developed to represent 1970 conditions. The socio-economic model is essentially a linear programming model designed to represent the regional economy with special emphasis placed upon the four counties under investigation. The model consists primarily of an input-output table of technical coefficients and a set of constraints placed on the predominantly water-connected resources. Economic growth in this model occurs through responses of the final demands in all sectors except the agricultural sectors which were required to respond only to internal processing demands.

Two basic growth projections were developed for analysis. One is a relatively high estimate of future production, while the other is much closer to recent projections which is of a much lower magnitude. The two basic growth projections are linked to estimates of population growth. Final demand is assumed to increase at the same rate as population growth. The high population projection was based on estimates by the New Mexico Bureau of Business Research in 1968. The low or anticipated population projection was based on OBERS Series C Projections. The anticipated annual rate of population growth from 1970 to 2020 is 1.126 percent for the New Mexico counties and 2.107 percent for the Texas counties. The high projection annual rate of population growth from 1970 to 2020 was estimated to be 9.686 percent for the region.

Three basic scenarios were developed for the Rio Grande Region which incorporated various water availability constraints and alternative socio-economic model solutions. The first scenario did not include a constraint on the water availability for the region and included two alternative socio-economic model solutions. Alternative I incorporated the anticipated population growth scenario and Alternative II incorporated the high population growth scenario. These two alternatives presents production, employment, and water depletions that could be expected for the region with unlimited water availabilities.

Surface water depletions are expected to increase by less than 30 percent under Alternative I and are expected to increase by more than 110 percent under Alternative II by the year 2020 (Table 1). Grounwater depletions are expected to increase in even greater magnitudes. Groundwater withdrawals follow a similar pattern in the rates of increase for the two alternatives. To support Alternative II (the high growth scenario), the 2020 groundwater depletion and diversion requirements will more than double those required by 1970. The doubling point is expected to be reached in the New Mexico

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Table 1. Summary of value of production and water depletions for 1970 and 2020 by subregion for alternatives I through V, Rio Grande Region

Major Sector	1970				2020			
	New Mexico Subregion		Texas Subregion		New Mexico Subregion		Texas Subregion	
	Value of Production (000 dollars)	Water Depletions (acre-feet)	Value of Production (000 dollars)	Water Depletions (acre-feet)	Value of Production (000 dollars)	Water Depletions (acre-feet)	Value of Production (000 dollars)	Water Depletions (acre-feet)
ALTERNATIVE I--ANTICIPATED GROWTH AND NO WATER CONSTRAINT								
Agriculture	43,141	222,803	33,416	235,823	59,570	286,106	39,089	291,135
Mining	4,528	106	4,705	110	8,282	194	9,662	226
Manufacturing	56,586	785	740,055	12,429	89,904	1,251	1,514,236	25,433
Comm., Ut., Trp.	17,002	769	149,012	6,012	26,515	1,193	302,561	12,193
Trade & Services	82,272	724	490,929	4,223	128,612	1,131	1,001,215	8,622
Municipal & Rural	--	5,420	--	30,023	--	9,106	--	62,404
Total	203,529	230,607	1,418,117	288,620	312,883	298,981	2,866,763	400,013
ALTERNATIVE II--HIGH GROWTH AND NO WATER CONSTRAINT								
Agriculture	43,141	222,803	33,416	235,823	121,755	528,012	60,886	505,852
Mining	4,528	106	4,705	110	26,088	610	27,492	643
Manufacturing	56,586	785	740,055	12,429	328,266	4,559	4,307,248	72,346
Comm., Ut., Trp.	17,002	769	149,012	6,012	95,781	4,284	859,460	34,606
Trade & Services	82,272	724	490,929	4,223	468,459	4,116	3,486,401	32,249
Municipal & Rural	--	5,420	--	30,023	--	37,105	--	178,909
Total	203,529	230,607	1,418,117	288,620	1,040,349	578,686	8,741,487	824,605
ALTERNATIVE III--ANTICIPATED GROWTH AND SURFACE WATER CONSTRAINT								
Agriculture	43,141	222,803	33,416	235,823	50,269	226,090	36,314	238,876
Mining	4,528	106	4,705	110	8,273	194	9,661	226
Manufacturing	56,586	785	740,055	12,429	89,552	1,247	1,513,751	25,425
Comm., Ut., Trp.	17,002	769	149,012	6,012	26,208	1,177	302,211	12,177
Trade & Services	82,272	724	490,929	4,223	127,602	1,120	1,000,545	8,617
Municipal & Rural	--	5,420	--	30,023	--	9,106	--	62,404
Total	203,529	230,607	1,418,117	288,620	301,904	238,934	2,862,482	347,725
ALTERNATIVE IV--ANTICIPATED GROWTH, SURFACE WATER CONSTRAINT WITH WATER AVAILIBILITY RESPONSES*								
Agriculture	43,141	222,803	33,416	235,823	57,646	217,072	37,771	246,589
Mining	4,528	106	4,705	110	8,278	194	9,662	226
Manufacturing	56,586	785	740,055	12,429	89,873	1,250	1,514,129	25,429
Comm., Ut., Trp.	17,002	769	149,012	6,012	26,388	1,187	302,469	12,189
Trade & Services	82,272	724	490,929	4,223	128,277	1,129	1,001,063	8,621
Municipal & Rural	--	5,420	--	30,023	--	9,106	--	62,404
Total	203,529	230,607	1,418,117	228,620	310,462	229,938	2,865,094	355,458
ALTERNATIVE V--ANTICIPATED GROWTH, SURFACE AND GROUNDWATER CONSTRAINTS WITH WATER AVAILIBILITY RESPONSES*								
Agriculture	43,141	222,803	33,416	235,823	57,635	216,807	36,412	196,001
Mining	4,528	106	4,705	110	8,278	194	9,662	226
Manufacturing	56,586	785	740,055	12,429	89,873	1,250	1,514,129	25,429
Comm., Ut., Trp.	17,002	769	149,012	6,012	26,388	1,187	302,469	12,189
Trade & Services	82,272	724	490,929	4,223	128,277	1,129	1,001,063	8,621
Municipal & Rural	--	5,420	--	30,023	--	9,106	--	62,404
Total	203,529	230,607	1,418,117	228,620	310,451	229,673	2,863,735	304,870

*The surface water flows (availability) were assumed to be reduced by 100 acre-feet annually in the New Mexico Subregion and increased by 325 acre-feet annually in the Texas Subregion in response to groundwater withdrawals.

subregion by 2000 and by 1990 in the Texas subregion. The high population growth scenario (Alternative II) was not considered to be realistic for the region since water requirements were substantial.

The second scenario (Alternatives III and IV) incorporated a constraint on the surface water availability in the region at the level used in 1970. For Alternative III, the return flows resulting from groundwater withdrawals were assumed to equal the aquifer recharge from the surface flows due to pumpage. Therefore, the groundwater depletions (withdrawals minus return flows) constitute the extent of groundwater mining. Thus, surface water availabilities were assumed to remain constant over time. For Alternative III, the surface water depletions are expected to increase only slightly by 2020. Groundwater depletions, however, are expected to increase 8.01 and 50.4 percent for the New Mexico and Texas subregions, respectively by 2020. Under Alternative III, purchases of agricultural sector production is estimated to reach $9,301,000 by 2020 in the New Mexico subregion and $2,775,000 by 2020 in the Texas subregion (Table 1).

For Alternative IV the aquifer recharge from surface flows were assumed to not be offset by the return flows. In the New Mexico subregion, a net reduction in surface water availability of about 100 acre-feet was assumed to occur annually. In the Texas subregion, aquifer recharge from surface flows was assumed to be more than offset by the return flows by about 325 acre-feet annually. In addition to incorporating the surface water availability constraint and the surface water availability response to groundwater withdrawals in Alternative IV, the agricultural sectors were permitted to respond to the water shortages and increased demands for agricultural products by shifting sector production to the next higher-valued enterprise. For Alternative IV, the surface water depletions are expected to increase initially and then decrease about 0.01 percent by 2020 from the 1970 level in the New Mexico subregion. This is due to the surface water availability response to groundwater withdrawals. For the Texas subregion, the surface water depletions are expected to increase about 5.25 percent by 2020.

The effect of the different surface water availability responses to groundwater withdrawals for Alternatives III and IV and the allowance for agricultural production shifts to the next higher-valued enterprise in Alternative IV resulted in decreases in the quantities of water (both surface and ground) in the New Mexico subregion and increases in the quantities of water (both surface and ground) in the Texas subregion.

The effect of the surface water constraint on water depletions is a reduction of about 6,542 acre-feet of surface water by 1980 increasing to about 43,890 acre-feet of surface water by 2020 in the New Mexico subregion and about 5,834 acre-feet of surface water by 1980 increasing to about 38,356 acre-feet of surface water by 2020 in the Texas subregion when compared to the 1970 surface water constraint level--Alternative I. Groundwater depletions are expected to be reduced by about 16,152 acre-feet by 2020 in the New Mexico subregion and about 13,932 acre-feet by 2020 in the Texas subregion.

For the third scenario (Alternative V), a constraint was incorporated on both the surface water availability and groundwater withdrawals in the region at the levels used in 1970. In addition, for Alternative V, in the New Mexico subregion a reduction in surface water availability of about 100 acre-feet was assumed to occur annually and in the Texas subregion aquifer recharge from surface flows was assumed to be more than offset by the return flows by 325 acre-feet annually. The agricultural sectors were also permitted to respond to the water shortages and increased demands for production by shifting sector production to the next higher-valued enterprise. The agricultural sectors production purchases required indicate that the constraint on groundwater withdrawals reduces the level of agricultural production. The additional constraint on groundwater withdrawals has a greater effect on the agricultural production in the Texas subregion than in the New Mexico subregion. In the New Mexico subregion, the surface water depletions are not affected by the incorporation of the groundwater constraint. In the Texas subregion, both surface water and groundwater depletions are reduced considerably by the additional constraint. The demands for groundwater by the municipal and industrial sectors in the Texas subregion require that surface water depletions be reduced so that groundwater depletions may be increased (Table 1).

In the three scenarios, interregional transfers of water between the regions were not permitted. If a surface water constraint was imposed as in Alternative II, Scenario I, and if interregional transfers of water were permitted, additional shifts in water use and regional production would be expected. The water use in the Texas subregion would be expected to shift from a predominant surface supply to primarily a groundwater supply. Production in the Texas subregion would be expected to be primarily in the industrial sectors, with minor agricultural production expected. In the New Mexico subregion, the surface water use would be expected to increase due to the transfer of surface water from the Texas subregion into the New Mexico subregion. The agricultural production of the New Mexico subregion would be expected to increase substantially, since the bulk of the production would be expected in this subregion. The industrial production is not expected to increase in the New Mexico subregion above earlier scenario levels. Thus, for the region as a whole, the interregional transfers of water would be expected to permit the economy to approach the unconstrained state (Alternative I). In general, the New Mexico subregion has a comparative advantage in agricultural production if it is not constrained by surface water supplies, and the Texas subregion certainly would be expected to have an advantage in industrial production. By permitting interregional water transfers, the total regional economy would be expected to approach the no-water constraint alternative (Alternative I), with increased interregional trade flows occurring.

A number of observations summarized from the socio-economic evaluation is presented below:

- WITHOUT A WATER CONSTRAINT, ANTICIPATED GROWTH IN THE REGIONAL POPULACE WOULD REQUIRE INCREASES IN AGRICULTURAL PRODUCTION THAT IN TIME WOULD REQUIRE (1) MORE WATER THAN IS AVAILABLE, (2) SHIFTS IN THE WATER SOURCE TO GROUND SUPPLIES AT A FASTER RATE THAN OBSERVED IN THE PAST, OR (3) SHIFTS IN PRODUCTION FROM HOUSEHOLD, GOVERNMENTAL, AND EXPORT CONSUMPTION TO AGRICULTURAL PRODUCTION FOR LOCAL DEMANDS AT A MUCH FASTER RATE AND LEVEL THAN MIGHT NORMALLY BE EXPECTED.

- WITH NO CONSTRAINT ON WATER AVAILABILITY, AN ADDITIONAL 180,000 ACRE-FEET OF DEPLETIONS WOULD BE REQUIRED BY 2020 FOR ANTICIPATED REGIONAL GROWTH (OBERS SERIES C PROJECTIONS). FOR HIGH REGIONAL GROWTH (MORE THAN FOUR-FOLD ANTICIPATED), AN ADDITIONAL 880,000 ACRE-FEET OF DEPLETIONS WOULD BE REQUIRED BY 2020. AGRICULTURAL PRODUCTION INCREASES ARE LIMITED TO LOCAL DEMANDS.

- WITH SURFACE WATER DEPLETIONS CONSTRAINED AT THE 1970 LEVEL, APPROXIMATELY 67,000 ACRE-FEET OF ADDITIONAL GROUNDWATER DEPLETIONS (134,000 ACRE-FEET OF ADDITIONAL GROUNDWATER WITHDRAWALS) WOULD BE REQUIRED TO SUSTAIN THE ANTICIPATED GROWTH OF THE REGION BY THE YEAR 2020 WHEN INCREASES IN AGRICULTURAL PRODUCTION ARE LIMITED TO LOCAL DEMANDS.

- With both surface and groundwater depletions constrained at the 1970 levels, agricultural acreage must be removed from production to permit increases in anticipated municipal and industrial water requirements. Approximately $4.6 million annually in purchases of agricultural products would then be required to meet the internal processing demands of the region by the year 2020.

- When surface flows (availabilities) are permitted to respond to increased ground withdrawals through time--reduced availability in New Mexico, increased availability in Texas--only small differences were noted in both the agriculture production and groundwater withdrawals from those resulting without the surface response (Alternative III). The effect on the surface water response was offset to a large extent by allowance from agricultural production shifts to higher-valued sectors. The degree to which this would take place (agricultural production shifts) depends on the differences in sector value and unit water requirements.

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CHAPTER I

INTRODUCTION

El Paso, Texas, Juarez, Mexico, and Las Cruces, New Mexico, form the major population nucleus along a stretch of the Rio Grande with considerable industrial potential and a rapidly growing population. A relatively young, inexpensive labor force makes the region especially attractive. However, proper management is crucial if growth is to occur without damaging the quality of the environment, one of the area's prime assets.

The region's ability to grow in a positive way depends in large part upon wise use of the scarce water supply. In 1961, a U. S. Senate Select Committee estimated that the Upper Rio Grande and Pecos basins had the least water in relation to projected demands for 1980 of any basins in the continental U. S. A study by the U. S. Water Resources Council in 1968 documented these predictions in the process of examining the entire Rio Grande drainage area in Colorado, New Mexico, and Texas (Figure 1). The major problems identified were:

--water deficiencies and groundwater storage depletion;

--poor water quality due to mineral pollution;

--heavy sediment loads in many tributaries;

--too much waste;

--frequent flood damage.

The Council stressed the importance of solving these problems since water needs for the year 2020 are expected to be about two and a half times the region's present average runoff.

The complexity of modern resource requirements virtually demands the disciplined application of various technologies. The legal and institutional structures of water use make their understanding and application a requisite to good management. Although economic justification is critical in water allocation decisions, the social and cultural implications must also be fully considered since the optimum use of water implies a maximization of benefits to society through a broad range of uses.

The Problem

How best to use the fully appropriated and consumed water supply of the Rio Grande between Elephant Butte Reservoir in New Mexico and Fort Quitman, Texas (Figure 2) is the region's major continuing problems. State and federal agencies involved in efforts to deal with it include: the New Mexico State Engineer Office; the New Mexico Interstate Stream Commission; the Texas Water Development Board; the Bureau of Reclamation; the U. S. Army Corps of Engineers; the U. S. Geological Survey; and the Soil Conservation Service.

Although certain aspects of this river system's problems have been subject to detailed investigation, the rapid advances in computer technology make it highly desirable for persons whose primary

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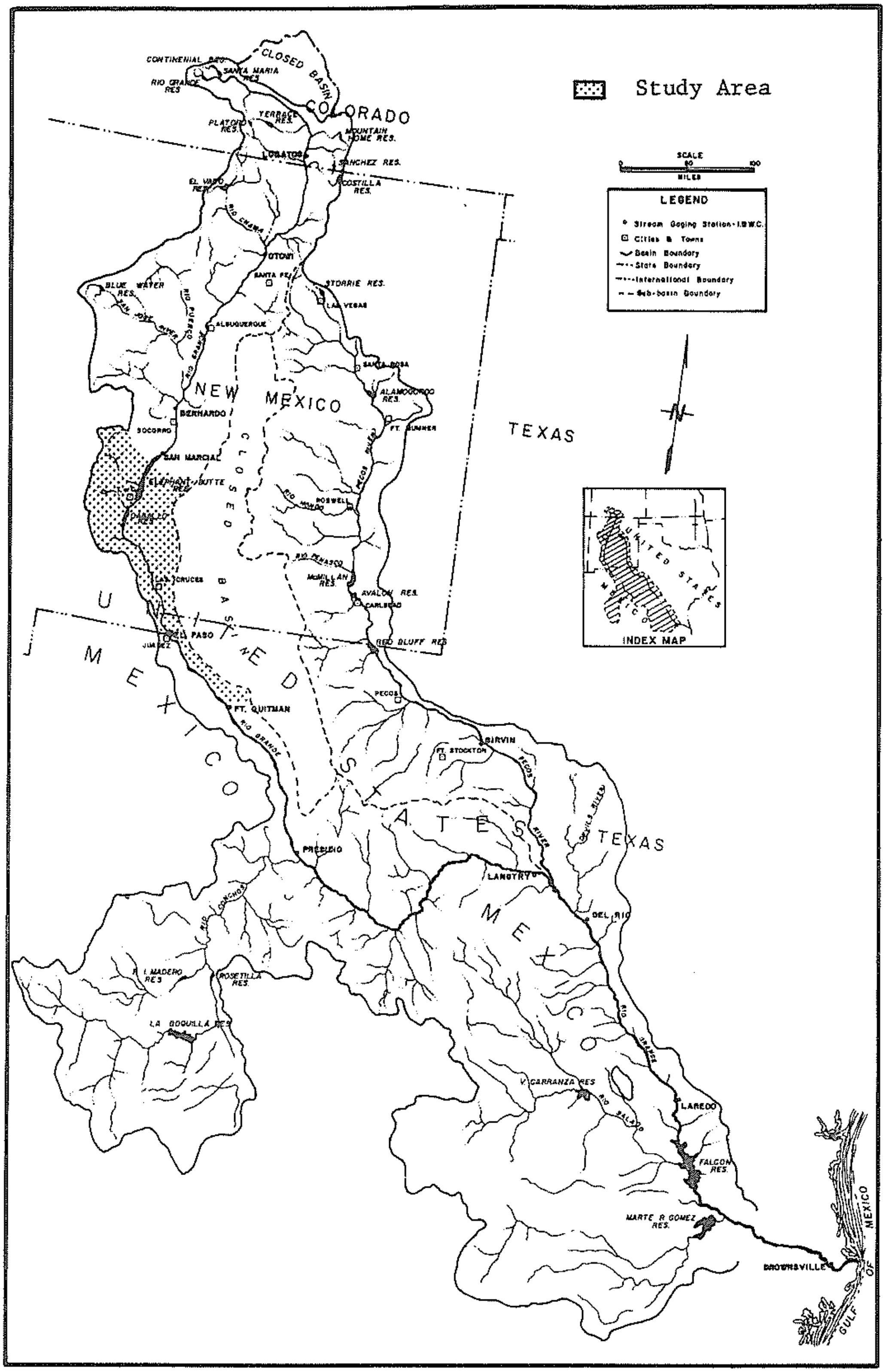

Figure 1. Map of Rio Grande.

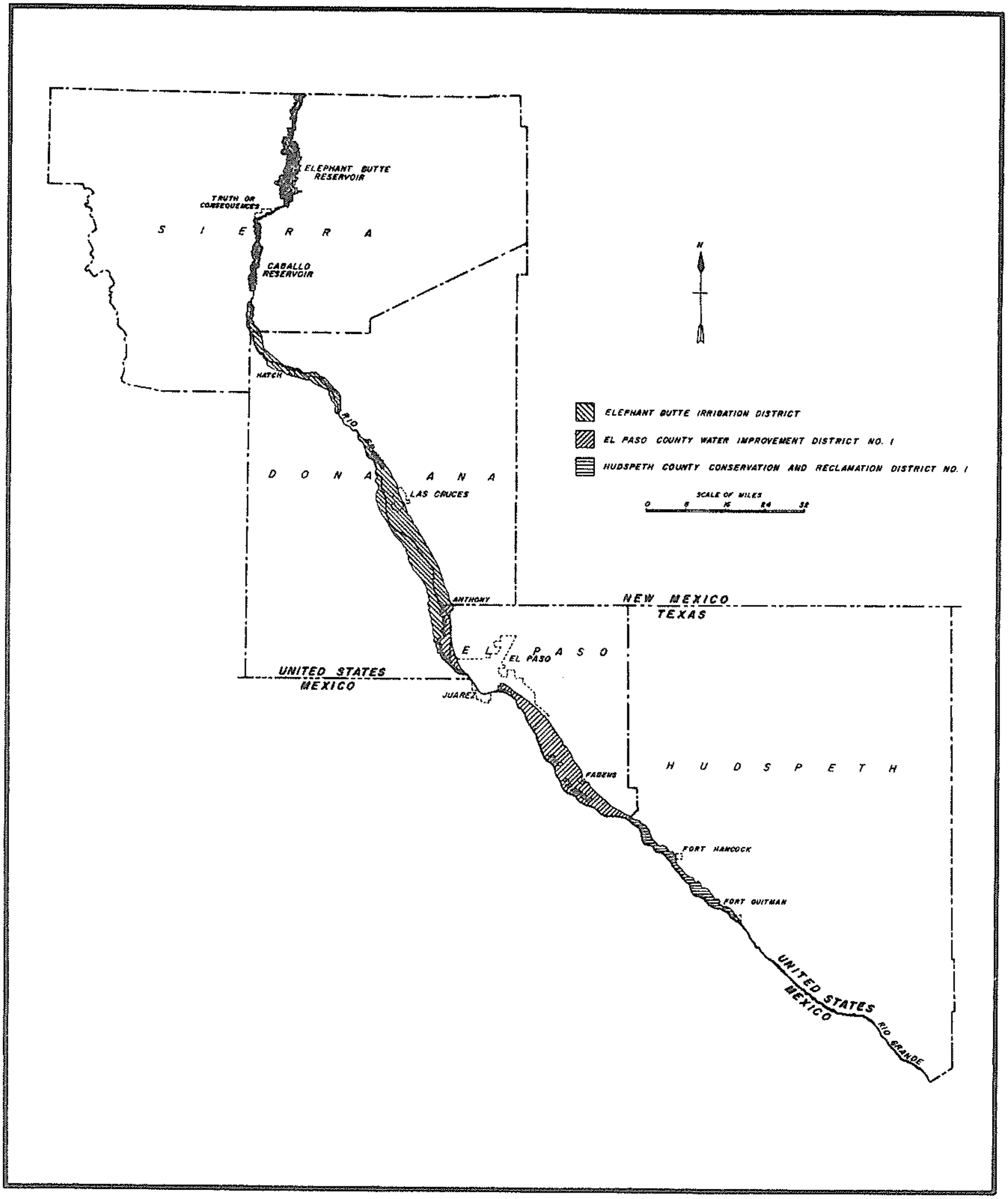

Figure 2. Map of Rio Grande Study Region area.

concern is not with the institutional structure of existing water resources agencies to study, evaluate, and develop proposals to enhance the use of the Rio Grande's resources. The present document outlines procedures and results of an investigation of water resource problems between Elephant Butte and Fort Quitman.

Objectives

This study has as its objective an evaluation of social and economic impacts caused by alternative strategies for dealing with water scarcity in the region. This made necessary the development of a model to:

1. Describe the water supply and demand characteristics of the region;
2. Describe the economic conditions of the region as related to water resources availability;
3. Identify selected alternative futures with respect to water use, industrial development, and population growth and their impact upon the agricultural sector of the economy;
4. Evaluate these alternatives in terms of water use, employment, agricultural and industrial development, environmental impacts, and other related factors;
5. Identify and discuss institutional changes necessary for efficient management of the regional water resources.

Related Research

The present work uses as its departure point the 1973 findings presented in *An Analytical Interdisciplinary Evaluation of the Utilization of the Water Resources of the Lower Rio Grande in New Mexico* [Lansford, et al., 1973]. This earlier study contemplated three different water strategies. It examined growth possibilities assuming: (1) no water constraint; (2) surface water constraints; and (3) constraints on both surface and groundwater. Table 1 shows the conclusions for all three cases.

Assuming each policy produced its maximum possible effect, the 1973 study indicated economic activity and water depletion would rise most (by 62 and 43 percent, respectively) in the absence of any restrictions at all. Controls on surface water would reduce economic output some $13.6 million by 2020 with water depletions decreasing about 22 percent, or 51,404 acre-feet. Total restrictions seemed likely to reduce economic output by no more than $4.8 million in comparison to the figure derived with surface restraints only. Meanwhile, it was estimated that the tighter limitations would save only 6,000 acre-feet of water while forcing the output of goods and services some $22 million below what it would be in a free-water-use situation.

The Rio Grande basin has been the subject of many over-all studies as well as the target of specific inquiries into such topics as groundwater hydrology. The New Mexico State Engineer, the Texas Water Development Board, the Bureau of Reclamation, the U. S. Geological Survey and the International Boundary and Water Commission are among the agencies which have carried out investigations on the Rio Grande.

Table 1. Summary of alternative solutions by major sectors in the Rio Grande region, and in the Lower Rio Grande Region, New Mexico, 1970-2020

			Total Rio Grande Region						Lower Rio Grande Region					
			Value of Production				Water Depletions		Value of Production				Water Depletions	
Alternative	Year	Major Sector		Change from 1970	Value Added	Employment		Change from 1970		Change from 1970	Value Added	Employment		Change from 1970
			($1 million)	(percent)	($1 million)		(acre-feet)	(percent)	($1 million)	(percent)	($1 million)		(acre-feet)	(percent)
Basic Optimal Solution	1970	Agriculture	84.775		44.402	7,196	497,268		36.918		23.867	3,226	222,328	
		Mining	108.062		71.393	1,920	4,571		4.739		3.003	136	111	
		Manufacturing	258.834		104.327	10,451	1,826		20.118		9.214	843	87	
		Trade & Services	1,670.001		1,012.630	90,463	20,059		143.711		88.956	9,598	1,950	
		Municipal & Rural	--		--	--	39,144		--		--	--	5,222	
		Total	2,122.660*		1,232.753*	110,030	562,866*		205.486		125.070*	13,803	229,697*	
No Water Constraint	2020	Agriculture	117.244	38.3	61.778	9,997	724,603	45.7	50.556	36.9	32.752	4,336	327,780	47.4
		Mining	170.924	58.2	112.895	3,027	7,199	57.5	7.407	54.5	4.740	212	173	55.8
		Manufacturing	415.920	60.7	167.459	16,781	2,928	60.3	31.418	56.1	14.391	1,315	136	56.3
		Trade & Services	2,686.207	60.8	1,627.409	145,374	32,221	60.6	234.636	63.2	144.325	15,460	3,166	62.3
		Municipal & Rural	--		--	--	62,660	60.1	--	--	--	--	8,163	56.3
		Total	3,390.292*	59.7	1,969.539	175,178*	829,610*	47.4	323.636*	57.4	196.207*	21,324*	329,417*	47.7
Surface Water Constraint	2020	Agriculture	110.305	30.1	57.334	9,213	586,215	17.9	47.167	27.7	30.580	3,916	266,502	19.8
		Mining	170.922	58.2	112.894	3,027	7,199	57.5	7.407	56.2	4.740	212	173	55.8
		Manufacturing	415.629	60.7	167.336	16,767	2,926	60.2	31.404	56.0	14.384	1,314	136	56.3
		Trade & Services	2,675.342	60.1	1,621.299	144,827	32,088	60.0	223.996	55.8	138.662	14,953	3,039	55.8
		Municipal & Rural	--		--	--	62,660	60.1	--	--	--	--	8,163	56.3
		Total	3,372.196*	58.9	1,958.862*	173,833*	691,086	22.8	309.974	50.8	188.326	20,395	278,013	21.0
Total Water Constraint	2020	Agriculture	107.416	26.7	55.499	8,900	528,050	6.2	46.777	26.7	30.340	3,903	260,738	17.2
		Mining	170.921	58.2	112.894	3,027	7,199	57.2	7.407	56.2	4.740	212	173	55.8
		Manufacturing	415.794	60.6	167.407	16,776	2,926	60.2	31.404	56.0	14.384	1,314	136	56.3
		Trade & Services	2,673.967	60.0	1,620.464	144,699	32,070	59.9	223.957	55.8	138.596	14,951	3,039	55.8
		Municipal & Rural	--		--	--	62,660	60.1	--	--	--	--	8,163	56.3
		Total	3,368.097*	58.7	1,956.264	173,402	632,904*	12.4	309.545	50.6	188.061*	20,380	272,249	18.5

*Does not add because of rounding.

Source: Lansford, R. R., et al., An Analytical interdisciplinary Evaluation of the Utilization of the Water Resources of the Rio Grande in New Mexico: Lower Rio Grande Region, New Mexico Water Resources Research Institute Report no. 024, New Mexico State University, Las Cruces, New Mexico, May 1973, Table 33, page 89.

CHAPTER II

A DESCRIPTION OF THE REGION AND ITS PROBLEMS

A description of the region, its geographical and historical setting, its socio-economic problems, its people--their cultural background and their use of the land and water is presented in this chapter. Much of the discussion is drawn from a publication by John Hernandez (1973).

Geographical Setting

The region under consideration, referred to as the Rio Grande Region in this study, is the U. S. lands along the 285 river-miles of the Rio Grande from the upper reaches of Elephant Butte Reservoir in Sierra and Socorro counties, New Mexico, where the surface water supply for the region is stored, downstream to Fort Quitman in Hudspeth county, Texas, where the last of this water is used (Figure 2). The river forms the boundary between the U. S. A. and Mexico for 81 miles in the study area and includes lands in New Mexico and Texas.

The region is characterized by open areas of sloping plains whose outer edges are formed by steep ranges of mountains with isolated peaks and by areas with significant differences in local relief. The Rio Grande Valley cuts through the plains in a north-to-south direction from Elephant Butte to about the northern Dona Ana county, New Mexico, line and then in a more southeasterly direction to Fort Quitman about 80 miles south of El Paso. Beginning at El Paso, the Rio Grande forms the boundary between Texas and Mexico.

Land Resources

The flood plains and valleys of the Rio Grande are the developed zones in the region. The headwaters of Elephant Butte Reservoir partially fill the uppermost valleys. The dam is set in a narrow canyon that cuts the sedimentary formations of the north end of the Sierra Caballo fault. Below the dam, the river enters the 22-mile long, relatively narrow Palomas Valley which is bounded by the Sierra Caballo on the east and the highlands on the west. Caballo Dam is built on a constriction where the river cuts through a series of low hills to run in a shallow, narrow canyon.

The next valley below Caballo Reservoir is the Rincon Valley that begins at Percha Dam, an irrigation diversion structure on the Rio Grande. This section is about 32-miles long and is bounded by highlands on both the east and west; it terminates at the Seldon Canyon constriction, a very narrow seven-mile long gap that just contains the river, the Santa Fe railroad tracks, and U. S. Highway 85.

Seldon Canyon is followed by the Mesilla Valley. Most of the irrigated lands of this valley are in the incised river sub-valley that varies in width from about two to five miles and extends approximately 60 miles downstream to the "pass" at El Paso.

The El Paso Canyon is a gorge between the Franklin Mountains in Texas and the Cerro De Muleros in Mexico. Below the "pass" the river enters the El Paso Valley, part of which lies on the Mexican side of the river. This valley extends about 90 miles to a narrow canyon in the south end of the Quitman Mountains. This point, near the Fort Quitman gauging station in Hudspeth county, Texas, marks the lower end of the region.

The bulk of the U. S. irrigated lands of the region was developed under the Bureau of Reclamation's Rio Grande Project that has a maximum water-right acreage of 159,650 acres: 90,640 acres are in New Mexico and 69,010 acres are in Texas. In addition to these farmlands are 18,000 acres that are part of the Hudspeth Irrigation District below the El Paso Valley.

Groundwater is used extensively in all of the valleys to supplement the surface supply. The river alluvium in the entire San Marcial-Fort Quitman reach constitutes a major source of irrigation water. The quality varies from place to place, generally becoming poorer in the downstream direction. Organic compounds, hydrogen sulfide, and high salt concentrations make the shallow supply undesirable for domestic use in many areas.

Demographic and Economic Characteristics

Population Characteristics

The population of the region approaches one-half million people. El Paso, Texas and Las Cruces, New Mexico are the main population centers with most of the region's population living in urban areas. El Paso county is 96 percent urban; over 66 percent (461,189) of Dona Ana county's population is classified as urban. Sierra county is also about 66 percent urban, but Hudspeth is classified as totally rural.

Regional Economic Base

One of the effects of the migration of Mexican people into the El Paso area is to generate significant reserves of unskilled and semi-skilled labor. This tends to reduce average earnings, but this factor is attractive to some facets of industry which tend to follow a relatively low-cost labor market.

El Paso is the fifth largest city in Texas and the largest U. S. city on the southern border of the U. S. It is the financial, cultural, transportation, medical, and commercial center of the region, an area whose economic base is founded on four activity sectors: military and other government installations; light manufacturing utilizing semi-skilled labor; retail trade and tourism; and agriculture.

Cultural and education centers in the region are the state universities at El Paso (University of Texas at El Paso) and at Las Cruces (New Mexico State University). In addition to acting as significant factors in the local economies, the two institutions are a source of technical expertise in business, agriculture, and engineering. Cultural facilities at the schools add to those in the three major communities in the region.

Military and other U. S. government payrolls contribute significantly to the regional economy. The military population of Fort Bliss, Biggs Air Force Base, and William Beaumont General Hospital has averaged about 25,000 men during the past 10 years. White Sands Missile Range and NASA's Apollo site near Las Cruces have also contributed heavily to the regional economy. The growth of government employment, including military associated employment, in the region is attributable to the accelerated tempo of U. S. defense and space activities in the 1960's. Major portions of the government-related economic base of the area must be described as tenuous. Changing national military commitments and a redirection of national priorities will have a significant impact upon the economy of the area.

Light manufacturing plants, principally makers of work and sports clothing, have been attracted to the area by the abundance of unskilled and semi-skilled, low-cost labor. El Paso is now one of the largest clothing manufacturing centers in the United States.

The region is the home base of construction companies of state and national importance, and the construction industry employs six percent of the region's labor force. The El Paso area also has some heavy industry, including smelting and refining of copper and associated metals, refining of petroleum, steel product mills, and the manufacturing of cement, bricks, and other building products.

Geographic setting has been a determining factor in the establishment of the El Paso-Juarez metropolitan areas as a major transportation, communications, and distribution center for northern

Mexico and southwestern U. S. Las Cruces, El Paso, and Juarez are all significant transportation junctions; three interstate highways converge on the region, two rails lines in the U. S. and one in Mexico serve the area, and El Paso has an international air traffic terminal.

El Paso's dominance of the regional economy is characterized by its significant volume of retail sales. The strongest segments of El Paso retail trade are general merchandise, automotive, furniture, appliances, and food. Related wholesaling activities have increased markedly during the past 20 years. These gains can be attributed to the increasing importance of El Paso as a trade center to the regional importance of wholesaling of natural gas products. Retail sales in Las Cruces, a secondary trading center generate per capita sales similar to El Paso.

Tourism is a major industry in the region due to the year-round mild climate and the local attractions. An active advertising program, conducted in part in national magazines, promotes area tourism. Regional tourist attractions are the gypsum sand dunes at White Sands National Monument; the mountain resorts of Cloudcroft and Ruidoso, New Mexico, with their scenic drives, Indian reservations, mountain trout streams and lakes, winter sports, and many other features; Elephant Butte and Caballo Lakes; the Black Mountain Range; the Carlsbad Caverns National Park; the historic and cultural sites in El Paso and Las Cruces; and the city of Juarez. Ciudad Juarez is probably the major tourist attraction in the region.

Agriculture represents a significant aspect of the regional economy. The livestock industry is very important in the region. Carrying capacities range from two to about 13 animal units per square mile, and roughly 100 acres of grazing land are required to support one animal unit. In addition to range cattle, there are several intensive livestock operations including dairy cattle, feeder cattle, and poultry in the region. Large numbers of cattle have been imported from Mexico in some years, and cattle feedlots and slaughtering and processing of beef are becoming important.

There are three irrigation districts in the region: the Elephant Butte Irrigation District in New Mexico, the El Paso County Water Improvement District No. 1, and the Hudspeth County Conservation and Reclamation District No. 1 in Texas. Irrigation is essential to farming in the region; however, no expansion of irrigated agriculture is anticipated as all of the surface water rights are assigned by either the Rio Grande Project of the Bureau of Reclamation or the International Water Treaty of 1906 which allocated Mexico 60,000 acre-feet per year. The Rio Grande Project includes irrigated lands in both U. S. states.

The Hudspeth District is threatened as an economic entity because its surface water supply is based on contractual privileges for excess and return-flow waters from the Rio Grande Project. These return flows are no longer a dependable source of supply. The drought in the 1950's caused the surface supply to be significantly less than needed to meet the requirements for the Rio Grande Project and, as a consequence, the Hudspeth District suffered serious reductions in both the quantity and quality of excess surface and return-flow water availability.

Employment Characteristics

Unemployment and under-employment is endemic in the region. Unemployment in Dona Ana county, New Mexico, was as high as seven to eight percent during some months in 1971. Dona Ana county averaged 6.4 percent in 1970, and El Paso county averaged 5.4 percent. Minority group members comprised a larger percentage (52.3) of the labor force than non-minority group members (47.7), but unemployment among minority group people is significantly higher than for the remainder of the labor force (8.0 percent versus 5.8 percent for Dona Ana county in 1960).

An estimated 15,000 Mexican nationals who reside in Juarez cross the border daily to work in the U. S. The demand for unskilled farm labor in the U. S. is decreasing as farms become more mechanized.

This factor, combined with decreasing U. S. imigration quotas, has resulted in a build-up of applicants for permanent working papers who must wait one, two or more years for their papers to be processed. As long as the border region maintains a higher standard of living than the rural areas of Mexico, migration will continue, providing continuous renewal of the unskilled labor supply in Juarez.

Retail sales employment in El Paso is responsible for about 20 percent of the non-agricultural labor force. While retail activity is primarily viewed as an industry serving the local community, its growth, as well as the importance of retail employees in the overall picture, indicates that some local growth can be attributed to outside demands. To the extent that El Paso is a trading center for the surrounding territory, population increases in the trade area account for the rise in retail employment. Retail trade contributes less than nine percent of the employment in Las Cruces.

Manufacturing employment in El Paso accounts for about 20 percent of the non-agricultural labor force. During the 12-year span between 1950 and 1962, new manufacturing jobs in El Paso county increased by 61.5 percent, a growth rate significantly higher than the national average. In the Las Cruces area, manufacturing employment has increased significantly. In 1966, less than three percent of the work force was employed in manufacturing while in 1970 manufacturing employed 6.9 percent of the work force.

Income Characteristics

The median family income in 1969 for the U. S. was $8,323, and for El Paso county, $7,792; for Dona Ana county in New Mexico it was $7,395. In Dona Ana county, 20.5 percent of the families had incomes below poverty level in 1969. Approximately one-third (32.8 percent) of the Spanish families have incomes below poverty level, and the percentage of Black families is almost as high (31.5 percent). While the median family income of El Paso is lower than would be expected for a city of its size, the distribution of family income shows less dispersion than the balance of urban Texas. In 1960 in Dona Ana county, New Mexico, almost 53 percent of the residents were from one of the three regional minority groups; Spanish-surnamed, Black, or Indian. The 1969 per capita income of Spanish-surnamed people in Dona Ana county was $1,487, and their median family income was $5,587.

Water Resources

Historical Development and Allocation of Water

Irrigation in the San Marcial to Fort Quitman section of the Rio Grande basin dates back to the establishment of a mission church in 1659 in Ciudad Juarez. While under the control of Spain, irrigated agriculture in the upper El Paso Valley reached approximately 40,000 acres. However, by the mid-1800's this acreage had been reduced to a fraction of the initial development because of drought, political turmoil, depredations by hostile Apache Indians, lack of proper drainage, and other reasons. Following the Mexican War, the irrigated areas of this section were confined to lands that were contiguous to settlements, and farmland did not amount to more than a few thousand acres. Much of the region's commerce centered around the development of the many small communities along the river that relied on the diversion of the flow of the Rio Grande for irrigation of valley farms. A number of private irrigation companies began developments in the Rincon, Mesilla, and El Paso Valleys; most were ill-conceived, relatively crude attempts to divert the flow of the river into a ditch, to water a few hundred acres at best. As early as 1878 water shortages occurred in the Mesilla and El Paso Valleys.

The 1848 Treaty of Guadalupe Hidalgo established the territorial division and boundaries between the U. S. and Mexico, but it made no reference to the division of waters of the Rio Grande. The treaty established the first joint commission of the two governments for the purpose of marking the boundary from San Diego to the mouth of the Rio Grande. This project was completed in the early 1850's. At that time the principal concern of both countries was the use of the river for navigation, for at that time there was little development along the river and therefore little need for water for either domestic or irrigation use. The treaty prohibited construction, without mutual consent, of works to enable regulation of the waters "that may impede or interrupt in whole or in part the exercise of the navigation rights of each country." This same prohibition was confirmed in the Treaty of 1853 which continued in effect until the Water Treaty of 1906 and the subsequent Water Utilization Treaty of 1944 were agreed upon.

The Convention of 1889 established the International Boundary Commission consisting of a U. S. Section and a Mexican Section, each headed by a Commissioner appointed by its government. This Convention was called to resolve all differences or questions that had arisen along the border, but it made no decisions on the regulation or allocation of water resources.

The first indications of water supply problems in the El Paso-Juarez Valley came in 1878, and shortages became increasingly serious for farmers in both countries by the 1880's. In 1894, local Mexican officials complained to their Minister in Washington that the Juarez region was becoming depopulated due to increased uses of water upstream in the U. S. which resulted in shortages in the Juarez Valley area. In 1896, the U. S. and Mexican representatives of the International Boundary Commission met to study the problem. The findings were that upstream diversions had reduced the flow of the river in the El Paso-Juarez areas and that a dam was needed for regulation to preserve flood flows. Studies were made and a site selected that became the Elephant Butte Dam.

The Water Treaty of 1906 resulted from these studies and negotiations to divide the waters of the Rio Grande above Fort Quitman (located at the end of the El Paso-Juarez Valley). This Treaty provided that after the completion of the proposed storage dam, the U. S. would deliver 60,000 acre-feet annually to Mexico in the bed of the Rio Grande at the head of the Acequia Madre, the Mexican canal opposite El Paso, except at times of extraordinary drought or serious accidents to the system in the U. S., and that during such times, the water supply delivered to Mexico would be diminished in the same proportion as waters delivered to lands under irrigation systems in the U. S. section. This was to be effective upon completion of the dam. The dam, diversion works, and the canal system were completed in 1916. When created, Elephant Butte Reservoir had a capacity of 2.6 million acre-feet. Soon after irrigation was started, water-logging of the farmlands made apparent the need for a drain system to lower the groundwater table. Such a system was completed in 1925.

The dam was built, but it did not solve all the problems. There was still a need for equitable diversion and regulation of the remainder of the Rio Grande. This need was recognized by both countries in the early 1900's, but no progress was made. In 1924, the two governments established a joint commission--the International Water Commission--but the negotiators were unable to reach final agreement. The International Boundary Commission assumed the duties, powers, and functions of this Commission in 1932. During all these years there was continued development of irrigated agriculture on both sides of the river. Flows which were often too low to serve the needs of the developed land were common and high flood flows that caused heavy damages to both urban and irrigated lands were experienced, particularly in the lower reaches of the Rio Grande.

In 1938, Caballo Dam was built 22 miles downstream from Elephant Butte to provide an additional 0.34 million acre-feet of storage to permit the use of Elephant Butte Dam as a hydro-electric facility and to provide flood control.

The Water Treaty of 1944 resulted from a need to regulate the river because of flows too low on the Lower Rio Grande to serve the needs of the developed land and because of high flood-flows that regularly caused heavy damages to both the urban and irrigated lands. This Treaty provided for the renaming of the 1889 Convention Commission to the International Boundary and Water Commission and for its powers to regulate the waters of the Rio Grande. The 1944 Water Utilization Treaty provided for an International Boundary and Water Commission and gave it power to regulate the waters of the Rio Grande. Under its provisions, international storage and diversion dams have been built.

Division and regulation of the flows of the river in the region are exercised through international treaties and interstate compacts. The administration mechanisms for water allocation and use are now well developed and appropriate to deal with water problems of this nature.

Regional Water Resources

The production of water in this reach of the Rio Grande is negligible, and this region probably comes as close to using the last drop of available water for man's needs as any other major river basin in the United States. Some tributaries have relatively large drainage areas, but all are ephemeral; the flow of the Rio Grande is normally depleted and the river bed is often dry in some reaches.

The three main sources of water available for use in this region are:

(a) surface flow of the Rio Grande into Elephant Butte and Caballo Reservoirs;

(b) local runoff and infiltration originating from precipitation; and

(c) local groundwater reserves.

All surface water in the Rio Grande is fully appropriated, and changes in surface flow have caused some concern. The 1970, 75-year mean average for the Rio Grande at San Marcial is 924,000 acre-feet; however, the 10-year moving average (1960-1970) is 621,000 acre-feet. The amount of water being delivered to Elephant Butte Reservoir has decreased over the years due to drought and increased water use in the San Luis Valley in Colorado.

The Rio Grande Compact contemplates that a "normal" water supply for the Rio Grande Project, including the 60,000 acre-feet allocated to Mexico, would be a release of 790,000 acre-feet from project storage. In many years the surface supply has failed to meet diversion demands and deliveries to Mexico under the 1906 Convention met the 60,000 acre-feet obligation in only 13 of the years between 1931 and 1968. The surface flow reaching the gaging station, Rio Grande at El Paso which is at the head of the El Paso-Juarez Valley, is approximately one-half of the volume flowing into the region at San Marcial in the upper reach of the river for the period of record 1951-70, inclusive. The difference between the volume of the flow into Elephant Butte and the supply at El Paso represents the gains and losses to the river; water is lost through evaporation in Elephant Butte and Caballo Reservoirs through the river and canal transmission en route to El Paso, through phreatophytes, through urban uses, and through the consumptive use of water by the irrigation of lands above El Paso; water is gained through tributary inflows. Virtually every sector of the region's economy is being sustained in some degree by groundwater; however, these groudwater resources have not been quantified or qualified and much detailed information is required to inventory this resource. Since 1951, over 1,800 wells have been drilled in the Rincon-Mesilla Valley, primarily for supplemental irrigation purposes due to a critical shortage of previously available irrigation water between 1951 and 1957. The quality of the water from many of these wells is considerably lower than surface flow quality. Over the last 20 years, approximately 40 percent of irrigation water in the region was well water, and this is a considerable increase over the years prior to 1951.

Agricultural Use of Water

Agriculture constitutes a fundamental segment of the region economy. This area produces between 25-30 percent of the cultivated crop production of New Mexico.

Farm applications of about three acre-feet of water per acre are required for crop production in the region, although the amount of water needed depends on the crop, the weather, the farm soils, water quality, and time of irrigation. Surface farm applications averaged only a little over two acre-feet in the 20-year period 1951-1970, and groundwater was needed to supplement the surface supply. Groundwater withdrawals for irrigation purposes are estimated to have been between 1.0 and 1.7 acre-feet per acre per year since 1951 in the Mesilla Valley.

The shortages of irrigation water have led to the use of much poorer quality groundwater and to insufficient leaching of accumulated salts in farm soils. Irrigation return flow constitutes a significant portion of the flow in the Rio Grande at El Paso, and salinity increases as a result. Because of this water quality degradation, heavy applications of water must be made to remove accumulated salts in the soil profile which may then contaminate groundwater supplies. Increases in salinity affect municipalities and industry as well as agriculture, and salinity of soils and groundwater within the area is increasing at an unknown rate.

Because of the build-up of salts in its water supply, the Hudspeth Irrigation District has suffered drastic crop production declines. Reduced agricultural yields in the El Paso Valley, because of crop sensitivities, have resulted from high salinities in the river flow. Economic loss in the Mesilla Valley may not be as great because of the wider range of crops that can be grown with the better quality surface and groundwater available.

Municipal and Industrial Use of Water

The major source of municipal and industrial water for the users in the Las Cruces-El Paso area has been the fresh groundwater aquifers underlying the general areas. All of the cities in the basin utilize groundwater for municipal drinking water although El Paso also uses the surface supply during periods when major releases are made from the upstream reservoirs.

El Paso derives only 10-15 percent of its total water requirement from surface water which is provided by an allocation from the Rio Grande. A major part of the El Paso municipal water supply comes from a well field located approximately four miles south of Anthony, Texas, taking water from Mesilla Valley aquifers. The 1970 El Paso groundwater pumpage was 9,396.2 acre-feet for municipal use and 18,411.1 acre-feet for industrial use. The 1965 El Paso water consumption was 174 gallons per person per day and is expected to increase to over 200 gallons per person per day in the 1970's. Las Cruces is supplied by wells located in the city which produced 8,879.4 acre-feet of water in 1970 making the 1970 per-capita daily consumption approximately 200 gallons.

Long-term projections for El Paso show that municipal and industrial water needs approximate the flow of the Rio Grande at El Paso. It is presently anticipated that a large portion of this future water demand for El Paso will come from groundwater supplies. The region water resource problems are compounded by the rapid growth rate of Juarez. Degradation of groundwater quality due to irrigation return flows moving through the soil profile could result in additional treatment costs when such water supplies are used to satisfy municipal and industrial water requirements.

The existing municipal water supply facilities in the region are, for the most part, adequate to meet the present water demands although many of the systems are deficient in one aspect or another. The greatest deficiencies are encountered in those communities that rely on individual wells which are supplied by the groundwater from the shallower basin sediments. Though the amount of water may be adequate, the chemical composition in some places makes the water from these sources unacceptable for domestic uses.

Above Canutillo, Texas, in the Lower Mesilla Valley, water from shallow formations often requires treatment for iron and manganese content while water from deeper formations is usually potable without treatment. Below Canutillo, but above El Paso, water in all formations may be brackish or saline and these waters would require demineralization for domestic use. Water quality in these aquifer systems is quite variable; consequently, it is an area where additional study is needed.

The extent of fresh groundwater available and the amount which can be recovered from the aquifers of the Hueco Bolson and the Lower Mesilla Valley depend in part on the extent and movement of the more mineralized water which overlies, underlies, and adjoins the fresh water. The rate of saline water movement depends on the distribution of groundwater pumping throughout these basins, the rate of withdrawal, the rate and nature of recharge to the aquifers, and the amount of water moving into an area. Water quality for domestic use remains a significant regional problem that warrants detailed evaluation.

In the area of Las Cruces and south to El Paso, a gradual change from commercial agricultural to non-commercial agricultural uses occurs, largely due to population pressures from Las Cruces to El Paso. Pollution of shallow groundwater in the Mesilla Valley north and south of Las Cruces, and around El Paso, is taking place through increased usage of single-family residential subdivisions and trailer parks that use septic tanks and drain fields for disposal of domestic wastes.

Water quality problems related to municipal waste waters involve excessive bacteriological contamination. The fecal coliform count often exceeds 5,000 organisms per 100 ml. in this stretch of the Rio Grande. Single grab samples both below Elephant Butte and near Las Cruces have established fecal coliform counts far in excess of this level. Exact causes of this bacterial contamination are yet to be determined, since municipal sewage is responsible for only part.

The quality of streamflow in the region is adequately monitored at only two points on the Rio Grande, at San Marcial and at El Paso. The water quality station at El Paso is on international waters and this gaging station is part of the national stream quality surveillance system. The station at San Marcial is operated through a joint agency effort involving EPA, the U. S. Geological Survey, the New Mexico Environmental Improvement Agency, and the New Mexico Interstate Stream Commission.

Water pollution from municipal and industrial liquid-wastes is concentrated almost totally along the Rio Grande, particularly in the urbanized zones of Las Cruces and El Paso-Juarez. There are five municipal waste-water treatment plants in the New Mexico portion of the basin. Major waste-water treatment facilities are maintained by the city of El Paso.

Industrial point sources currently determined to be contributing to water pollution in the basin are limited to the urban area. There are a variety of small, mostly agricultural related industries (cattle ranching, chile, cotton, and pecan processing) in and around El Paso and Las Cruces, but none of these firms is causing serious water pollution problems.

Recreational Use of Water

Expanding leisure time, increased affluence, growing interest in water-related recreation, increased mobility of people, and a rising standard of living make it possible for more and more people in the region to seek and utilize water-based recreation. The demand for recreation facilities is increasing at an even greater rate than the population. Many of the most popular forms of outdoor recreation in the region such as fishing, boating, camping, picnicking, swimming, waterfowl hunting, and water skiing are restricted by limited availability of water. Even such urban activities as gardening and golf involve a significant consumption of an already scarce regional resource.

The use of water for recreation is significantly limited by the development of the region's surface water resources for irrigated agriculture. Although the value added per acre-foot of water when used for recreation is normally several times that added to the economy through agricultural activity [Wollman 1962] in the past, on a few occasions, the water levels in Elephant Butte and Caballo Reservoirs were lowered to the extent that substantial numbers of fish were killed. This took place because the right to the use of Rio Grande surface water stored in these reservoirs is exclusively for irrigation. Law suits have resulted over the distribution of water during periods of shortage. The irrigation district farmers have property rights based on historical development of the use of the water in the lakes and have made payments for a large portion of the construction and operation costs for the structure. A recreation minimum pool of 50,000 acre-feet was established by P. L. S-1119 for a period of 10 years, beginning in the winter of 1975-76 from water delivered under the San Juan-Chama Project.

The Rio Grande through southern New Mexico has a narrow flood plain along the river banks between the constructed levees. The levees are part of a flood control project operated by the International Boundary and Water Commission. Federal and state lands important to future recreational use are now in long-term lease to private individuals for non-recreation activities, principally agricultural uses. Although the area is one where water, trees, and grass for public use are in short supply, much of this flood plain is now leased for grazing. Serious efforts are now being made to insure reservation of some of these lands for future recreational needs.

Water Resources Administration

Both New Mexico and Texas have water right systems under which surface waters are subject to appropriation. The surface waters of the region have been fully allocated for many years, but the closely associated groundwater system is still open to development. In addition to the municipal water wells that pump from various aquifers making up the common system, there are a large number of irrigation wells used to supplement the surface water supply. At the present time, there are no restrictions in either New Mexico or Texas to limit additional wells or to control the drilling of wells, although in New Mexico the State Engineer could declare the New Mexico portion of the region a closed basin and regulate and restrict further withdrawals.

CHAPTER III

METHOD AND PROCEDURES

The region's economic structure was described in two input-output (I-O) models, one for El Paso and Hudspeth counties in Texas and the other for Sierra and Dona Ana counties in New Mexico. The two subregion I-O models were linked together in terms of trade flows between them to form an integrated model of the economy of the total study region. Appendix A includes more detailed analysis of the construction of the I-O model. A mathematical formulation of the socio-economic model appears in Appendix B.

This chapter centers on a methodological discussion of: the socio-economic model; regional hydrologic characteristics; water diversions and depletions; data concerning local recreational and employment needs; and resource availability.

Socio-Economic Model

The socio-economic model is essentially a linear programming model designed to represent the economy of southcentral New Mexico and southwest Texas with special emphasis on the four counties under investigation. The technical coefficients for the socio-economic model are derived from two subregion I-O models for (a) the two New Mexico counties and (b) the two Texas counties. It places sets of constraints upon the predominantly water-related resources for each subregion.

These constraints include:

(1) Recreational resources available
- a) Water skiing
- b) Boating
- c) Fishing

(2) Water resources available
- a) Surface supplies
- b) Ground supplies
- c) A combination of both

(3) Pollution carrying capacities
- a) Biological oxygen demand (BOD)
- b) Chemical oxygen demand (COD)
- c) Total dissolved solids (TDS)
- d) Suspended soils (SS)
- e) Nutrients (both phosphorus and nitrogen compounds)

(4) Human resources
- a) Labor force
- b) Population

Model Description

The socio-economic model, a mathematical programming model, was developed to incorporate I-O coefficients for the production sectors of the economy and the socio-environmental impacts similar to Lansford's 1973 model for studying the Rio Grande in New Mexico. It includes outputs from prior subinvestigations of the Rio Grande study area [Lansford, et al., 1973] and can be used to project future water-use patterns and economic development under a variety of legal, institutional, social and environmental assumptions.

The model's optimum solution for a given set of economic and demographic conditions is obtainable by maximizing its objective function expressed as net total value added. Each production sector in each subregion contributes to the total value added according to output. Negative impacts like water pollution or unemployment impose a cost to the system. In any given case, the optimum solution will match production sectors and their geographical distribution in a way which meets final demands and resource availabilities while also taking environmental and social effects into account.

A key component of the current model is the I-O model based on the 1967 Upper Rio Grande (URG)-Texas Input-Output Table compiled in 1972 by George and Richards of the University of Texas at El Paso. URG data served to facilitate development of I-O tables for both parts of the region. Calculating transactions between them made it possible to derive an interregional I-O table.

The URG material included 65 production sectors. For purposes of the present investigation, these were aggregated into a 38-sector matrix for each subregion (Table 2).[1] This was necessary for two reasons: (1) lack of reliable secondary sources for updating all 65 private sectors and (2) the time and cost of gathering more data would necessarily come at the expense of economic analysis and consideration of policy implications.

Three major criteria governed creation of the 38-sector matrix. First, was the need to account for labor skill patterns among the original sectors to assure comparable SIC codes. Second, water-use patterns and similarities in water coefficients according to national and regional studies played a role in the aggregation process. And third, the new matrix had to possess a set of input structures similar to the original 65-sector model.

The objective function was constructed to maximize value added within the study region to several cost components (for a mathematical description, see Appendix B). Typically, value added per unit measures payments to households as wages, to government as taxes and to business as profits. The goal, therefore, is to achieve the greatest possible "net addition" to the study region. Cost components serve as mechanisms which encourage the system to use the "resources" in an "efficient" manner.

One cost component puts a high price in the initial model on generating recreation capacity in a subregion. This keeps the building of recreational facilities to a minimum until all resources present are in use and maximum transfers have taken place.[2] Another cost component places a price on the system for "transferring" recreational capacity. This is less than the cost of new construction, but it still remains a factor since the absence of facilities nearby leads to decreased use and the expense of travel to facilities elsewhere.

Violations of pollution standards or the need to treat water before discharging it imposes a further cost on the system. Thus, a price is paid for excessive pollution. Similarly, there is a cost assigned to transferring pollution-carrying capacity from one subregion to the other, but it is lower than for clean-up efforts within a single subregion. Cost varies according to several stream flow characteristics and the relationship between the actual point of pollution and surrounding areas.

Transferring surface water between subregions also imposes a cost on the system. Shifts in the location of water use produce definite losses or gains. Taking advantage of water's waste-carrying ability or its recreational value in one place means diminishing its value for these purposes in another. In addition, any such transfer leads to legal restraints and costs.

[1] Irrigated agriculture was disaggregated into three separate sectors.

[2] These transfers include movement to and from recreational areas outside the four county study region.

Table 2. Economic sectors and SIC codes for study area I-O models

Sector Number	Sector Title	Related SIC Codes*
1	Grain & Hay	0113, 0313
2	Cotton	0112
3	Other Irrigated Crops	0122, 0123, 0119
4	Livestock, Dairy, Poultry	0235, 0135-36, 0132, 0133-34
5	Agri. Service & Supply	5962, 69, 0712-15, 19, 22-23, 0729, 31, 41
6	Mining	1311, 12, 81-82, 89, 1411, 22-23, 29, 42, 46, 52, 56, 59, 76-77, 92, 99, 101-103, 05-06, 08-09
7	Construction	1511, 1611, 21
8	Maintenance & Repair	1700
9	Food Processing	2011, 13, 15, 21-24, 26, 42, 51-52, 31-38, 91-99, 61-63, 7-72, 82, 84, 86-87, 2121
10	Textiles & Apparel	2211, 21, 31, 41, 51, 53, 56, 59, 2261-62, 69, 71-72, 79, 81, 84, 91, 93-95, 97-99, 2311, 21-23, 27-29, 31, 35-37, 99, 41-42, 51-52, 61, 63, 69, 2371, 81, 84-87, 89, 91-97, 99
11	Lumber	2421, 26, 29, 31-33, 41-45, 91, 99
12	Furniture	2511-12, 14-15, 19, 21-22, 41-42, 91, 99
13	Boxes & Paper Containers	2641-47, 49
14	Printing & Publishing	2651-55, 2721, 31-32, 41, 51-53, 61, 71, 82, 89, 91, 93-94, 99
15	Chemicals	28121-24, 32-34, 91-99, 28211-17, 19, 2841-44, 51, 61, 91-93, 95, 99
16	Petroleum	2911, 51-52, 92, 99
17	Rubber & Leather	3069, 79, 3111, 31, 41-42, 51, 61, 71-72, 99
18	Glass, Stone, Clay, Cement	3221, 29, 31, 51, 53, 55, 59, 61-62, 69, 81, 91-92, 95-97, 99, 74-75, 01, 93, 71-73, 41
19	Primary & Fabri. Metals	3312, 13, 15-17, 31-33, 39, 41, 62, 69, 91-92, 99, 3441-44, 46, 49, 71, 79
20	Machinery	3532-36, 61-62, 64-67, 69, 81-82, 86, 89, 99, 3611-13, 21-22, 24, 29, 41-42, 44, 31-36, 39, 51, 61-62, 71, 74, 79, 93-94, 52, 99, 91, 3713-15, 11, 3811, 41-43, 51, 31, 61, 71, 3941-42, 49, 11, 13-14, 31, 51-53, 55, 61-64, 82-84, 87, 91, 93, 95, 99
21	Railroad Transportation	4011, 13, 21, 41
22	Intercity Freight	4131-32, 4213, 31
23	Trucking & Warehousing	4212, 14, 21-23, 24-26
24	Air Transportation	4511, 21, 82-83
25	All Other Transportation	4612-13, 19, 4111, 19, 21, 40-42, 50, 71-72, 4742, 82-84, 89, 4721
26	Communication Services	4811, 21, 32-33, 99
27	Gas Utility	4922-23, 32, 9149, 9249, 9349
28	Electric Utility	4911, 31, 9151, 9251, 9351
29	Water Utility	9102, 9202, 9302, 4941, 52-53, 59, 61
30	General Wholesale	5012-14, 41-49, 52-54, 59, 4731, 5081-85, 87-88, 92, 22, 28-29, 33-34, 36-37, 39, 63-65, 72, 74, 77, 91, 93-99
31	General Retail	5211, 52, 21, 31, 41, 51, 5311, 31, 99, 5411, 21, 31, 41, 51, 62, 99, 5611, 21, 31, 41, 51, 61, 71, 81, 99, 5712-15, 19, 22, 32-33, 5912, 21, 32-33, 42-43, 52-53, 91-92, 99, 71, 82, 84, 93-97, 99, 41, 51
32	Auto Dealers	511, 21, 31, 7549, 31, 34-35, 38-39, 42
33	Gas Service Stations	554
34	Eating & Drinking Places	5812-13
35	FIRE	6011-59, 6112-61, 6312-99, 6411, 6211-81, 6512-61, 6611, 6711-99
36	Lodging	7011, 21, 41, 31-32
37	Personal Services	3111, 8931, 7211-18, 31, 41, 51, 61, 71, 99, 7813-18, 21, 7395, 7221, 7331-32, 39, 7311-13, 19, 7832-33, 7911, 29, 32-33, 41-43, 45, 49, 7523, 25, 7512-13, 19, 7622-23, 29, 7631, 41, 92, 94, 99
38	Professional Services	8011, 21, 31, 41, 61, 71-72, 92, 99, 8211, 8221-22, 31, 41-42, 99, 8911, 7361, 7391, 8921, 7341-42, 49, 51, 92-94, 96-99, 73, 8999, 8411, 21, 8611, 21, 31, 41, 51, 61, 71, 99, 8811

*Source: *U. S. Office of Management and Budget, Standard Industrial Classification Manual.*

Still other costs arise for "allowing" segments of the labor force to remain idle within a subregion. Unemployment insurance and welfare benefits are just two of the burdens worker lay-offs place upon the study region.

There is also a definite price to the entire system whenever more water is made available to one subregion through measures like water salvage, intrabasin transfers and acquisition of water rights. Reduction in agricultural production in either subregion due to reduced availability of water or the bidding away of this scarce resource by other economic sectors will impose some costs upon the whole system. This may be reflected in increased agricultural imports, decreases in some land values and reductions in sales revenues. Under these circumstances, exact losses may vary considerably according to how local prices are affected.

Thus, the model serves its objective function by maximizing value added subject to the following costs:

(1) Under-utilization of the labor force (unemployment);

(2) Transfer cost

a) Pollution-carrying capacity of a stream

b) Excess recreation capacity

c) Excess water

(3) Maintaining stream standards

(4) Creating additional recreational use capacity

(5) Adding additional water to each subregion

(6) Reducing agricultural production and capacity

It is worth noting that the actual value of the objective function is of less importance than the transfers, movements and additions of resources which may be examined individually in various solution sets from the model. Differential pricing of the above cost components can be evaluated in terms of impacts on the model solutions by the optimum allocation mechanism of the objective function.

Model Components

Conclusions drawn from the socio-economic model are only as good as the assumptions involved in its creation and the reliability of basic input data. Consequently, much of the time and effort for this study went in preparing basic hydrologic, agricultural and economic data. This involved the use of much material from previous studies either in its original form or in specially modified or updated form for use here.

Hydrologic Data

No evaluation of water use can proceed without determining the availability of both surface and groundwater. Within the trough of the Rio Grande study region, exchange between the river and the surrounding alluvium is continual [Lansford, et al., 1973; Meyer, 1976]. For a good description of the pumping effect there must be a model of this exchange.

Due to natural conveyance and evaporation losses, it cannot be assumed that water in one subregion can be transferred intact to the other. There must, therefore, be adjustments in varying proportion to quantities transferred. Moreover, the intimate relationship between the region's ground and surface water means the availability of the former is affected not only by pumping but also by precipitation, the amount and frequency of stream runoff, return of irrigation water and evaporation. The management of such a system should always take into consideration how drawing on one type of water will affect supplies of the other.

Comprehensive analysis of alternative uses depends upon knowing both groundwater availability and the likely behavior of the aquifer under stress. Since historical records of the hydrologic system are generally too sketchy for direct assessment of basin behavior, the present study used previously developed groundwater system simulators for both the New Mexico and Texas subregions [Lansford, et al., March 1973; Lansford et al., May 1973; Meyer, 1976]. For a more complete description of the New Mexico model, see Brutsaert and Way (1973) and for Texas see Bredhoeft and Pinder (1970).

Water Diversions and Depletions

The quantity of water used in the study region for all purposes was an important precondition for evaluating alternative uses. Diversions and depletions by agriculture, municipalities and industry, the three major water-using sectors, were determined for both subregions.

Agricultural

Irrigation water in the region comes from both surface and ground sources with the latter used primarily as a supplemental source. Since there were no records of groundwater pumping, it was necessary to estimate its extent theoretically. The approach developed by Blaney and Criddle in 1962 was used to estimate the consumptive irrigation (CIR) needs of the study regions. The Blaney-Criddle formula has seen widespread use and is considered a reasonable estimator of agricultural water use.

This method offered a theoretical figure for total water consumption by irrigated agriculture. The Bureau of Reclamation supplied data on surface water delivery for Elephant Butte Irrigation District to which calculations for the remaining smaller community and private systems were added. Subtracting surface water delivery from total irrigation requirements provided an estimate of how much groundwater pumping had occurred.

Good cropping data for the Texas subregion were not available outside the irrigation districts. In its absence, researchers used the *1969 Census of Agriculture* and annual Bureau of Reclamation reports for estimates of crop acreage and patterns. Where differences turned up between the New Mexico and Texas subregions, the theoretical CIR and irrigation requirement coefficients for Dona Ana and Sierra counties were adjusted to reflect Texas conditions. Coefficients thus constructed for El Paso and Hudspeth counties should furnish a reasonable indication of their agricultural water use.

Municipal and Rural Domestic

Figures from the New Mexico State Engineer Office and the Bureau of Census served for estimated diversions and depletions. These calculations on a per capita basis with adjustments to reflect only actual withdrawal by the urban population were judged to be adequate measures of rural and domestic water use in the region.

Industrial

Estimates of water diversion and depletion per unit of industrial production came from several sources. Manufacturing estimates were calculated using national data and averages based upon SIC code classifications (Census of Manufacturers). For each sector within each subregion, a weighted national average was used to estimate coefficients. For mining, Dona Ana's and Sierra's portion of New Mexico's total mineral production was weighted against Stotelmeyer's estimate of the state's total water use in 1962. Similar procedures yielded indicates of water use in oil and gas production.

The sector's remaining coefficients, relating mainly to trade and allied services, were derived from several studies made in California, Utah, and Arizona. Model construction assumed there was no difference among subregion water-use coefficients in mining, manufacturing, and trade and services. It was assumed that all coefficients developed were applicable for the study region.

Population and Employment Data

Figures and coefficients dealing with population came from the U. S. Censuses of 1950, 1960 and 1970 and though the hydrologic and political boundaries do not exactly coincide, the vast majority of economic and demographic activity occurs within the hydrologic drainage area. Reports on the population of each subregion made it possible to calculate percentages of distribution and change within the study area.

The Upper Rio Grande Valley--Texas Industry study by George and Richards (1972) plus reports by the New Mexico Employment Security Commission and the Texas Employment Commission provided employment data. Adjusting aggregate statistics from the latter two bodies produced coefficients for the region which could then be calibrated for each economic sector in the present study. Such adjustment was necessary to make sure that a summation of each subregion's employment equalled overall economic activity in the counties as reported by the Commissions. Government and miscellaneous employment for each subregion were included as aggregate numbers in each subregion's total.

Recreation

The socio-economic model also incorporates the primary water-related forms of recreation: boating, water skiing, and fishing. In any given year, each person in each subregion will demand a certain number of activity occasions in any or all of these activities. Investigators may regard the demand thus created in one of two ways: (1) as actual participation; and (2) as desired participation. Recreation demand studies in the United States have made use of both of these concepts.

The need for a detailed breakdown in the mathematical programming model led to the use of ORREC study report 19 entitled "National Recreation Report" (1962). This study used demand in the "desired" sense which implies that not all demand would actually be realized during every time period in every area of the country. Desired demand has the additional drawback of failing to consider willingness to pay as does economic demand. The model overstates somewhat the actual demand for recreation. However, this overstatement may not be too severe since the ORREC study dates from 1960-61.

Previously developed criteria for New Mexico's recreational needs [Lansford, et al., 1973] are also used here. Final-use criteria regarding the state's ability to provide boating, water skiing and fishing came from several sources, primarily the State Game and Fish Department, the Department of Parks and Recreation, and the State Planning Office. The estimated inventory for Dona Ana and Sierra counties appears in Table 3. Also included are estimates for Texas based on various publications from that state. The combined acreage is assumed to be available for all three activities with water skiing and boating being the dominant uses.

The use criteria or standards used for this study were as follows:

(1) Boating--1.67 acres of water per activity occasion per day (three people per boat)

(2) Water skiing--2 acres of water per activity occasion per day.

Total surface areas in the combined category were assumed to be used primarily by boating and water skiing since fishing uses these areas with the least intensity. Surface acreage was evenly divided between boating and water skiing and standards adjusted downward somewhat to account for

Table 3. Estimated recreational availability of stream and lakes, by region, Lower Rio Grande Study Region

Region	Miles of Stream			Acres of Water in Lakes and Reservoirs[a]		
	Trout Stream	Warm Water	Total Miles	Fishing Only	Combined Use	Total
	-miles-			-acres-		
New Mexico Subregion	34	182	216	28,095	23,734	51,829
Texas Subregion	0	113	113	18	52	70
Total	34	295	329	28,113	23,786	51,899

[a]Maximum supply available at spillway.

fishing that would normally take place upon combined acreage. The use criteria presented above reflects the adjustments.

(3) Fishing--each activity occasion per day requires 3.5 surface acres (taking into account the combined acreage) or 1/2 to 1 mile of trout stream, or 1/4 to 1/2 mile of river.

The stream and river standards were not the same for each subregion because of the varying conditions on each stretch of water. Certain portions of the Lower Rio Grande Region, for example, are best suited to fishing. Such use criteria are intended as maximal rates given the quantity and quality of waterways, past quantity and quality of fish (both native and stocked), and future analysis of carrying capacities of the river's main stem and certain streams that flow into it. Inventory and use-criteria standards made possible estimates of the upper limit for future use was assuming that actual use manifests itself daily and that lakes, reservoirs, streams, and rivers maintain their 1967 levels and water-carrying capacities. These upper limits are presented in Table 4. Multiplying each activity by 365 (number of days in a year), one can obtain the maximum possible supply on a yearly basis for each activity in each subregion.

Nearly all recreational facilities in the region are located in New Mexico, primarily at the Elephant Butte and Caballo Reservoirs on the Rio Grande. Therefore, all but a small percentage of the realized opportunities Texans have for fishing, boating, and water skiing will be in New Mexico.

Table 4. Estimated water-based activity-occasion per day capacity by type and subregion, Lower Rio Grande Study Region

Subregion	Activity Occasion Per Day Capacity		
	Fishing	Boating	Water Skiing
	-activity-occasion days-		
New Mexico Subregion	12,000	7,106	5,934
Texas Subregion	590	15	10
Total	12,590	7,121	5,944

CHAPTER IV

RESULTS AND IMPLICATIONS

The purpose of this chapter is to present alternative futures for the study region using three scenarios incorporating two population growth alternatives and three water policy alternatives. In this chapter, water use and the agricultural sector results will be stressed because of their importance to the study region and in the interpretation of the socio-economic model results.

Secondary data were compiled and used whenever possible. The basic secondary data included the input-output and hydrologic models. Primary data were obtained to supplement the secondary in a number of the study areas where more detailed information was required for the socio-economic model.

The Socio-Economic Model

The socio-economic model was utilized to simulate long-run production and water utilization patterns in the region under alternative assumptions. Each simulation process starts with the same basic solution to the model and continues with annual changes to satisfy the alternative conditions for a period of 50 years. The base period (basic solution) used 1967-1970 conditions and closely approximates the actual production levels and resources used in the base year (1970). Differences between the base period of the model and the actual production levels in 1970 result from the optimization procedures used. The optimal use of resources in the model allows for social considerations such as recreation demands, stream quality standards, and unemployment levels. This base period was used as a point of departure for the alternatives; hence a description of the base period is presented first.

Base Period

The economy of the subregions, New Mexico (Dona Ana and Sierra county) and Texas (El Paso and Hudspeth counties), has been discussed in some detail previously. By adjusting the production or output estimates developed for the input-output tables by inventory changes, and allowing for round-off errors, a match is obtained between those estimates and the estimates contained in the base period. The base period in terms of output, value added, employment, and water use for both subregions is presented in Table 5.

The Texas subregion far out-produces the New Mexico subregion in most sectors, and consequently utilizes more of the water resource. Manufacturing plays a greater role in the Texas economy than in New Mexico, and subsequently constitutes a greater proportion of value added and employment. By examining the first several tables in Appendix C, a better description of the economies and sector-by-sector water utilization of each subregion can be obtained.

A summary of the values contained in Table 5 for both the New Mexico and Texas subregions is presented in Table 6. Although the estimated total water consumption is not significantly different from one subregion to the other, economic output measured in either dollars or employees is. In addition, there are very noticeable differences in the make-up and distribution of output, value added, employment, and water use within each subregion's economy.

Agricultural output in the New Mexico subregion is approximately 30 percent greater than in the Texas subregion, and yet requires less water due to the lower proportion of irrigated crops as opposed to livestock, dairy, and poultry production (which needs far less water per unit of output). Agriculture is much more dominant in the New Mexico subregion's economy than the Texas subregion (Table 6). Manufacturing and Trade and Services comprise 20 percent more of the production base in Texas than in New Mexico.

Table 5. Production, value-added, employment, and water uses by production sector, Rio Grande Study Region, base period, 1970

		New Mexico Subregion					Texas Subregion				
Sector[a]	No	Output ($ thousand)	Value Added ($ thousand)	Employment	Water Depletion (acre-feet)	Water Diversions (acre-feet)	Output ($ thousand)	Value Added ($ thousand)	Employment	Water Depletion (acre-feet)	Water Diversions (acre-feet)
Agriculture											
Grain & hay	1	1,709	1,080	96	71,471	154,118	2,403	906	97	89,439	137,620
Cotton	2	5,507	3,513	621	93,784	204,915	7,005	2,800	567	119,295	183,531
Other irr crops	3	15,005	3,722	903	47,416	103,534	4,106	1,348	177	15,028	23,138
Livestock	4	18,110	4,628	1,650	10,100	19,567	17,702	4,523	1,154	12,033	23,375
Ag service	5	2,810	957	330	33	55	2,200	749	185	26	43
Mining	6	4,528	3,374	38	106	265	4,705	3,506	158	110	275
Construction											
Construction	7	37,024	14,667	1,148	652	1,629	178,500	70,714	5,569	3,142	7,854
Maintenance & repair	8	3,800	2,501	100	67	669	19,389	12,761	708	341	3,412
Manufacturing											
Food processing	9	6,514	2,238	510	34	339	85,417	29,350	9,276	444	442
Textiles & apparel	10	1,656	655	41	11	106	164,382	65,002	5,704	1,052	10,520
Lumber	11	0[b]	0	0	0	0	6,180	244	262	40	396
Furniture	12	0[b]	0	0	0	0	2,213	757	273	14	142
Boxes & paper cont	13	0[b]	0	0	0	0	597	141	15	2	17
Printing	14	1,908	1,107	71	5	53	12,661	7,346	653	35	355
Chemicals	15	0[b]	0	0	0	0	5,594	1,932	77	209	2,092
Petroleum	16	0[b]	0	0	0	0	183,928	32,950	368	6,879	68,789
Rubber & leather	17	0[b]	0	0	0	0	7,252	3,165	223	59	587
Glass, stone, cement	18	1,240	515	41	8	79	15,712	6,525	724	101	1,006
Primary & Fab metals	19	249	86	1	*	5	41,067	14,230	201	78	780
Machinery	20	4,195	2,111	307	8	80	17,163	8,637	1,740	33	326
Transportation											
Rail	21	1,500	858	138	4	9	12,384	7,085	998	31	77
Intercity Freight	22	900	479	94	2	6	23,631	12,586	2,167	59	148
Trucking & warehousing	23	901	549	162	2	6	1,218	743	191	3	8
Air	24	22	8	1	*	*	8,297	3,049	469	21	52
Other	25	777	377	91	2	5	3,306	1,604	341	8	21
Communications	26	5,101	3,096	362	300	750	29,196	17,718	1,816	1,717	4,292
Utilities											
Gas	27	100	55	7	6	15	35,633	19,742	2,238	2,095	5,238
Electric	28	7,601	5,286	204	477	1,117	28,045	19,502	662	1,649	4,123
Water	29	100	54	10	6	15	7,302	3,942	615	429	1,073
Trade											
General Wholesale	30	6,903	4,324	223	34	85	105,290	65,950	5,075	516	1,290
General retail	31	18,500	11,314	1,998	31	227	103,599	63,359	16,669	508	1,269
Auto dealers	32	2,201	854	66	20	50	11,900	4,616	531	108	271
Gas service sta.	33	1,502	909	835	14	34	3,702	2,241	3,065	34	84
Eating & drinking est.	34	2,199	1,669	253	20	50	9,999	7,590	1,712	91	227
Fin, Ins, & real est.	35	31,507	20,887	643	309	772	71,352	47,301	3,939	699	1,748
Services											
Lodging	36	3,690	1,673	448	45	112	12,532	5,683	397	152	379
Personal	37	13,673	8,784	2,397	165	414	37,908	24,353	1,736	459	1,147
Professional	38	2,097	1,220	787	29	64	134,647	78,337	13,195	1,656	4,140

*Less than one acre-foot.

[a]See Table 2, page 19, for complete description of sectors.

[b]No production from these sectors in the New Mexico subregion.

Table 6. Production, value added, employment, and water use by major sector in the Rio Grande Study Region, base period, 1970

Major Sector[a]	Total Output ($ 000)	(%)	Total Value Added ($ 000)	(%)	Employment	(%)	Total Water Depletions (acre-feet)	(%)	Total Water Diversions (acre-feet)	(%)	Output per Acre-Foot[b] (dollars)	Value Added per Acre-Foot[b] (dollars)	Water Depletions per Employee[b] (acre-feet)
New Mexico Subregion[c]													
Agriculture	43,141	21.2	13,899	13.4	3,600	24.7	222,803	98.9	482,188	98.6	193[d]	62[d]	61.900[d]
Mining	4,528	2.2	3,374	3.3	38	.3	106	*	265	*	42,717	31,830	2.789
Manufacturing	56,586	27.8	23,881	23.1	2,219	15.2	785	0.4	2,960	0.6	72,084	30,422	.353
Comm, Ut, Trp	17,002	8.4	10,762	10.4	1,070	7.3	769	0.4	1,922	0.4	22,109	13,995	.719
Trade & Services	82,272	40.4	51,634	49.8	7,649	52.5	728	0.3	1,807	0.4	106,986	71,416	.095
Total	203,529	100.0	103,558	100.0	14,576	100.0	225,186	100.0	489,142	100.0			
Texas Subregion[e]													
Agriculture	33,416	2.4	10,327	1.6	2,180	2.6	235,822	91.2	367,706	74.4	147[d]	44[d]	108.175[d]
Mining	4,705	0.3	3,506	0.5	158	0.2	110	*	275	*	42,772	31,873	.696
Manufacturing	740,055	52.2	255,951	39.1	25,793	30.7	12,428	4.8	100,717	20.4	59,547	20,595	.482
Comm, Ut, Trp	149,012	10.5	85,971	13.1	9,497	11.3	6,012	2.3	15,031	3.1	24,786	14,300	.633
Trade & Services	490,929	34.6	299,429	45.7	46,319	55.2	4,222	1.6	10,556	2.1	116,279	70,921	.091
Total	1,418,117	100.0	655,184	100.0	83,947	100.0	258,594	100.0	494,285	100.0			

[a]Sectors: Agriculture 1-5; Mining 6; Manufacturing 7-20; Communication, Utilities, and Transportation 21-29; Trade and Services 30-38.

[b]These are weighted averages per acre-foot of water depletion.

[c]Dona Ana and Sierra counties.

[d]These figures are considerably higher than might be expected due to the influence of Sector 5, Agricultural Services, which contributes much to output, value added, and employment while requiring little water directly.

[e]El Paso and Hudspeth counties.

* Less than 0.05 percent.

For the base period, water utilization was measured in both diversion and depletion requirements by source, either ground or surface. Although the estimates obtained from the model do not always agree with other estimates, it is believed that the model estimates are reasonable in terms of representing a base case for alternative futures. Municipal (including "governmental") and rural water use are excluded in Table 6. The estimates indicate the quantity of water required to maintain the present regional economy. This is especially true in the New Mexico subregion where over 98 percent of production water requirements (measured as either depletions or diversions) goes to agriculture. In the Texas subregion, new water intake (diversion) requirements for agriculture are somewhat less in percentage terms due to the higher industrialized base of El Paso, but still represent a large portion of the total diversions.

Alternative Growth Projections

Two basic growth projections were developed for utilization in the various model runs. One is a relatively high estimate of future production, while the other is much closer to the majority of recent projections which is of a much lower magnitude. These two growth projections, although varying at times due to the type of alternative chosen for examination, will serve as the end points of a probable range of economic growth postulates in this study.

Although not necessary for the present model, the two basic growth projections are linked to estimates of population growth. Final demand, the driving force behind derivations of production estimates in any input-output framework, was assumed to increase at the same rate as population growth.

The population projections used in the model for the high and anticipated growth scenario are presented in Table 7. The high estimates were derived from projections made for Dona Ana and Sierra counties by the New Mexico Bureau of Business Research for 1968. Recent trends have indicated that the "high" projection is much too high. However, these projections nevertheless are utilized by governmental agencies to represent the upper bound of possible growth.

Table 7. Population projections by subregion, Rio Grande Study Region, 1970-2020

	High[a]		Anticipated[b]	
Year	New Mexico[c]	Texas[d]	New Mexico[c]	Texas[d]
1970	76,962	361,683	76,962	361,683
1980	151,510	712,000	85,630	437,870
1990	226,060	1,062,320	94,300	514,060
2000	300,610	1,412,640	102,970	590,250
2010	375,160	1,762,960	111,640	666,440
2020	449,700	2,113,280	120,300	742,630
	9.686	9.686	1.126	2.107

[a]Based upon county projections for New Mexico by the Bureau of Business Research and referred to as high in the New Mexico State Water Plan. Since no equivalent estimates exist for Texas, New Mexico's percent increases were assumed applicable to Texas.

[b]Based upon OBERS Series C projections: for Texas--utilizing the state average for both El Paso and Hudspeth counties; and for New Mexico--utilizing the BBRII county projections made for the New Mexico State Water Plan.

[c]Dona Ana and Sierra counties.

[d]El Paso and Hudspeth counties.

Texas had no equivalent high estimates. The majority of population projections or estimates available on a county, or even state-wide basis were more atuned to recent trends. Therefore, for purposes of establishing a scenario that would represent a high estimate of possible increase in the population, New Mexico's high projection percentage was applied to both El Paso and Hudspeth counties.

Even though zero population growth has been discussed and proposed as a goal recently, some expansion in the population has been occurring and will likely continue in the foreseeable future. Most estimates (projections) within the last few years are based upon (1) recent trends that take into account the lower fertility rate and (2) economic factors which lower the yearly percentage increase. The two most recent estimates developed by the Bureau of Census for the OBERS projections are Series C and the lower magnitude Series E.

Similar estimates have been made by other governmental (local, state, and federal) agencies which are believed to be more realistic for certain subareas of the nation, state, or region in question. To maintain a consistent base, the Series C projections were used as the anticipated growth rates because: (1) they were more in agreement with other projections; (2) they are the "low" estimates used in the New Mexico State Water Plan [U. S. Bureau of Reclamation, 1976]; and (3) they are further utilized as the "low" estimates for planning purposes by other state and local governmental agencies.

The high and anticipated estimates, to some extent represent projections based upon two differing trends of population growth, one prevalent in the early and mid-1960's and the other in the early 1970's. New Mexico's anticipated population growth scenario was based upon the New Mexico Bureau of Business Research's apportionment of the Series C state projections to the individual counties. No such county apportionment of the state projection has been made for Texas, therefore both El Paso and Hudsepth were assumed to mirror the state annual average increase. This likely over estimates the growth of Hudspeth county which is predominantly rural, while underestimating that of El Paso county which is urban in nature.

The final demand growth for both the anticipated and high scenarios were tied explicitly to the population increase. In the anticipated growth scenario, final demand in New Mexico was increased 1.126 percent annually, while in Texas it was expanded at a 2.107 annual percentage rate. For the high growth scenario, final demand was increased annually by 9.686 percent for both the New Mexico and Texas subregions.

Final Demand Estimates

Final demand within the socio-economic model was comprised of three separate and distinct components: household regional final consumption, governmental purchases, and exports. To maintain simplicity and consistent scenarios all three components were aggregated into the "final demand" for each subregion and tied exclusively to population growth as discussed above. However, the model will easily allow independent projections of all three components of final demand, as well as an aggregate projection for all considered together (not necessarily based exclusively upon growth in the general populace). Household consumption is primarily a function of the regional population size (but includes other components such as income, climate, and tastes). Therefore, household consumption could reasonably be directly based upon population figures. However, this may not be the case for the governmental and export components. Purchases by the local and state levels of government are related to a great extent upon regional population, but at the federal level these population-expenditure relationships are extremely weak. Exports are determined by other variables than population, such as regional and national economic activity. Perhaps a much more realistic picture of potential growth scenarios would be based upon a separate analysis of export and governmental demand. Because of the data requirements and research effort necessary to develop realistic estimates of future demand components, all final demand was based only upon the population projections in this study.

The base period values of sector output and final demand for each subregion are presented in Table 8. The percentage of output (total production) actually being allocated to final demand is reported for both subregions. A uniform increase in final demand across all sectors within the region will manifest itself according to final demands into varying production levels for the sectors. The initial production base would be significantly different by sector.

The annual dollar increase associated with each sector for both the high and anticipated growth scenario is also portrayed for each subregion in Table 8. In all of the alternatives either the high or anticipated increment was added to the base period final demand in yearly or annual increments to represent the economy at that time.

The expansion in this scenario has been tempered considerably for the agricultural sectors because (1) the non-availability of additional surface water supplies and (2) the increasing scarcity of additional suitable irrigable lands. Therefore, real increases in agricultural output are to be much smaller than in other sectors. For purposes of this analysis, no exogenous increase in agricultural final demand was permitted to take place until all processing or intermediate needs were met, i.e. food processing purchasing raw produce. In the high growth portion of the scenario, the intermediary demands were of such magnitude that greater and greater proportions of regional agricultural production were required to satisfy those needs. For the anticipated growth scenario, the same situation was evident on a smaller scale, i.e. agricultural production became more and more channeled into satisfying local processing demands.

Even with little or no growth in the final demand for agricultural production, it generally became necessary to (1) acquire more water than was available, (2) shift to ground supplies at a faster rate than is taking place today, (3) shift production from household, governmental, and export consumption to local intermediary demands at a much faster rate and level than might normally be assumed. All of the above can be measured through various mechanisms within the socio-economic model depending upon the alternative assumptions embodied in any given analysis. In the discussion on each of the major alternatives analyzed for this study, a few of the more important agricultural changes are discussed.

Recreation

Water recreation demands in the Rio Grande Study Region in the base year (1970) and selected years (10-year intervals) are presented in Table 9. Recreational demand eminating from anticipated and high population growth projections are also constructed within the table. The Elephant Butte and Caballo Reservoirs in the New Mexico subregion are capable of meeting most needs for the study region as a whole but will fall considerably short in the future due to the pressure from other areas in both states, as well as serving some of the needs of visitors from other states. Therefore, if demand is to be satisfied, additional supplies must be made available within the study region, adjacent areas, or near population centers that utilize New Mexico's reservoirs presently (such as Albuquerque in central New Mexico). Alternatively, individuals from either subregion could also satisfy their demands by traveling to the recreational areas in other areas.

No attempt was made to measure the transfer of supply from one subregion to the other as defined by movements of recreationalists to available facilities. Currently most of the movement occurs from Texas to New Mexico.

Table 8. Output, final demand, high and anticipated population growth projections for final demand changes, Rio Grande Study Region

Sector[c]			New Mexico Subregion[a] Output ($1 thousand)	Final Demand ($1 thousand)	Final Demand as % of Output	High Growth[d] Final Demand ($1 thousand)	Anticipated Growth[e] Final Demand ($1 thousand)	Texas Subregion[b] Output ($1 thousand)	Final Demand ($1 thousand)	Final Demand as % of Output	High Growth[d] Final Demand ($1 thousand)	Anticipated Growth[e] Final Demand ($1 thousand)
AG	Gr & hay	1	1,709	226	13.2	21.88[f]	2.54[f]	2,403	1,049	43.7	101.65[f]	22.11[f]
	Cotton	2	5,507	4,746	86.2	459.71[f]	53.44[f]	7,005	5,165	73.7	500.27[f]	108.82[f]
	Other irr	3	15,005	14,262	95.0	1,381.40[f]	160.59[f]	4,106	2,717	66.2	263.19[f]	57.25[f]
	Lvstk	4	18,110	5,578	30.8	540.27[f]	62.81[f]	17,702	17,094	96.6	1,665.70[f]	360.17[f]
	Services	5	2,810	770	27.4	74.59	8.67	2,200	1,460	66.4	141.46	30.77
MIN		6	4,528	901	19.9	87.32	10.15	4,705	3,738	79.4	362.11	78.77
CON	Const	7	37,024	34,210	92.4	3,313.55	385.20	178,500	178,500	100.0	17,289.51	3,760.99
	Man & rep	8	3,800	2,161	56.9	209.35	24.34	19,389	6,871	35.4	665.52	144.77
MAN	Food	9	6,514	5,744	88.2	556.41	64.68	85,417	77,727	91.0	7,528.62	1,637.71
	Text & ap	10	1,656	1,592	96.1	154.21	17.93	164,382	159,280	96.9	15,427.82	3,356.02
	Lumber	11	*					6,180	1,409	22.8	136.52	29.70
	Furn	12	*					2,213	1,786	80.7	172.97	37.63
	Boxes etc	13	*					597	341	57.1	33.01	7.18
	Print	14	1,908	1,510	79.2	146.28	17.0	12,661	10,260	81.0	993.74	216.17
	Chem	15	*					5,594	2,909	52.0	281.78	61.30
	Petro	16	*					183,928	164,125	89.2	15,897.16	3,458.12
	Rubber	17	*					7,252	6,563	90.5	635.65	138.27
	Stone	18	1,240	132	10.6	12.74	1.48	15,712	1,804	11.5	174.78	38.02
	Pr & fab	19	249	233	93.6	22.58	2.62	41,067	37,242	90.7	3,607.24	784.69
	Mach	20	4,195	3,642	86.8	352.79	41.01	17,163	14,164	82.5	1,371.95	298.44
TRP	Rail	21	1,500	868	57.9	84.06	9.77	12,384	4,594	37.1	445.02	96.81
	Incity Ft	22	900	576	64.0	55.76	6.49	23,631	15,977	67.6	1,547.54	336.64
	Truck	23	901	597	66.2	57.81	6.72	1,218	45	3.7	4.32	.94
	Air	24	22	21	95.0	2.17	.25	8,297	5,076	61.2	491.65	106.95
	Other	25	777	681	87.6	65.92	7.66	3,306	2,107	63.7	204.12	44.40
COM		26	5,101	3,200	62.7	309.98	36.04	29,196	17,370	59.4	1,682.43	365.98
UT	Gas	27	100	88	88.2	8.54	.99	35,633	20,104	56.4	1,947.25	423.58
	Elect	28	7,601	4,912	64.6	475.78	55.31	28,045	13,766	49.1	1,333.34	290.04
	Water	29	100	89	89.4	8.66	1.01	7,302	4,778	65.4	462.78	100.67
TR	Gen whsl	30	6,903	4,903	71.0	474.86	55.20	105,290	82,590	78.4	7,999.65	1,740.17
	Gen retl	31	18,500	18,110	97.9	1,754.09	203.91	103,599	100,444	96.9	9,728.98	2,116.35
	Auto	32	2,201	1,835	83.4	177.71	20.66	11,900	11,165	93.8	1,081.40	235.24
	Ser Sta	33	1,502	833	55.5	80.73	9.39	3,702	2,615	70.7	253.34	55.11
	Eat & dr	34	2,199	2,057	93.5	199.26	23.16	9,999	9,413	94.1	911.72	198.33
FIRE		35	31,507	22,088	70.1	2,139.46	248.71	71,352	29,101	40.8	2,818.69	613.15
SER	Lodg	36	3,690	3,415	92.5	330.76	38.45	12,532	10,735	85.7	1,039.78	226.18
	Pers	37	13,673	10,195	74.6	987.50	114.80	37,908	22,649	59.7	2,193.79	477.22
	Prof	38	2,097	1,919	91.5	185.92	21.61	134,647	115,054	85.4	11,144.10	2,424.18

*There was no production from these sectors in the New Mexico subregion in 1967-1970 and is assumed that there will be no production in the future.

[a]Dona Ana and Sierra counties.

[b]El Paso and Hudspeth counties.

[c]See Table 2, page 19, for complete description of sectors.

[d]High growth annual percentage increase is 9.686 for both the New Mexico and Texas subregions.

[e]Anticipated growth annual percentage increase is 1.126 for the New Mexico subregion and 2.107 for the Texas subregion.

[f]These values are set to zero usually due to the unlikely ability of agriculture to increase autonomously. See the text for further explanation.

Table 9. Recreation demand* by type, year, and subregion in the Rio Grande Study Region

	Boating		Water Skiing		Fishing	
	New Mexico[a]	Texas[b]	New Mexico[a]	Texas[b]	New Mexico[a]	Texas[b]
	(activity occasions*)					
Base Period						
1970	62,500	429,300	29,900	217,400	220,600	1,078,600
Anticipated Growth						
1980	69,400	518,500	33,200	262,600	244,800	1,301,000
1990	76,400	607,600	36,600	307,900	269,000	1,523,400
2000	83,400	696,700	40,000	353,100	293,200	1,745,800
2010	90,400	785,900	43,300	398,400	317,400	1,968,200
2020	97,400	875,000	46,700	443,700	341,500	2,190,600
High Growth						
1980	120,300	840,500	58,200	426,200	418,800	2,103,000
1990	178,200	1,251,600	86,500	635,100	616,900	3,127,500
2000	236,000	1,662,700	114,800	843,900	815,100	4,151,900
2010	293,900	2,073,900	143,100	1,052,800	1,013,300	5,176,300
2020	351,800	2,485,000	171,400	1,261,600	1,211,400	6,200,800

*Measured as desired recreational demand rather than actual recreational demand; population 12 years of age and older.

[a]Dona Ana and Sierra counties.

[b]El Paso and Hudspeth counties.

Alternative Scenarios

Three scenarios and five alternatives will be examined. The first scenario does not include constraints on the water availability in the region and includes two alternatives: (1) Alternative I is an examination of the anticipated population growth and (2) Alternative II is an examination of the high population growth scenario. The second scenario incorporates a constraint on the surface water availability in the region and includes two alternatives: (1) Alternative III is an examination of the anticipated population growth scenario with a constant surface water availability response to groundwater withdrawals and (2) Alternative IV is an examination of the anticipated population growth scenario with variable surface water availability responses to groundwater withdrawals. The third scenario incorporates constraints on both the surface and groundwater availability (Alternative V) and includes an examination of the anticipated population growth scenario and variable surface water availability responses to groundwater withdrawals.

In the base period, both the surface and groundwater requirements were computed. Subsequent alternatives incorporating surface and/or groundwater constraints are limited to these requirements. Table 10 contains the constraint levels utilized within the socio-economic model. These values should approximate other estimates of surface and groundwater use but may differ somewhat because they were

Table 10. Surface and groundwater constraints utilized within the socio-economic model, Rio Grande Study Region

Constraint	New Mexico[a]	Texas[b]
	-(acre-feet/year)-	
Surface Water Constraint		
Surface diversions	395,000	277,000
Surface depletions	170,000	180,000
Groundwater Constraint		
Ground diversions	112,000	177,000
Ground depletions	66,000	115,000

[a]Dona Ana and Sierra counties.

[b]El Paso and Hudspeth counties.

derived from the optimization model. The water-use estimates are used as a starting point for the alternatives and therefore should permit relative comparisons. The water-use coefficients per unit of output for all sectors are reported in Appendix B.

For the alternatives which include surface or groundwater constraints, water depletions were the governing constraints, with water diversions being reported only to indicate changes in the total. In the alternatives where water was a limiting constraint, two types of basic tradeoffs were examined: (1) making the necessary water available through theoretical purchasing or importing or (2) reducing agricultural production from that which would have occurred had the necessary water been available. In the agricultural sectors, tradeoffs occurred which results in either final demand decreasing, imports increasing, or changes to higher-value crops occurring simultaneously with reductions in either exports or increases in imports for the crops dropping out of production. Increases in the agricultural sector's output will be far less than the other sectors because final demand increases were set at zero for all scenarios. With no exogenous agricultural demand increases permitted, increases in agricultural production are such that the additional water requirements are for intermediary or processing demands.

For each alternative several components can be examined either individually or in concert with each other. The purchase of additional water necessary to satisfy demands is permitted in many cases to meet needs over and above the constraint. It is possible from this to see how much more water must be available for growth to proceed as programmed in the alternative.

If purchases of additional water are not permitted, additional imports of agricultural products will be required to satisfy the increased processing demands, or agricultural exports and purchases by government will be decreased by an amount equal to the increased processing demands.

Agricultural sales to the regional household final consumption component may also be decreased by an amount equal to the increased processing demands. Agricultural production in the region will normally be increased because adjustments will be made to higher-valued-less-water-intensive crops in the same agricultural sector or to a higher-valued-less-water-intensive agricultural sector. Agricultural production may also be increased by shifting to groundwater sources if no constraint exists on these supplies.

No Water Constraint Scenario

Alternative I--Anticipated Growth Scenario

Alternative I incorporates the anticipated population growth scenario presented in Table 7. All final demands except agricultural are required to increase in response to these growth rates. The agricultural sectors are required to increase only to the extent necessary to satisfy the internal processing demands from the other sectors and were not permitted to respond to exogenous agricultural final demands. No constraints were placed upon either the surface or groundwater supplies, with all needs to be satisfied from essentially an unlimited supply from both sources. The primary purpose of this alternative was to determine the potential quantities of water required to meet the needs of the region for the anticipated population growth scenario. Tables 11 and 12 present the production levels, employment, and water depletions by sector and subregion for the years 2000 and 2020, respectively. The value of production, employment, and water depletions by major sector and subregion for the 1970 base period and the 2000 and 2020 periods are presented in Table 13. The Texas subregion accounted for about 87.5 percent of the production within the region in 1970, but is expected to increase to about 89.5 percent of the regional production by 2000, and to about 90.2 percent by 2020. Both subregions are expected to increase, but the Texas subregion increases at a faster rate than the New Mexico subregion.

For the New Mexico subregion, the value of production is expected to increase 33.2 percent by 2000 and 53.7 percent by 2020 over the 1970 base period. Employment is expected to increase about 31.9 percent by 2000 and 53.2 percent by 2020 over the 1970 base period. However, water depletions in the New Mexico subregion are expected to increase only 17.8 percent by 2000 and 29.6 by 2020 over the 1970 base period. This is expected because agricultural sectors which are the heavy water users are not expected to increase as much as the other sectors due to the constraints on exogenous agricultural final demand increases (Table 13).

For the Texas subregion, the value of production is expected to increase about 61.3 percent by 2000 and 102.2 percent by 2020 over the 1970 base period. Employment is expected to increase in a similar fashion (61.1 and 101.8 percent). However, water depletions in the Texas subregion are expected to increase only by 23.2 percent by 2000 and 38.6 percent by 2020 over the 1970 base period. This is also expected because of the constraints on agricultural sectors increases in exogenous final demands.

In the 1970 base period, $203,529,000 of production was generated in the New Mexico subregion with 230,607 acre-feet of water or about $882.58 of production per acre-foot of water depleted. In 2000, production per acre-foot is expected to be $990.87 and in 2020 is expected to be $1,046.50. In the Texas subregion in the 1970 base period, $1,418,117,000 of production was generated with 288,620 acre-feet of water or about $4,913.44 of production per acre-foot of water depleted. In 2000, production per acre-foot is expected to be $6,437.07 and in 2020 is expected to be $7,166.67. These differences in the value of production per acre-foot of water depleted between the subregions are due to the higher industrial and services sectors in the Texas subregion than in the New Mexico subregion.

The quantities of additional water depletions necessary to obtain the projected growth in production in the subregions are 68,374 acre-feet for the New Mexico subregion and 111,392 acre-feet for the Texas subregion. The next alternative will examine the requirements of the "high" population growth scenario.

Table 11. Value of production, employment, and water depletions by sector and subregion for Alternative I, year 2000

Sector[a]			New Mexico Subregion			Texas Subregion		
			Value of Production ($ 000)	Employment	Water Depletions (acre-feet)	Value of Production ($ 000)	Employment	Water Depletions (acre-feet)
AG	Gr & hay	1	2,333	131	97,566	2,740	111	101,983
	Cotton	2	5,910	667	100,647	8,068	653	137,398
	Other irr	3	15,246	918	48,177	4,754	205	17,400
	Lvstk	4	25,742	2,345	14,356	17,999	1,174	12,236
	Services	5	3,768	442	44	3,260	274	38
MIN		6	6,780	57	159	7,679	258	180
CON	Const	7	50,304	1,559	885	291,330	9,089	5,127
	Man & rep	8	5,091	134	90	31,366	1,145	552
MAN	Food	9	8,758	686	46	138,057	14,993	718
	Text & ap	10	2,214	55	14	268,204	9,307	1,717
	Lumber	11	*	*	*	9,835	417	63
	Furn	12	*	*	*	3,590	443	23
	Boxes etc	13	*	*	*	955	24	3
	Print	14	2,554	95	7	20,594	1,063	58
	Chem	15	*	*	*	8,979	124	336
	Petro	16	*	*	*	299,343	599	11,195
	Rubber	17	*	*	*	11,835	365	96
	Stone	18	1,682	56	11	25,596	1,180	164
	Pr & fab	19	334	1	1	66,989	328	127
	Mach	20	5,643	413	11	27,895	2,829	53
TRP	Rail	21	2,005	184	5	19,965	1,609	50
	Incity Ft	22	1,206	126	3	38,405	3,522	96
	Truck	23	1,262	227	3	1,975	310	5
	Air	24	31	1	**	13,459	760	34
	Other	25	1,042	122	3	5,388	556	13
COM		26	6,840	486	402	47,356	2,946	2,785
UT	Gas	27	133	9	8	57,633	3,619	3,389
	Elect	28	10,060	270	592	45,205	1,067	2,658
	Water	29	134	13	8	11,756	990	691
TR	Gen whsl	30	9,197	297	45	169,980	8,193	833
	Gen retl	31	24,740	2,672	121	168,465	27,106	825
	Auto	32	2,925	88	27	19,305	861	176
	Ser Sta	33	1,990	1,106	18	5,953	4,928	54
	Eat & dr	34	2,943	339	27	16,315	2,793	148
FIRE		35	42,178	860	413	115,352	6,367	1,130
SER	Lodg	36	4,938	599	60	20,437	648	247
	Pers	37	18,359	3,218	222	61,735	2,827	747
	Prof	38	2,807	1,053	35	219,559	21,517	2,701

*There was no production from these sectors in the New Mexico subregion in 1967-1970 and is assumed that there will be no production in the future.

**Less than 0.5

[a]See Table 2, page 19, for more complete description of sectors.

Table 12. Value of production, employment, and water depletions by sector and subregion for Alternative I, year 2020

Sector[a]			New Mexico Subregion Value of Production ($ 000)	New Mexico Subregion Employment	New Mexico Subregion Water Depletions (acre-feet)	Texas Subregion Value of Production ($ 000)	Texas Subregion Employment	Texas Subregion Water Depletions (acre-feet)
AG	Gr & hay	1	2,749	154	114,963	2,963	120	110,283
	Cotton	2	6,178	697	105,211	8,776	710	149,455
	Other irr	3	15,407	928	48,686	5,186	224	18,981
	Lvstk	4	30,830	2,809	17,194	18,197	1,186	12,370
	Services	5	4,406	517	52	3,967	334	46
MIN		6	8,282	70	194	9,662	325	226
CON	Const	7	59,156	1,834	1,041	366,550	11,436	6,451
	Man & rep	8	5,952	157	105	39,350	1,436	693
MAN	Food	9	10,253	803	53	173,150	18,804	900
	Text & ap	10	2,585	64	17	337,417	11,708	2,159
	Lumber	11	*	*	*	12,271	520	79
	Furn	12	*	*	*	4,508	556	29
	Boxes etc	13	*	*	*	1,194	30	3
	Print	14	2,984	111	8	25,882	1,336	72
	Chem	15	*	*	*	11,235	155	420
	Petro	16	*	*	*	376,286	753	14,073
	Rubber	17	*	*	*	14,889	459	121
	Stone	18	1,976	65	13	32,185	1,484	206
	Pr & fab	19	390	2	1	84,270	413	160
	Mach	20	6,608	484	13	35,049	3,554	67
TRP	Rail	21	2,342	215	6	25,019	2,017	63
	Incity Ft	22	1,409	147	4	48,254	4,425	121
	Truck	23	1,501	270	4	2,480	389	6
	Air	24	36	2	**	16,901	955	42
	Other	25	1,218	143	3	6,776	699	17
COM		26	7,999	568	470	59,462	3,699	3,496
UT	Gas	27	155	11	9	72,299	4,540	4,251
	Elect	28	11,698	314	688	56,645	1,337	3,331
	Water	29	157	16	9	14,725	1,240	866
TR	Gen whsl	30	10,726	346	53	213,107	10,272	1,044
	Gen retl	31	28,899	3,121	142	211,709	34,064	1,037
	Auto	32	3,408	102	31	24,241	1,081	221
	Ser Sta	33	2,316	1,287	21	7,454	6,171	68
	Eat & dr	34	3,439	396	31	20,526	3,514	187
FIRE		35	49,292	1,006	483	144,684	7,987	1,418
SER	Lodg	36	5,769	700	70	25,707	815	311
	Pers	37	21,483	3,766	260	77,620	3,555	939
	Prof	38	3,280	1,231	40	276,167	27,064	3,397

*There was no production from these sectors in the New Mexico subregion in 1967-1970 and is assumed that there will be no production in the future.

**Less than 0.5

[a]See Table 2, page 19, for more complete description of sectors.

Table 13. Value of production, employment, and water depletions by major sector and subregion for 1970 base period, 2000, and 2020 Alternative I

		New Mexico Subregion						Texas Subregion					
		Value of Production		Employment		Water Depletions		Value of Production		Employment		Water Depletions	
Year	Major Sector[a]		Change from 1970		Change from 1970		Change from 1970		Change from 1970		Change from 1970		Change from 1970
		(000)	(percent)		(percent)	(ac-ft)	(percent)	(000)	(percent)		(percent)	(ac-ft)	(percent)
1970 (base period)	Agriculture	43,141		3,600		222,803		33,416		2,180		235,823	
	Mining	4,528		38		106		4,705		158		110	
	Manufacturing	56,586		2,219		785		740,055		25,793		12,429	
	Comm., Ut., Trp.	17,002		1,069		769		149,012		9,497		6,012	
	Trade & Services	82,272		7,650		724		490,929		46,319		4,223	
	Municipal & Rural	--		--		5,420		--		--		30,023	
	Total	203,529		14,576		230,607		1,418,117		83,947		288,620	
2000	Agriculture	52,999	22.9	4,503	25.1	260,790	17.0	36,821	10.2	2,417	10.9	269,055	14.1
	Mining	6,780	49.7	57	50.0	159	50.0	7,679	63.2	258	63.3	180	63.6
	Manufacturing	76,580	35.3	2,999	35.2	1,065	35.7	1,204,568	62.8	41,906	62.5	20,232	62.8
	Comm., Ut., Trp.	22,713	33.6	1,438	34.5	1,024	33.2	241,142	61.8	15,379	61.9	9,721	61.7
	Trade & Services	110,077	33.8	10,232	33.8	968	33.7	797,101	62.4	75,240	62.4	6,861	62.5
	Municipal & Rural	--	--	--	--	7,632	40.8	--	--	--	--	49,451	64.7
	Total	269,149	33.2	19,229	31.9	271,638	17.8	2,287,311	61.3	135,200	61.1	355,500	23.2
2020	Agriculture	59,570	38.1	5,105	41.8	286,106	28.4	39,089	17.0	2,574	18.1	291,135	23.5
	Mining	8,282	82.9	70	84.2	194	83.0	9,662	105.4	325	105.7	226	105.5
	Manufacturing	89,904	58.9	3,520	58.6	1,251	59.4	1,514,236	104.6	52,644	104.1	25,433	104.6
	Comm., Ut., Trp.	26,515	56.0	1,686	57.7	1,193	55.1	302,561	103.0	19,301	103.2	12,193	102.8
	Trade & Services	128,612	56.3	11,955	56.3	1,131	56.2	1,001,215	103.9	94,523	104.1	8,622	104.2
	Municipal & Rural	--	--	--	--	9,106	68.0	--	--	--	--	62,404	107.9
	Total	312,883	53.7	22,336	53.2	298,981	29.6	2,866,763	102.2	169,367	101.8	400,013	38.6

[a]Sectors: Agriculture 1-5; Mining 6; Manufacturing 7-20; Communication, Utilities, and Transportation 21-29; Trade and Services 30-38.

Alternative II--High Growth Scenario

For this alternative, no constraints were placed upon either surface or groundwater supplies. All water needs were permitted to be satisfied from an essentially unlimited supply from both sources.

The primary purpose of unlimited water supplies was to determine potential quantities of water required to meet the needs of each region for the high growth scenario. Tables 14 and 15 present production levels, employment, and water depletions by sector and subregion for the year 2000 and 2020, respectively.

Since all alternatives begin with the same base period, the results are not repeated in detail for each alternative. A comparison is presented between the alternative and the base period by major sector in Table 16. By 2000, for the high growth scenario, it is expected that the value of production would increase by approximately 247 percent in the New Mexico subregion and approximately 283 percent in the Texas subregion. Employment is expected to increase by about 243 percent in the New Mexico subregion and about 282 percent in the Texas subregion over the 1970 base period by 2000. Water depletions required for the high growth scenario in the year 2000 are expected to be about 1,045,032 acre-feet of which 439,400 acre-feet are required by the New Mexico subregion and 605,592 acre-feet are required by the Texas subregion. These are increases of about 91 percent in the New Mexico subregion and about 110 percent in the Texas subregion over the 1970 base period requirements. For the 2020 time period, the value of production in the region is expected to reach $9,781 million of which about $1,040 million would be generated in the New Mexico subregion and about $8,741 million would be generated in the Texas subregion. The increase over 1970 levels for the New Mexico subregion exceeds 411 percent and for the Texas subregion 516 percent. Employment increases over 1970 levels exceed 405 and 493 percent for the New Mexico and Texas subregions, respectively. Water depletions are expected to reach a regional total of 1,403,291 acre-feet, with 578,686 acre-feet required by the New Mexico subregion and 824,605 required by the Texas subregion. These are increases over 1970 levels of about 151 percent and 186 percent for the New Mexico and Texas subregions, respectively.

The annual water depletion needs of this alternative would require importation or groundwater mining of about 208,833 acre-feet in the New Mexico subregion and about 316,972 acre-feet in the Texas subregion by the year 2000. These increases in the annual water depletion requirements more than exceed the 1970 level in the Texas subregion and approach the 1970 level in the New Mexico subregion. By the year 2020, the water depletion needs of the region are expected to require the importation or groundwater mining of about 884,064 acre-feet of new water. These enormous requirements are not considered to be realistic and therefore the high growth scenario is not included in subsequent alternatives.

Surface Water Constraint Scenario

Alternative III--Anticipated Growth With Constant Surface Water Availabilities

Alternative III incorporates the anticipated population growth scenario and places a constraint upon the surface water supplies, with all needs above surface supplies permitted to be satisfied from the groundwater source. All final demands except agricultural were required to increase in response to the anticipated growth rates. The agricultural sectors were required to increase only to the extent necessary to satisfy the internal processing demands from the other sectors and were not permitted to respond to exogenous agricultural final demands. The primary purpose of this alternative was to determine the effects on regional growth of a limited surface water supply and also the potential quantities of groundwater required to meet the needs of the region for the anticipated population growth scenario. The surface water depletions were limited to the quantities reported in Table 10.

Table 14. Value of production, employment, and water depletions by sector and subregion for Alternative II, year 2000

Sector[a]			New Mexico Subregion Value of Production ($ 000)	New Mexico Subregion Employment	New Mexico Subregion Water Depletions (acre-feet)	Texas Subregion Value of Production ($ 000)	Texas Subregion Employment	Texas Subregion Water Depletions (acre-feet)
AG	Gr & hay	1	4,679	263	195,676	4,068	164	151,411
	Cotton	2	7,565	853	128,832	12,131	981	206,591
	Other irr	3	16,311	982	51,543	7,303	315	26,729
	Lvstk	4	53,373	4,862	29,766	19,200	1,252	13,052
	Services	5	8,382	984	98	7,197	605	84
MIN		6	17,464	147	409	18,377	617	430
CON	Const	7	144,377	4,476	2,541	697,185	21,752	12,270
	Man & rep	8	14,355	378	253	74,695	2,726	1,315
MAN	Food	9	24,947	1,953	130	329,809	35,817	1,715
	Text & ap	10	6,437	160	41	641,684	22,266	4,107
	Lumber	11	*	*	*	23,032	977	147
	Furn	12	*	*	*	8,603	1,062	55
	Boxes etc	13	*	*	*	2,259	57	6
	Print	14	7,424	276	21	49,300	2,544	138
	Chem	15	*	*	*	21,269	294	795
	Petro	16	*	*	*	716,020	1,432	26,779
	Rubber	17	*	*	*	28,320	872	229
	Stone	18	4,834	160	31	61,260	2,824	392
	Pr & fab	19	971	4	2	160,249	785	304
	Mach	20	16,251	1,190	31	66,689	6,762	127
TRP	Rail	21	5,766	530	14	47,792	3,852	119
	Incity Ft	22	3,396	355	8	91,665	8,406	229
	Truck	23	3,478	625	9	4,713	739	12
	Air	24	90	4	**	32,234	1,821	81
	Other	25	3,031	355	8	12,893	1,329	32
COM		26	19,248	1,367	1,132	112,805	7,016	6,633
UT	Gas	27	380	27	22	137,084	8,609	8,061
	Elect	28	28,252	757	1,661	107,913	2,547	6,345
	Water	29	390	39	23	28,185	2,373	1,657
TR	Gen whsl	30	25,555	825	125	405,822	19,561	1,989
	Gen retl	31	71,987	7,775	353	403,334	64,896	1,976
	Auto	32	8,104	243	74	45,953	2,050	418
	Ser Sta	33	5,212	2,897	47	14,065	11,644	128
	Eat & dr	34	8,578	987	78	39,040	6,684	355
FIRE		35	119,011	2,428	1,166	274,215	15,137	2,687
SER	Lodg	36	14,384	1,746	174	48,895	1,550	592
	Pers	37	52,988	9,289	641	147,599	6,760	1,786
	Prof	38	8,167	3,065	100	525,293	51,479	6,461

*There was no production from these sectors in the New Mexico subregion in 1967-1970 and is assumed that there will be no production in the future.

**Less than 0.5

[a]See Table 2, page 19, for more complete description of sectors.

Table 15. Value of production, employment, and water depletions by sector and subregion for Alternative II, year 2020

Sector[a]			New Mexico Subregion Value of Production ($ 000)	New Mexico Subregion Employment	New Mexico Subregion Water Depletions (acre-feet)	Texas Subregion Value of Production ($ 000)	Texas Subregion Employment	Texas Subregion Water Depletions (acre-feet)
AG	Gr & hay	1	6,660	374	278,521	5,177	209	192,688
	Cotton	2	8,936	1,008	152,180	15,548	1,258	264,782
	Other irr	3	17,181	1,034	54,292	9,434	407	34,528
	Lvstk	4	76,881	7,004	42,877	20,199	1,317	13,731
	Services	5	12,097	1,420	142	10,528	885	123
MIN		6	26,088	219	610	27,492	924	643
CON	Const	7	215,945	6,694	3,801	1,042,976	32,541	18,356
	Man & rep	8	21,392	563	376	111,566	4,072	1,964
MAN	Food	9	37,236	2,916	194	492,737	53,511	2,562
	Text & ap	10	9,623	239	62	959,884	33,308	6,143
	Lumber	11	*	*	*	34,266	1,453	219
	Furn	12	*	*	*	12,863	1,587	82
	Boxes etc	13	*	*	*	3,366	84	9
	Print	14	11,101	413	31	73,725	3,804	206
	Chem	15	*	*	*	31,718	438	1,186
	Petro	16	*	*	*	1,070,748	2,141	40,046
	Rubber	17	*	*	*	42,365	1,305	343
	Stone	18	7,229	239	46	91,625	4,224	586
	Pr & fab	19	1,452	6	3	239,703	1,175	455
	Mach	20	24,288	1,778	46	99,706	10,110	189
TRP	Rail	21	8,610	792	22	71,397	5,755	178
	Incity Ft	22	5,060	528	13	137,021	12,565	343
	Truck	23	5,196	934	13	7,042	1,104	18
	Air	24	134	6	**	48,191	2,723	120
	Other	25	4,934	578	12	19,284	1,988	48
COM		26	28,679	2,036	1,686	168,543	10,483	9,910
UT	Gas	27	567	40	33	204,718	12,856	12,037
	Elect	28	42,018	1,126	2,471	161,158	3,803	9,476
	Water	29	583	58	34	42,106	3,545	2,476
TR	Gen whsl	30	37,989	1,227	186	606,175	29,218	2,970
	Gen retl	31	107,644	11,626	527	603,157	97,048	2,955
	Auto	32	12,039	361	110	68,654	3,062	625
	Ser Sta	33	7,686	4,273	70	20,973	17,364	191
	Eat & dr	34	12,831	1,477	117	58,400	9,998	531
FIRE		35	177,347	3,618	1,738	409,456	22,602	4,013
SER	Lodg	36	21,513	2,612	260	713,136	22,606	8,629
	Pers	37	79,197	13,883	958	220,726	10,109	2,671
	Prof	38	12,213	4,584	150	785,724	77,001	9,664

*There was no production from these sectors in the New Mexico subregion in 1967-1970 and is assumed that there will be no production in the future.

**Less than 0.5.

[a]See Table 2, page 19, for more complete description of sectors.

Table 16. Value of production, employment, and water depletions by major sector and subregion for 1970 base period, 2000, and 2020, Alternative II

		New Mexico Subregion						Texas Subregion					
		Value of Production		Employment		Water Depletions		Value of Production		Employment		Water Depletions	
Year	Major Sector[a]	(000)	Change from 1970 (percent)		Change from 1970 (percent)	(ac-ft)	Change from 1970 (percent)	(000)	Change from 1970 (percent)		Change from 1970 (percent)	(ac-ft)	Change from 1970 (percent)
1970 (base period)	Agriculture	43,141		3,600		222,803		33,416		2,180		235,823	
	Mining	4,528		38		106		4,705		158		110	
	Manufacturing	56,586		2,219		785		740,055		25,793		12,429	
	Comm., Ut., Trp.	17,002		1,069		769		149,012		9,497		6,012	
	Trade & Services	82,272		7,650		724		490,929		46,319		4,223	
	Municipal & Rural	--		--		5,420		--		--		30,023	
	Total	203,529		14,576		230,607		1,418,117		83,947		288,620	
2000	Agriculture	90,310	109.3	7,944	120.4	405,915	82.2	49,899	49.3	3,317	52.2	397,867	68.7
	Mining	17,464	285.7	147	286.8	409	285.8	18,377	290.6	617	290.5	430	290.9
	Manufacturing	219,596	288.1	8,597	287.4	3,050	288.5	2,880,374	289.2	100,170	288.4	48,379	289.2
	Comm., Ut., Trp.	64,031	276.6	4,059	279.7	2,877	274.1	575,284	286.1	36,692	286.4	23,169	285.4
	Trade & Services	313,986	281.6	29,255	282.4	2,758	280.9	1,904,216	287.9	179,761	288.1	16,392	288.2
	Municipal & Rural	--		--		24,431	350.8	--		--		119,355	297.6
	Total	705,387	246.6	50,002	243.0	439,440	90.6	5,428,150	282.8	320,557	281.9	605,592	109.8
2020	Agriculture	121,755	182.2	10,840	201.1	528,012	137.0	60,886	82.2	4,076	87.0	505,852	114.5
	Mining	26,088	476.1	219	476.3	610	475.5	27,492	484.3	924	484.8	643	484.5
	Manufacturing	328,266	480.1	12,848	479.0	4,559	480.8	4,307,248	482.0	149,753	480.6	72,346	482.1
	Comm., Ut., Trp.	95,781	463.4	6,098	470.4	4,284	457.1	859,460	476.8	54,822	477.3	34,606	475.6
	Trade & Services	468,459	469.4	43,661	470.7	4,116	468.5	3,486,401	610.2	289,008	524.0	32,249	663.7
	Municipal & Rural	--	--	--	--	37,105	584.6	--	--	--	--	178,909	495.9
	Total	1,040,349	411.2	73,666	405.9	578,686	150.9	8,741,487	516.4	498,583	493.9	824,605	185.7

[a]Sectors: Agriculture 1-5; Mining 6; Manufacturing 7-20; Communication, Utilities, and Transportation 21-29; Trade and Services 30-38.

For this alternative the return flows resulting from groundwater withdrawals are assumed to equal the aquifer recharge from the surface flows due to pumpage. Therefore, the groundwater depletions (withdrawals minus return flows) constitute the extent of groundwater mining. Thus, surface water availabilities are assumed to remain constant over time.

Tables 17 and 18 present the production levels, employment, and water depletions by sector and subregion for the years 2000 and 2020, respectively. The value of production, employment, and water depletions by major sector and subregion for the 1970 base period and the 2000 and 2020 periods are presented in Table 19. The Texas subregion accounted for about 87.5 percent of the production within the region in 1970, but is expected to increase to about 89.6 percent of the regional production by 2000, and to be about 90.5 percent by 2020. Both subregions are expected to increase, but the Texas subregion increases at a faster rate than the New Mexico subregion.

For the New Mexico subregion, the value of production is expected to increase 30.4 percent by 2000 and 48.3 percent by 2020 over the 1970 base period. Employment is expected to increase about 29.7 percent by 2000 and 46.6 percent by 2020 over the 1970 base period. However, water depletions in the New Mexico subregion are expected to increase only 2.7 percent by 2000 and 3.6 percent by 2020 over the 1970 base period. This is expected because nearly all of the production and employment increases are in the relatively low water-using sectors (Table 19).

For the Texas subregion, the value of production is expected to increase about 61.2 percent by 2000 and 101.9 percent by 2020 over the 1970 base period. Employment is expected to increase in a similar fashion (60.9 and 101.4 percent). However, water depletions in the Texas subregion are expected to increase only by 12.7 percent by 2000 and 20.5 percent by 2020 over the 1970 base period. This is also expected because nearly all of the production and employment increases are in the relatively low water-using sectors (Table 19). However, the increases in water depletions are greater for the Texas subregion than for the New Mexico subregion because of the higher industrial base in Texas.

In the 1970 base period, $203,529,000 of production was generated in the New Mexico subregion with 230,607 acre-feet of water or about $882.58 of production per acre-foot of water depleted. In 2000, production per acre-foot is expected to be $1,120.00 and in 2020 is expected to be $1,263.55. In the Texas subregion in the 1970 base period, $1,418,117,000 of production was generated with 288,620 acre-feet of water or about $4,913.44 of production per acre-foot of water depleted. In 2000, production per acre-foot is expected to be $7,024.48 and in 2020 is expected to be $8,232.03. These differences in the value of production per acre-foot of water depleted between the subregions are due to the higher industrial and services sectors in the Texas subregion than in the New Mexico subregion.

The quantities of additional groundwater depletions necessary by 2000 to obtain the projected growth in production in the subregions are 6,315 acre-feet for the New Mexico subregion and 36,719 acre-feet for the Texas subregion. The quantities of additional groundwater depletions necessary by 2020 to obtain the projected growth in the subregions are expected to be 8,327 acre-feet for the New Mexico subregion and 59,105 acre-feet for the Texas subregion. These are also quantities of groundwater (depletions) that would be mined over the 1970 base period to sustain the anticipated growth of the region. The next alternative will examine the effects of the groundwater withdrawals when aquifer recharge from surface water flows are not exactly offset by return flows.

Alternative IV--Anticipated Growth Scenario With Varying Surface Water Availabilities

Alternative IV is similar to Alternative III in that a constraint was placed only upon the surface water supplies. In this alternative, the aquifer recharge from surface flows was assumed to not be offset by the return flows. In the New Mexico subregion, interpretation of the hydrological model results [Lansford, et al. 1973; Brutsaert and Way, 1973] indicated that a net reduction in surface water availability of about 100 acre-feet annually would occur. This results in the surface water availability

Table 17. Value of production, employment, and water depletions by sector and subregion for Alternative III, year 2000

Sector[a]			New Mexico Subregion			Texas Subregion		
			Value of Production ($ 000)	Employment	Water Depletions (acre-feet)	Value of Production ($ 000)	Employment	Water Depletions (acre-feet)
AG	Gr & hay	1	1,709	96	71,470	2,404	97	89,477
	Cotton	2	5,508	621	93,801	7,033	569	119,772
	Other irr	3	15,005	903	47,416	4,750	205	17,385
	Lvstk	4	23,947	2,182	13,355	17,996	1,173	12,234
	Services	5	3,639	427	43	3,215	270	38
MIN		6	6,766	57	159	7,679	258	180
CON	Const	7	50,300	1,559	885	291,330	9,089	5,127
	Man & rep	8	5,057	133	89	31,354	1,144	552
MAN	Food	9	8,707	682	45	138,006	14,987	718
	Text & ap	10	2,212	55	14	268,195	9,306	1,716
	Lumber	11	*	*	*	9,833	417	63
	Furn	12	*	*	*	3,589	443	23
	Boxes etc	13	*	*	*	955	24	3
	Print	14	2,552	95	7	20,590	1,062	58
	Chem	15	*	*	*	8,959	124	335
	Petro	16	*	*	*	299,274	599	11,193
	Rubber	17	*	*	*	11,835	365	96
	Stone	18	1,682	56	11	25,593	1,180	164
	Pr & fab	19	333	1	1	66,986	328	127
	Mach	20	5,633	412	11	27,889	2,828	53
TRP	Rail	21	1,999	184	5	19,951	1,608	50
	Incity Ft	22	1,198	125	3	38,395	3,521	96
	Truck	23	1,260	227	3	1,974	310	5
	Air	24	31	1	**	13,454	760	34
	Other	25	1,041	122	3	5,387	555	13
COM		26	6,792	482	399	47,344	2,945	2,784
UT	Gas	27	133	9	8	57,602	3,617	3,387
	Elect	28	10,002	268	588	45,161	1,066	2,655
	Water	29	134	13	8	11,747	989	691
TR	Gen whsl	30	9,110	294	45	169,865	8,187	832
	Gen retl	31	24,724	2,670	121	168,427	27,100	825
	Auto	32	2,895	87	26	19,297	861	176
	Ser Sta	33	1,942	1,080	18	5,947	4,924	54
	Eat & dr	34	2,943	339	27	16,315	2,793	148
FIRE		35	42,006	857	412	115,295	6,364	1,130
SER	Lodg	36	4,936	599	60	20,436	648	247
	Pers	37	18,341	3,215	222	61,728	2,827	747
	Prof	38	2,805	1,053	35	219,547	21,516	2,700

*There was no production from these sectors in the New Mexico subregion in 1967-1970 and is assumed that there will be no production in the future.

**Less than 0.5.

[a]See Table 2, page 19, for more complete description of sectors.

Table 18. Value of production, employment, and water depletions by sector and subregion for Alternative III, year 2020

Sector[a]			New Mexico Subregion			Texas Subregion		
			Value of Production ($ 000)	Employment	Water Depletions (acre-feet)	Value of Production ($ 000)	Employment	Water Depletions (acre-feet)
AG	Gr & hay	1	1,709	96	71,470	2,404	97	89,477
	Cotton	2	5,508	621	93,801	7,006	567	119,312
	Other irr	3	15,005	903	47,416	4,830	208	17,678
	Lvstk	4	23,947	2,182	13,355	18,188	1,186	12,364
	Services	5	4,100	481	48	3,886	327	45
MIN		6	8,273	69	194	9,661	325	226
CON	Const	7	59,148	1,834	1,041	366,550	11,436	6,451
	Man & rep	8	5,842	154	103	39,319	1,435	692
MAN	Food	9	10,059	788	52	172,982	18,786	900
	Txt & ap	10	2,581	64	17	337,400	11,708	2,159
	Lumber	11	*	*	*	12,266	520	79
	Furn	12	*	*	*	4,504	556	29
	Boxes etc	13	*	*	*	1,192	30	3
	Print	14	2,980	111	8	25,870	1,335	72
	Chem	15	*	*	*	11,194	154	419
	Petro	16	*	*	*	376,112	752	14,067
	Rubber	17	*	*	*	14,889	459	121
	Stone	18	1,975	65	13	32,177	1,483	206
	Pr & fab	19	389	2	1	86,264	413	160
	Mach	20	6,578	482	12	35,032	3,552	67
TRP	Rail	21	2,326	214	6	24,975	2,013	62
	Incity Ft	22	1,387	145	3	48,232	4,423	121
	Truck	23	1,497	269	4	2,477	388	6
	Air	24	36	2	**	16,885	954	42
	Other	25	1,217	143	3	6,774	698	17
COM		26	7,851	557	462	59,434	3,697	3,495
UT	Gas	27	154	11	9	72,215	4,535	4,246
	Elect	28	11,584	310	681	56,523	1,334	3,324
	Water	29	156	16	9	14,696	1,237	864
TR	Gen Whsl	30	10,488	339	51	212,793	10,257	1,043
	Gen retl	31	28,860	3,117	141	211,592	34,045	1,037
	Auto	32	3,327	100	30	24,226	1,080	220
	Ser Sta	33	2,190	1,217	20	7,441	6,160	68
	Eat & dr	34	3,437	396	31	20,525	3,514	187
FIRE		35	48,824	996	478	144,530	7,978	1,416
SER	Lodg	36	5,765	700	70	25,704	815	311
	Pers	37	21,435	3,758	259	77,599	3,554	939
	Prof	38	3,276	1,229	40	276,135	27,061	3,396

*There was no production from these sectors in the New Mexico subregion in 1967-1970 and is assumed that there will be no production in the future.

**Less than 0.5.

[a]See Table 2, page 19, for more complete description of sectors.

Table 19. Value of production, employment, and water depletions by major sector and subregion for 1970 base period, 2000, and 2020, Alternative III

Year	Major Sector[a]	New Mexico Subregion: Value of Production (000)	Value of Production: Change from 1970 (percent)	Employment	Employment: Change from 1970 (percent)	Water Depletions (000)	Water Depletions: Change from 1970 (percent)	Texas Subregion: Value of Production (000)	Value of Production: Change from 1970 (percent)	Employment (000)	Employment: Change from 1970 (percent)	Water Depletions (000)	Water Depletions: Change from 1970 (percent
1970 (base period)	Agriculture	43,141		3,600		222,803		33,416		2,180		235,823	
	Mining	4,528		38		106		4,705		158		110	
	Manufacturing	56,586		2,219		785		740,055		25,793		12,429	
	Comm., Ut., Trp.	17,002		1,069		769		149,012		9,497		6,012	
	Trade & Services	82,272		7,650		724		490,929		46,319		4,223	
	Municipal & Rural	--		--		5,420		--		--		30,023	
	Total	203,529		14,576		230,607		1,418,117		83,947		288,620	
2000	Agriculture	49,808	15.5	4,229	17.5	226,085	1.5	35,398	5.9	2,314	6.1	238,906	1.3
	Mining	6,776	49.6	57	50.0	159	50.0	7,679	63.2	258	63.3	180	63.6
	Manufacturing	76,476	35.2	2,993	34.9	1,063	35.4	1,204,388	62.7	41,896	62.4	20,228	62.7
	Comm., Ut., Trp.	22,590	32.9	1,431	33.9	1,017	32.2	214,015	61.7	15,371	61.9	9,715	61.6
	Trade & Services	109,702	33.3	10,194	33.3	966	33.4	796,857	62.3	75,220	62.4	6,859	62.4
	Municipal & Rural	--	--	--	--	7,632	40.8	--	--	--	--	49,451	64.7
	Total	265,352	30.4	18,904	29.7	236,922	2.7	2,285,337	61.2	135,059	60.9	325,339	12.7
2020	Agriculture	50,269	16.5	4,283	19.0	226,090	1.5	36,314	8.7	2,385	9.4	238,876	1.3
	Mining	8,273	82.7	69	81.6	194	83.0	9,661	105.3	325	105.7	226	105.5
	Manufacturing	89,552	58.3	3,500	57.7	1,247	58.9	1,513,751	104.5	52,619	104.0	25,425	104.6
	Comm., Ut., Trp.	26,208	54.1	1,667	55.9	1,177	53.1	302,211	102.8	19,279	103.0	12,177	102.5
	Trade & Services	127,602	55.1	11,852	54.9	1,120	54.7	1,000,545	103.8	94,464	103.9	8,617	104.0
	Municipal & Rural	--	--	--	--	9,106	68.0	--	--	--	--	62,404	107.9
	Total	301,904	48.3	21,371	46.6	238,934	3.6	2,862,482	101.9	169,072	101.4	347,725	20.5

[a]Sectors: Agriculture 1-5; Mining 6; Manufacturing 7-20; Communication, Utilities, and Transportation 21-29; Trade and Services 30-38.

being reduced by about 3,000 acre-feet by the year 2000 and about 5,000 acre-feet by the year 2020 in the New Mexico subregion. For the Texas subregion, interpretation of the hydrologic model results [Meyer, 1976] indicated that the aquifer recharge from surface flows is more than offset by the return flows and would be approximately 325 acre-feet annually. This would result in the surface water availability being increased by about 9,700 acre-feet by the year 2000 and about 16,250 acre-feet by the year 2020 in the Texas subregion.

In addition to incorporating the surface water availability response to groundwater withdrawals in this alternative, the agricultural sectors (1-5) were permitted to respond to the water shortages and increased demands for agricultural products by shifting production to the next higher-valued enterprise per unit of water use. Thus, reductions are expected in sector 1 (food and feed grain) and increases are expected in sectors 2-5 that result in Agriculture (major sector) production being able to increase more than in Alternative III at the same time that water depletions are reduced. This occurs in both subregions but is more evident in the New Mexico subregion where water depletions are reduced because of the surface water availability response to groundwater withdrawals.

Tables 20 and 21 present production levels, employment, and water depletions by sector and subregion for the year 2000 and 2020, respectively. A comparison is presented between the alternative and the base period by major sector in Table 22. By 2000, it is expected that the value of production would increase by approximately 31.6 percent in the New Mexico subregion and approximately 61.2 percent in the Texas subregion. Employment is expected to increase by about 31.3 percent in the New Mexico subregion and about 61.2 percent in the Texas subregion over the 1970 base period by 2000. Water depletions required in the year 2000 are expected to be about 561,926 acre-feet of which 231,982 acre-feet are required by the New Mexico subregion and 329,944 acre-feet are required by the Texas subregion. These are increases of about 0.6 percent in the New Mexico subregion and about 14.3 percent in the Texas subregion over the 1970 base period requirements. For the 2020 time period, the value of production in the region is expected to reach $3,175.6 million of which about $310.5 million would be generated in the New Mexico subregion and about $2,285.1 million would be generated in the Texas subregion. The increase over the 1970 levels for the New Mexico subregion is about 52.5 percent and for the Texas subregion about 102 percent. Employment increases over 1970 levels are about 52 and 101.7 percent for the New Mexico and Texas subregions, respectively. Water depletions are expected to be about 585,396 acre-feet in the region with about 229,938 acre-feet required by the New Mexico subregion and 355,458 required by the Texas subregion. For the New Mexico subregion, this is a decrease of 0.3 percent or 669 acre-feet less than the 1970 level. Thus between the 2000 and 2020 time period, the withdrawals of groundwater to support the growth reduced the surface water (depletions) available to the point that less water (both surface and ground) was used. This is evident from the reductions necessary in agricultural depletions, 0.7 percent by 2000 and 2.6 percent by 2020. For the Texas subregion, water depletions increased by about 14.3 percent by 2000 and 23.2 percent by 2020. The Texas subregion was able to increase production over Alternative III levels because of increased surface water availabilities. Nearly all of this growth occurred in the agricultural sectors.

This alternative was considered to be the most realistic of the alternatives presented in terms of the constraints enforced. The constraint on surface water depletions at 1970 levels and the surface water availability responses to groundwater withdrawals in the two subregions were considered to be representative of the current and future conditions in the subregions. The surface water availability in the two subregions is not expected to increase above current levels and the interpretation of the hydrologic models was considered to be reasonable for the subregions. In both the New Mexico and Texas subregions, these assumptions represent a natural interconnected aquifer/surface condition. The negative effect in the New Mexico subregion is believed to be a result of the proximity of the majority of the wells to the river and the proportion of the groundwater withdrawals of agriculture compared

Table 20. Value of production, employment, and water depletions by sector and subregion for Alternative IV, year 2000

Sector[a]			New Mexico Subregion			Texas Subregion		
			Value of Production ($ 000)	Employment	Water Depletions (acre-feet)	Value of Production ($ 000)	Employment	Water Depletions (acre-feet)
AG	Gr & hay	1	1,385	78	57,921	2,054	83	76,450
	Cotton	2	5,910	667	100,647	8,067	653	137,381
	Other irr	3	15,246	918	48,177	4,754	205	17,400
	Lvstk	4	25,733	2,344	14,351	17,999	1,174	12,236
	Services	5	3,723	437	44	3,252	273	38
MIN		6	6,779	57	159	7,679	258	180
CON	Const	7	50,302	1,559	885	291,330	9,089	5,127
	Man & rep	8	5,081	134	89	31,361	1,145	552
MAN	Food	9	8,757	686	46	138,050	14,992	718
	Text & ap	10	2,213	55	14	268,200	9,307	1,716
	Lumber	11	*	*	*	9,834	417	63
	Furn	12	*	*	*	3,590	443	23
	Boxes etc	13	*	*	*	955	24	3
	Print	14	2,553	95	7	20,593	1,063	58
	Chem	15	*	*	*	8,967	124	335
	Petro	16	*	*	*	299,315	599	11,194
	Rubber	17	*	*	*	11,835	365	96
	Stone	18	1,682	56	11	25,595	1,180	164
	Pr & fab	19	334	1	1	66,988	328	127
	Mach	20	5,640	413	11	27,893	2,828	53
TRP	Rail	21	2,002	184	5	19,963	1,609	50
	Incity Ft	22	1,202	125	3	38,401	3,521	96
	Truck	23	1,261	227	3	1,975	310	5
	Air	24	31	1	**	13,459	760	34
	Other	25	1,041	122	3	5,388	556	13
COM		26	6,825	485	401	47,351	2,945	2,784
UT	Gas	27	133	9	8	57,615	3,618	3,388
	Elect	28	10,012	268	589	45,187	1,066	2,657
	Water	29	134	13	8	11,755	990	691
TR	Gen whsl	30	9,156	296	45	165,948	8,191	833
	Gen retl	31	24,731	2,671	121	168,458	27,105	825
	Auto	32	2,910	87	26	19,301	861	176
	Ser Sta	33	1,161	1,090	18	5,949	4,925	54
	Eat & dr	34	2,943	339	27	16,315	2,793	148
FIRE		35	42,099	859	413	115,324	6,366	1,130
SER	Lodg	36	4,937	599	60	20,437	648	247
	Pers	37	18,351	3,217	222	61,732	2,827	747
	Prof	38	2,806	1,053	35	219,556	21,516	2,701

*There was no production from these sectors in the New Mexico subregion in 1967-1970 and is assumed that there will be no production in the future.

**Less than 0.5.

[a]See Table 2, page 19, for more complete description of sectors.

Table 21. Value of production, employment, and water depletions by sector and subregion for Alternative IV, year 2020

Sector[a]			New Mexico Subregion Value of Production ($ 000)	New Mexico Subregion Employment	New Mexico Subregion Water Depletions (acre-feet)	Texas Subregion Value of Production ($ 000)	Texas Subregion Employment	Texas Subregion Water Depletions (acre-feet)
AG	Gr & hay	1	1,200	67	50,184	1,850	75	68,857
	Cotton	2	5,929	669	100,971	8,593	695	146,339
	Other irr	3	15,406	927	48,683	5,185	223	18,977
	Lvstk	4	30,813	2,807	17,184	18,196	1,186	12,370
	Services	5	4,298	505	50	3,947	332	46
MIN		6	8,278	70	194	9,662	325	226
CON	Const	7	59,153	1,834	1,041	366,550	11,436	6,451
	Man & rep	8	5,934	156	104	39,342	1,436	692
MAN	Food	9	10,252	803	53	173,137	18,803	900
	Txt & ap	10	2,583	64	17	337,410	11,708	2,159
	Lumber	11	*	*	*	12,270	520	79
	Furn	12	*	*	*	4,508	556	29
	Boxes etc	13	*	*	*	1,194	30	3
	Print	14	2,983	111	8	25,881	1,335	72
	Chem	15	*	*	*	11,215	155	419
	Petro	16	*	*	*	376,235	752	14,071
	Rubber	17	*	*	*	14,889	459	121
	Stone	18	1,976	65	13	32,184	1,484	206
	Pr & fab	19	390	2	1	84,268	413	160
	Mach	20	6,602	483	13	35,046	3,554	67
TRP	Rail	21	2,336	215	6	25,014	2,016	63
	Incity Ft	22	1,403	146	4	48,247	4,424	121
	Truck	23	1,499	270	4	2,479	389	6
	Air	24	36	2	**	16,899	955	42
	Other	25	1,218	143	3	6,775	699	17
COM		26	7,972	566	469	59,452	3,698	3,496
UT	Gas	27	155	11	9	72,268	4,538	4,249
	Elect	28	11,612	311	683	56,612	1,336	3,329
	Water	29	157	16	9	14,723	1,240	866
TR	Gen Whsl	30	10,649	344	52	213,045	10,269	1,044
	Gen retl	31	28,883	3,119	142	211,696	34,062	1,037
	Auto	32	3,380	101	31	24,234	1,081	221
	Ser Sta	33	2,264	1,259	21	7,446	6,165	68
	Eat & dr	34	3,439	396	31	20,526	3,514	187
FIRE		35	49,147	1,003	482	144,634	7,984	1,417
SER	Lodg	36	5,768	700	70	25,706	815	311
	Pers	37	21,468	3,763	260	77,615	3,555	939
	Prof	38	3,279	1,231	40	276,161	27,064	3,397

*There was no production from these sectors in the New Mexico subregion in 1967-1970 and is assumed that there will be no production in the future.

**Less than 0.5.

[a]See Table 2, page 19, for more complete description of sectors.

Table 22. Value of production, employment, and water depletions by major sector and subregion for 1970 base period, 2000, and 2020, Alternative IV

Year	Major Sector[a]	New Mexico Subregion: Value of Production (000)	Change from 1970 (percent)	Employment	Change from 1970 (percent)	Water Depletions (000)	Change from 1970 (percent)	Texas Subregion: Value of Production (000)	Change from 1970 (percent)	Employment	Change from 1970 (percent)	Water Depletions (000)	Change from 1970 (percent)
1970 (base period)	Agriculture	43,141		3,600		222,803		33,416		2,180		235,823	
	Mining	4,528		38		106		4,705		158		110	
	Manufacturing	56,586		2,219		785		740,055		25,793		12,429	
	Comm., Ut., Trp.	17,002		1,069		769		149,012		9,497		6,012	
	Trade & Services	82,272		7,650		724		490,929		46,319		4,223	
	Municipal & Rural	--		--		5,420		--		--		30,023	
	Total	203,529		14,576		230,607		1,418,117		83,947		288,620	
2000	Agriculture	51,997	20.5	4,444	23.4	221,140	-.7	36,126	8.1	2,388	9.5	243,505	3.3
	Mining	6,779	49.7	57	50.0	159	50.0	7,679	63.2	258	63.3	180	63.6
	Manufacturing	76,562	35.3	2,999	35.2	1,064	35.5	1,204,506	62.8	41,904	62.5	20,229	62.8
	Comm., Ut, Trp.	22,641	33.2	1,434	34.1	1,020	32.6	214,094	61.8	15,375	61.9	9,718	61.6
	Trade & Services	109,894	33.6	10,211	33.5	967	33.6	797,020	62.3	75,232	62.4	6,861	62.5
	Municipal & Rural	--	--	--	--	7,632	40.8	--	--	--	--	49,451	64.7
	Total	267,873	31.6	19,145	31.3	231,982	0.6	2,286,425	61.2	135,157	61.0	329,944	14.3
2020	Agriculture	57,646	33.6	4,975	38.2	217,072	-2.6	37,771	13.0	2,511	15.2	246,589	4.6
	Mining	8,278	82.8	70	84.2	194	83.0	9,662	105.4	325	105.7	226	105.5
	Manufacturing	89,873	58.8	3,518	58.5	1,250	59.2	1,514,129	104.6	52,641	104.1	25,429	104.6
	Comm., Ut., Trp.	26,388	55.2	1,680	57.2	1,187	54.4	302,469	103.0	19,295	103.2	12,189	102.7
	Trade & Services	128,277	55.9	11,916	55.8	1,129	55.9	1,001,063	103.9	94,509	104.0	8,621	104.1
	Municipal & Rural	--	--	--	--	9,106	68.0	--	--	--	--	62,404	107.9
	Total	310,462	52.5	22,159	52.0	229,938	-0.3	2,865,094	102.0	169,281	101.7	355,458	23.2

[a]Sectors: Agriculture 1-5; Mining 6; Manufacturing 7-20; Communication, Utilities, and Transportation 21-29; Trade and Services 30-38.

to the municipal and industrial sectors. The positive effect in the Texas subregion is thought to be a result of (1) greater municipal and industrial groundwater withdrawals relative to agriculture, (2) the majority of the wells are farther from the river, and (3) the restriction of the recharge from the surface flows to the alluvium by the river channel lining operations and the confining layer separating the alluvium and the Hueco Bolson aquifer.

Surface and Groundwater Constraint Scenario

Alternative V--Anticipated Growth Scenario

Alternative V incorporates the anticipated population growth scenario and places a constraint upon both the surface and groundwater supplies. All final demands except agricultural were required to increase in response to the anticipated growth rates. The agricultural sectors were required to increase only to the extent necessary to satisfy the internal processing demands from the other sectors and were not permitted to respond to exogenous agricultural final demands. The primary purpose of this alternative was to determine the effects on regional growth of a limited water supply and also the potential quantities of agricultural production that must be imported to meet the needs of the region for the anticipated population growth scenario. The water depletions (both surface and ground) were limited to the quantities reported in Table 10.

The rates of surface water response to groundwater withdrawals are similar to those of Alternative IV. In this alternative, the aquifer recharge from surface flows was assumed to not be offset by the return flows. In the New Mexico subregion, interpretation of the hydrological model results [Lansford, et al. 1973; Brutsaert and Way, 1973] indicated that a net reduction in surface water availability of about 100 acre-feet annually would occur. This results in the surface water availability being reduced by about 3,000 acre-feet by the year 2000 and about 5,000 acre-feet by the year 2020 in the New Mexico subregion. For the Texas subregion, interpretation of the hydrologic model results [Meyer, 1976] indicated that the aquifer recharge from surface flows is more than offset by the return flows and would be approximately 325 acre-feet annually. This would result in the surface water availability being increased by about 9,700 acre-feet by the year 2000 and about 16,250 acre-feet by the year 2020 in the Texas subregion.

In addition to incorporating the surface water availability response to groundwater withdrawals in this alternative, the agricultural sectors (1-5) were allowed to respond to the water shortages and increased demands for agricultural products by shifting production to the next higher-valued enterprise per unit of water use. Thus, reductions are expected in sector 1 (Food and Feed Grain) and increases are expected in sectors 2-5 that result in Agriculture (major sector) production being able to increase more than in Alternative III at the same time that water depletions are reduced. This occurs in both subregions but is more evident in the New Mexico subregion where water depletions are reduced because of the surface water availability response to groundwater withdrawals.

Tables 23 and 24 present the production levels, employment, and water depletions by sector and subregion for the years 2000 and 2020, respectively. The value of production, employment, and water depletions by major sector and subregion for the 1970 base period and the 2000 and 2020 periods are presented in Table 25. The Texas subregion accounted for about 87.5 percent of the production within the region in 1970, but is expected to increase to about 89.5 percent of the regional production by 2000, and to about 90.2 percent by 2020. Both subregions are expected to increase, but the Texas subregion increases at a faster rate than the New Mexico subregion.

For the New Mexico subregion, the value of production is expected to increase 31.6 percent by 2000 and 52.5 percent by 2020 over the 1970 base period. Employment is expected to increase about 31.3 percent by 2000 and 52.1 percent by 2020 over the 1970 base period. However, water deple-

Table 23. Value of production, employment, and water depletions by sector and subregion for Alternative V, year 2000

Sector[a]			New Mexico Subregion			Texas Subregion		
			Value of Production ($ 000)	Employment	Water Depletions (acre-feet)	Value of Production ($ 000)	Employment	Water Depletions (acre-feet)
AG	Gr & hay	1	1,387	78	58,004	1,206	48	44,876
	Cotton	2	5,907	666	100,596	8,067	653	137,381
	Other irr	3	15,244	918	48,171	4,754	205	17,400
	Lvstk	4	25,676	2,339	14,320	17,999	1,174	12,236
	Services	5	3,718	436	44	3,252	273	38
MIN		6	6,779	57	159	7,679	258	180
CON	Const	7	50,302	1,559	885	291,330	9,089	5,127
	Man & rep	8	5,081	134	89	31,361	1,145	552
MAN	Food	9	8,757	686	46	138,050	14,992	718
	Text & ap	10	2,213	55	14	268,200	9,307	1,716
	Lumber	11	*	*	*	9,834	417	63
	Furn	12	*	*	*	3,590	443	23
	Boxes etc	13	*	*	*	955	24	3
	Print	14	2,553	95	7	20,593	1,063	58
	Chem	15	*	*	*	8,967	124	335
	Petro	16	*	*	*	299,315	599	11,194
	Rubber	17	*	*	*	11,835	365	96
	Stone	18	1,682	56	11	25,595	1,180	164
	Pr & fab	19	334	1	1	66,988	328	127
	Mach	20	5,640	413	11	27,893	2,828	53
TRP	Rail	21	2,002	184	5	19,963	1,609	50
	Incity Ft	22	1,202	125	3	38,401	3,521	96
	Truck	23	1,261	227	3	1,975	310	5
	Air	24	31	1	**	13,459	760	34
	Other	25	1,041	122	3	5,388	556	13
COM		26	6,825	485	401	47,351	2,945	2,784
UT	Gas	27	133	9	8	57,615	3,618	3,388
	Elect	28	10,012	268	589	45,187	1,066	2,657
	Water	29	134	13	8	11,755	990	691
TR	Gen whsl	30	9,156	296	45	165,948	8,191	833
	Gen retl	31	24,731	2,671	121	168,458	27,105	825
	Auto	32	2,910	87	26	19,301	861	176
	Ser Sta	33	1,161	1,090	18	5,949	4,925	54
	Eat & dr	34	2,943	339	27	16,315	2,793	148
FIRE		35	42,099	859	413	115,324	6,366	1,130
SER	Lodg	36	4,937	599	60	20,437	648	247
	Pers	37	18,351	3,217	222	61,732	2,827	747
	Prof	38	2,806	1,053	35	219,556	21,516	2,701

*There was no production from these sectors in the New Mexico subregion in 1967-1970 and is assumed that there will be no production in the future.

**Less than 0.5.

[a]See Table 2, page 19, for more complete description of sectors.

Table 24. Value of production, employment, and water depletions by sector and subregion for Alternative V, year 2020

Sector[a]			New Mexico Subregion			Texas Subregion		
			Value of Production ($ 000)	Employment	Water Depletions (acre-feet)	Value of Production ($ 000)	Employment	Water Depletions (acre-feet)
AG	Gr & hay	1	1,098	62	45,918	491	20	18,269
	Cotton	2	6,170	696	105,075	8,593	695	146,339
	Other irr	3	15,402	927	48,670	5,185	223	18,977
	Lvstk	4	30,651	2,792	17,094	18,196	1,186	12,370
	Services	5	4,314	506	50	3,947	332	46
MIN		6	8,278	70	194	9,662	325	226
CON	Const	7	59,153	1,834	1,041	366,550	11,436	6,451
	Man & rep	8	5,934	156	104	39,342	1,436	692
MAN	Food	9	10,252	803	53	173,137	18,803	900
	Text & ap	10	2,583	64	17	337,410	11,708	2,159
	Lumber	11	*	*	*	12,270	520	79
	Furn	12	*	*	*	4,508	556	29
	Boxes etc	13	*	*	*	1,194	30	3
	Print	14	2,983	111	8	25,881	1,335	72
	Chem	15	*	*	*	11,215	155	419
	Petro	16	*	*	*	376,235	752	14,071
	Rubber	17	*	*	*	14,889	459	121
	Stone	18	1,976	65	13	32,184	1,484	206
	Pr & fab	19	390	2	1	84,268	413	160
	Mach	20	6,602	483	13	35,046	3,554	67
TRP	Rail	21	2,336	215	6	25,014	2,016	63
	Incity Ft	22	1,403	146	4	48,247	4,424	121
	Truck	23	1,499	270	4	2,479	389	6
	Air	24	36	2	**	16,899	955	42
	Other	25	1,218	143	3	6,775	699	17
COM		26	7,972	566	469	59,452	3,698	3,496
UT	Gas	27	155	11	9	72,268	4,538	4,249
	Elect	28	11,612	311	683	56,612	1,336	3,329
	Water	29	157	16	9	14,723	1,240	866
TR	Gen whsl	30	10,649	344	52	213,045	10,269	1,044
	Gen retl	31	28,883	3,119	142	211,696	34,062	1,037
	Auto	32	3,380	101	31	24,234	1,081	221
	Ser Sta	33	2,264	1,259	21	7,446	6,165	68
	Eat & dr	34	3,439	396	31	20,526	3,514	187
FIRE		35	49,147	1,003	482	144,634	7,984	1,417
Ser	Lodg	36	5,768	700	70	25,706	815	311
	Pers	37	21,468	3,763	260	77,615	3,555	939
	Prof	38	3,279	1,231	40	276,161	27,064	3,397

*There was no production from these sectors in the New Mexico subregion in 1967-1970 and is assumed that there will be no production in the future.

**Less than 0.5.

[a]See Table 2, page 19, for more complete description of sectors.

Table 25. Value of production, employment, and water depletions by major sector and subregion for 1970 base period, 2000, and 2020, Alternative V

Year	Major Sector[a]	New Mexico Subregion: Value of Production (000)	Change from 1970 (percent)	Employment	Change from 1970 (percent)	Water Depletions (000)	Change from 1970 (percent)	Texas Subregion: Value of Production (000)	Change from 1970 (percent)	Employment	Change from 1970 (percent)	Water Depletions (000)	Change from 1970 (percent)
1970 (base period)	Agriculture	43,141		3,600		222,803		33,416		2,180		235,823	
	Mining	4,528		38		106		4,705		158		110	
	Manufacturing	56,586		2,219		785		740,055		25,793		12,429	
	Comm., Ut., Trp.	17,002		1.069		769		149,012		9,497		6,012	
	Trade & Services	82,272		7,650		724		490,929		46,319		4,223	
	Municipal & Rural	--		--		5,420		--		--		30,023	
	Total	203,529		14,576		230,607		1,418,117		83,947		288,620	
2000	Agriculture	51,932	20.4	4,437	23.3	221,135	-0.7	35,278	5.6	2,353	7.9	211,931	-10.1
	Mining	6,779	49.7	57	50.0	159	50.0	7,679	63.2	258	63.3	180	63.6
	Manufacturing	76,562	35.3	2,999	35.2	1,064	35.5	1,204,506	62.8	41,904	62.5	20,229	62.8
	Comm., Ut., Trp.	22,641	33.2	1,434	34.1	1,020	32.6	241,094	61.8	15,375	61.9	9,718	61.6
	Trade & Services	109,894	33.6	10,211	33.5	967	33.6	797,020	62.3	75,232	62.4	6,861	62.5
	Municipal & Rural	--	--	--	--	7,632	40.8	--	--	--	--	49,451	64.7
	Total	267,808	31.6	19,138	31.3	231,977	0.6	2,285,577	61.2	135,122	61.0	298,370	3.4
2020	Agriculture	57,635	33.6	4,983	38.4	216,807	-2.7	36,412	9.0	2,456	12.7	196,001	-16.9
	Mining	8,278	82.8	70	84.2	194	83.0	9,662	105.4	325	105.7	226	105.5
	Manufacturing	89,873	58.8	3,518	58.5	1,250	59.2	1,514,129	104.6	52,641	104.1	25,429	104.6
	Comm., Ut., Trp.	26,388	55.2	1,680	57.2	1,187	54.4	302,469	103.0	19,295	103.2	12,189	102.7
	Trade & Services	128,277	55.9	11,916	55.8	1,129	55.9	1,001,063	103.9	94,509	104.0	8,621	104.1
	Municipal & Rural	--	--	--	--	9,106	68.0	--	--	--	--	62,404	107.9
	Total	310,451	52.5	22,167	52.1	229,673	-0.4	2,863,735	101.9	169,226	101.6	304,870	5.6

[a]Sectors: Agriculture 1-5; Mining 6; Manufacturing 7-20; Communication, Utilities, and Transportation 21-29; Trade and Services 30-38.

tions in the New Mexico subregion are expected to increase only 0.6 percent by 2000 and decrease 0.4 percent by 2020 from the 1970 base period. This is expected because the agricultural sectors which are the surface water users are not expected to increase as much as the other sectors due to the constraint placed on surface water depletions and the transfer necessary from surface to groundwater in response to the assumed aquifer/surface system (Tables 23 and 24).

For the Texas subregion, the value of production is expected to increase about 61.2 percent by 2000 and 101.9 percent by 2020 over the 1970 base period. Employment is expected to increase in a similar fashion (61 and 101.6 percent). However, water depletions in the Texas subregion are expected to increase by only 3.4 percent by 2000 and 5.6 percent by 2020 from the 1970 base period. This is expected because of the continued groundwater mining due to the assumed hydrologic relationship.

In the 1970 base period, $203,529,000 of production was generated in the New Mexico subregion with 230,607 acre-feet of water or about $882.58 of production per acre-foot of water depleted. In 2000, production per acre-foot is expected to be $1,154.46 and in 2020 is expected to be $1,351.71. In the Texas subregion in the 1970 base period, $1,418,117,000 of production was generated with 288,620 acre-feet of water or about $4,913.44 of production per acre-foot of water depleted. In 2000, production per acre-foot is expected to be $7,660.21 and in 2020 is expected to be $9,393.30. These differences in the value of production per acre-foot of water depleted between the subregions are due to the higher industrial and services sectors in the Texas subregion than in the New Mexico subregion.

The level of agricultural purchases (imports) required to meet the internal processing demands are expected to be about $1,067,000 for the New Mexico subregion by 2000 and about $1,935,000 by 2020. For the Texas subregion, agricultural purchases required to meet the internal processing demands are expected to be about $1,543,000 by 2000 and about $2,677,000 by 2020. Thus, for the New Mexico subregion the purchase of agricultural products is expected to account for about 2.0 percent of the subregion's agricultural products demand by 2000 and about 3.2 percent by 2020. For the Texas subregion, the purchases of agricultural products is expected to account for about 4.2 percent of the subregion's agricultural products demand by 2000 and about 6.8 percent by 2020.

Implications

Three basic scenarios were presented for the Rio Grande Region which incorporated various water availability constraints and alternative socio-economic futures. The first scenario did not include a constraint on the water availability for the region and included two socio-economic alternatives. Alternative I incorporated the anticipated population growth scenario and Alternative II incorporated the high population growth scenario. Since economic growth was tied to these growth scenarios in the two respective alternatives (through responses of the final demands in all sectors except the agricultural sectors which were required to respond only to internal processing demands), these two alternatives presented production, employment, and water depletions that could be expected for the region with unlimited water availabilities. The high population growth scenario (Alternative II) was not considered to be realistic for the region since water requirements were substantial. Table 26 presents a comparison of the water requirements for the region between Alternatives I and II.

Surface water depletions are expected to increase 28.27 percent in the New Mexico subregion and 23.13 percent in the Texas subregion under Alternative I and are expected to increase 136.17 percent in the New Mexico subregion and 112.88 percent in the Texas subregion under Alternative II by the year 2020. Groundwater depletions are expected to increase in even greater magnitudes, 33.25 percent and 62.78 percent for the New Mexico and Texas subregions, respectively under Alternative I by 2020. Under Alternative II, the comparable percentages were 189.39 and 299.59.

Table 26. Comparison of water requirements for Alternative I and Alternative II by subregion, Rio Grande Region

Year	Alternative I -- Anticipated Growth Scenario						Alternative II -- High Growth Scenario					
	Surface Water Depletions		Groundwater Depletions*		Groundwater Withdrawal*		Surface Water Depletions		Groundwater Depletions*		Groundwater Withdrawal*	
	(ac-ft)	Change from 1970 (%)	(ac-ft)	Change from 1970 (%)	(ac-ft)	Change from 1970 (%)	(ac-ft)	Change from 1970 (%)	(ac-ft)	Change from 1970 (%)	(ac-ft)	Change from 1970 (%)
	NEW MEXICO SUBREGION											
1970	166,594	--	64,012	--	111,253	--	166,594	--	64,012	--	111,253	--
1980	176,024	5.66	68,272	6.66	118,962	6.93	211,975	27.24	88,262	37.88	156,665	40.82
1990	185,439	11.31	68,272	6.66	118,962	6.93	257,341	54.47	112,506	75.76	202,068	81.63
2000	194,854	16.96	76,782	19.95	134,361	20.77	302,693	81.70	136,747	113.63	247,464	122.43
2010	204,268	22.61	81,037	26.60	142,060	27.69	348,088	108.94	161,004	151.52	292,889	163.26
2020	213,685	28.27	85,293	33.25	149,761	34.61	393,440	136.17	185,245	189.39	338,286	204.07
	TEXAS SUBREGION											
1970	176,038	--	112,580	--	290,830	--	176,038	--	112,580	--	290,830	--
1980	184,218	4.65	126,730	12.57	335,278	15.28	215,793	22.58	178,491	58.55	496,927	70.87
1990	192,359	9.27	140,865	25.12	379,697	30.56	255,549	45.17	244,401	117.09	703,024	141.73
2000	200,500	13.90	154,999	37.68	424,116	45.83	295,288	67.74	310,306	175.63	909,111	212.59
2010	208,615	18.51	169,123	50.22	468,514	61.10	335,044	90.32	380,089	237.62	1,124,904	286.79
2020	216,756	23.13	183,257	62.78	512,933	76.37	374,757	112.88	449,855	299.59	1,340,666	360.98

*Includes municipal and rural water requirements

Groundwater withdrawals follow a similar pattern in the rates of increase for the two alternatives. To support Alternative II (the high growth scenario), the groundwater depletion and diversion requirements will more than double in the year 2020 than those required in 1970. The doubling point is expected to be reached in the New Mexico subregion by 2000 and by 1990 in the Texas subregion (Table 26).

The second scenario (Alternatives III and IV) incorporated a constraint on the surface water availability in the region at the level used in 1970. For Alternative III, the return flows resulting from groundwater withdrawals were assumed to equal the aquifer recharge from the surface flows due to pumpage. Therefore, the groundwater depletions (withdrawals minus return flows) constitute the extent of groundwater mining. Thus, surface water availabilities were assumed to remain constant over time. For Alternative III, the surface water depletions are expected to increase 1.92 and 1.34 percent for the New Mexico and Texas subregions, respectively by 2020. Groundwater depletions are expected to increase 8.01 and 50.4 percent for the New Mexico and Texas subregions, respectively by 2020 (Table 27).

For Alternative IV the aquifer recharge from surface flows was assumed to not be offset by the return flows. In the New Mexico subregion, a net reduction in surface water availability of about 100 acre-feet was assumed to occur annually. In the Texas subregion, aquifer recharge from surface flows was assumed to be more than offset by the return flows by about 325 acre-feet annually. In addition to incorporating the surface water availability constraint and the surface water availability response to groundwater withdrawals in Alternative IV, the agricultural sectors were allowed to respond to the water shortages and increased demands for agricultural products by shifting sector production to the next higher-valued enterprise. For Alternative IV, the surface water depletions are expected to increase about 1.44 percent by 1980 and then decrease about 0.01 percent by 2000 from the 1970 base period in the New Mexico subregion. This is due to the surface water availability response to groundwater withdrawals. For the Texas subregion, the surface water depletions are expected to increase about 5.25 percent by 2020. Groundwater depletions are expected to increase about 2.01 percent by 1980 and then fall slightly to an increase of about 1.27 percent by 2010 and then increase to about 1.52 percent by 2020 in the New Mexico subregion. The decrease in the rate of increase in groundwater depletions by 2010 is due to the fixed mixture of surface and groundwater use by the agricultural water users and the corresponding reduction in surface water use. This is discussed further in a later section. The increase in groundwater withdrawals despite corresponding reductions in the groundwater depletions are due to shifts in sector production which result in a lower water use efficiency. In the Texas subregion, groundwater depletions are expected to increase over the 1970 base period about 51.6 percent by 2020 (Table 27).

The effect of the different surface water availability responses to groundwater withdrawals for Alternatives III and IV and the allowance for agricultural production shifts to the next higher-valued enterprise in Alternative IV resulted in decreases in the quantities of water (both surface and ground) in the New Mexico subregion and increases in the quantities of water (both surface and ground) in the Texas subregion.

The effect of the surface water constraint on water depletions is a reduction of about 6,542 acre-feet of surface water by 1980 increasing to about 43,890 acre-feet of surface water by 2020 in the New Mexico subregion and about 5,834 acre-feet of surface water by 1980 increasing to about 38,356 acre-feet of surface water by 2020 in the Texas subregion when compared to the 1970 surface water constraint level--Alternative I (Tables 26 and 27). Groundwater depletions are reduced by 2,726 acre-feet by 1980 and about 16,152 acre-feet by 2020 in the New Mexico subregion. In the Texas subregion, groundwater depletions are reduced by about 2,185 acre-feet by 1980 and about 13,932 acre-feet by 2020 (Tables 26 and 27).

The effect of the surface water constraint is summarized in Table 28 with a comparison of the agricultural value of production for Alternatives I and III and the purchase of agricultural sector production required under Alternative III to meet the needs of the region. Under Alternative III, purchases of

Table 27. Comparison of water requirements for Alternative III and Alternative IV by subregion, Rio Grande Region

Year	Alternative III						Alternative IV					
	Surface Water Depletions		Groundwater Depletions*		Groundwater Withdrawal*		Surface Water Depletions		Groundwater Depletions*		Groundwater Withdrawal*	
		Change from 1970		Change from 1970		Change from 1970		Change from 1970		Change from 1970		Change from 1970
	(ac-ft)	(%)	(ac-ft)	(%)	(ac-ft)	(%)	(ac-ft)	(%)	(ac-ft)	(%)	(ac-ft)	(%)
					NEW MEXICO SUBREGION							
1970	166,594	--	64,012	--	111,253	--	166,594	--	64,012	--	111,253	--
1980	169,482	1.73	65,546	2.40	114,394	2.82	168,999	1.44	65,300	2.01	113,977	2.45
1990	169,722	1.88	65,546	2.40	114,394	2.82	167,978	.83	65,140	1.76	114,272	2.71
2000	169,795	1.92	67,125	4.86	118,198	6.24	166,987	.24	64,992	1.53	114,588	3.00
2010	169,795	1.92	68,133	6.44	120,453	8.27	165,951	- .39	64,828	1.27	114,875	3.26
2020	169,795	1.92	69,141	8.01	122,709	10.30	164,949	- .99	64,986	1.52	115,728	4.02
					TEXAS SUBREGION							
1970	176,038	--	112,580	--	290,830	--	176,038	--	112,580	--	290,830	--
1980	178,384	1.33	124,545	10.63	331,373	13.94	179,771	2.12	124,849	10.90	331,729	14.06
1990	178,391	1.34	135,745	20.58	370,645	27.44	181,150	2.90	136,124	20.91	370,755	27.48
2000	178,398	1.34	146,941	30.52	409,898	40.94	182,542	3.69	147,403	30.93	409,788	40.90
2010	178,383	1.33	158,129	40.46	449,153	54.44	183,904	4.47	158,670	40.94	448,800	54.32
2020	178,400	1.34	169,325	50.40	488,444	67.95	185,285	5.25	170,173	51.16	488,429	67.94

*Includes municipal and rural water requirements

Table 28. Comparison of agricultural sectors value of production for Alternatives I and III, and agricultural production purchases required under Alternative III, Rio Grande Region

	Value of Production and Purchases											
	1970 Base Period		1980		1990		2000		2010		2020	
Sector	New Mexico	Texas	New Mexico	Texas	New Mexico	Texas	New Mexico	Texas	New Mexico	Texas	New Mexico	Texas
	(1,000 Dollars)											
	ALTERNATIVE I											
Agriculture												
1	1,709	2,403	1,917	2,516	2,125	2,628	2,333	2,740	2,541	2,851	2,749	2,963
2	5,507	7,005	5,642	7,360	5,776	7,714	5,910	8,068	6,044	8,422	6,178	8,776
3	15,005	4,106	15,086	4,322	15,166	4,538	15,246	4,754	15,326	4,970	15,407	5,186
4	18,110	17,702	20,654	17,801	23,198	17,900	25,742	17,999	28,286	18,098	30,830	18,197
5	2,810	2,200	3,129	2,553	3,448	2,907	3,768	3,260	4,087	3,614	4,406	3,967
Total	43,141	33,416	46,428	34,552	49,713	35,687	52,999	36,821	56,284	37,955	59,570	39,089
	ALTERNATIVE III											
Agriculture												
1	1,709	2,403	1,790	2,404	1,709	2,404	1,709	2,404	1,709	2,404	1,709	2,404
2	5,507	7,005	5,609	7,134	5,508	7,083	5,508	7,033	5,508	7,005	5,508	7,006
3	15,005	4,106	15,085	4,322	15,149	4,538	15,005	4,750	15,005	4,852	15,005	4,830
4	18,110	17,702	20,650	17,801	23,187	17,900	23,947	17,996	23,947	18,092	23,947	18,188
5	2,810	2,200	3,115	2,544	3,391	2,880	3,639	3,215	3,870	3,550	4,100	3,886
Total	43,141	33,416	46,168	34,205	48,944	34,805	49,808	35,398	50,039	35,903	50,269	36,314
	PRODUCTION PURCHASES REQUIRED*											
Agriculture												
1			208	112	416	224	624	336	832	447	1,040	559
2			33	226	268	631	402	1,035	536	1,417	670	1,770
3			1		17		241	4	321	118	402	356
4			4		11		1,795	3	4,339	6	6,883	9
5			14	9	57	27	129	45	217	64	306	81
Total			260	347	769	882	3,191	1,423	6,245	2,052	9,301	2,775

*Difference between value of production for Alternative I and value of production for Alternative III. Provides estimate of the value of purchases required as result of surface water constraint.

agricultural sector production is estimated to be $260,000 by 1980 and reach $9,301,000 by 2020 in the New Mexico subregion (Table 28). In the Texas subregion, agricultural purchases are expected to be $347,000 by 1980 and reach $2,775,000 by 2020 (Table 28). Purchases of agricultural production is expected to be basically in sector 1 (Food and Feed Grains) through 1990 and then shift to sector 4 (Livestock, Dairy, Poultry) through 2020 in the New Mexico subregion. In the Texas subregion, purchases of agricultural production are expected to be primarily in sector 2 (Cotton) throughout the period (Table 28).

In Alternatives III and IV, the assumption was incorporated that agricultural water use was made up of a fixed mixture of both surface and groundwater. Thus, the constraint on surface water in effect limited the quantity of groundwater that could be used in the agricultural sectors. If this assumption is relaxed and additional water needs by agriculture above the surface water availabilities could be obtained from the groundwater source then the surface water depletions would not be reduced as indicated in Table 27 (Alternative III), but used to their fullest in combination with a larger quantity of groundwater. However, an additional assumption must be made that production efficiency (crop yields) would not be affected by the altered source of water. The water depletion requirements under such a variable-source use ratio as described above would result in the agricultural production being the same as in Alternative I, surface water depletions the same as in Alternative III, and groundwater depletions as reported in Table 29. The groundwater depletions would be increased over Alternative III levels (Table 27) by about 9,267 acre-feet in 1980 and 60,016 acre-feet in 2020 in the New Mexico subregion, and about 8,017 acre-feet in 1980 and 52,258 acre-feet in 2020 in the Texas subregion (Table 27 and 29).

The net result of the different surface water availability responses to groundwater withdrawals in Alternatives III and IV can be evaluated by not permitting agricultural production shifts to the next higher-valued enterprise in Alternative IV. When this is not permitted, agricultural production would be required to respond only to the internal processing demands as in Alternative III, but with more (Texas subregion) or less (New Mexico subregion) surface water depletion availabilities than in Alternative III. Table 30 presents a comparison of agricultural production and water depletions for Alternative III and a modified Alternative IV. For the New Mexico subregion, the value of production for the agricultural sectors is expected to be reduced (comparing Alternative III and modified Alternative IV) by 0.04 percent by 1980, and 0.14 percent by 1990, 0.24 percent by 2000, and 0.34 percent by 2010, and 0.43 percent by 2020. For the Texas subregion, the value of production for the agricultural sectors is expected to be increased by 0.29 percent by 1980, 0.53 percent by 1990, 0.76 percent by 2000, and 0.99 percent by 2010, and 1.25 percent by 2020.

In the New Mexico subregion, the result of the surface water availability response to groundwater withdrawals was a reduction in the value of production from the agricultural sectors. The effect of the allowance for agricultural production shifts to the next higher-valued enterprise was to increase the value of production for the agricultural sectors. Since the values of production for the agricultural sectors in Alternative IV are greater than in Alternative III (Table 31), the effect of the shifts to the next higher-valued enterprises in the agricultural sectors was more important and more than offset the negative effects of the surface water availability response to groundwater withdrawals. In the Texas subregion, the result of the surface water availability response to groundwater withdrawals was to increase the value of production from the agricultural sectors. The effect of permitting agricultural production shifts to the next higher-valued enterprise was also to increase the agricultural sectors value of production. The value of production for the agricultural sectors is expected to be increased (comparing Alternatives III and IV) by 0.22 percent by 1980, 0.76 percent by 1990, 1.29 percent by 2000, 2.06 percent by 2010, and 2.76 percent by 2020 as a result of permitting agricultural production shifts to the next higher-valued enterprise (Table 31).

Table 29. Groundwater depletions required for agricultural production to satisfy internal processing demands with a surface water constraint[a]

Year	Groundwater Depletions[b]			
	New Mexico Subregion		Texas Subregion	
		Change from 1970		Change from 1970
	(acre-feet)	(%)	(acre-feet)	(%)
1970	64,012	---	112,580	---
1980	74,813	16.87	132,562	17.75
1990	87,568	36.80	154,829	37.53
2000	101,831	59.08	177,091	57.30
2010	115,493	80.42	199,334	77.06
2020	129,157	101.77	221,583	96.82

[a]Obtained by adding the difference in agricultural production between Alternatives I and III (purchases in Table 28) multiplied by the sum of the surface and groundwater coefficients to the groundwater depletions for Alternative III (Table 27).

[b]Includes municipal and rural water requirements.

In both the New Mexico and Texas subregions, the effect of permitting agricultural production shifts to the next higher-valued enterprise was more important (except in 1980 in the Texas subregion) than the effect of the surface water availability responses to groundwater withdrawals.

For the third scenario (Alternative V), a constraint was incorporated on both the surface water availability and groundwater withdrawals in the region at the levels used in 1970. In addition, for Alternative V, in the New Mexico subregion a reduction in surface water availability of about 100 acre-feet was assumed to occur annually and in the Texas subregion aquifer recharge from surface flows was assumed to be more than offset by the return flows by 325 acre-feet annually. The agricultural sectors were also permitted to respond to the water shortages and increased demands for production by shifting sector production to the next higher-valued enterprise. A comparison of the agricultural sectors value of production for Alternatives IV and V is presented in Table 32. The differences are a result of the incorporation of the constraint on groundwater withdrawals. The agricultural sectors production purchases required (Table 32) indicate that the constraint on groundwater withdrawals reduces the level of agricultural production. The additional constraint on groundwater withdrawals has a greater effect on the agricultural production in the Texas subregion than in the New Mexico subregion. In the Texas subregion, agricultural purchases are required primarily in sector 1 (Food and Feed Grains) in 1980 and 1990, but by 2000, the largest purchases are required in sector 2 (Cotton).

The effect of the groundwater constraint on the water depletions of the region are reported in Table 33. In the New Mexico subregion, the surface water depletions are not affected by the incorporation of the groundwater constraint. The small differences in surface water depletions for Alternatives IV and V are due to rounding. The groundwater depletions are almost the same for the two alternatives. The minor differences between 1980 and 2010 are due primarily to rounding, but by 2020 the constraint results in a small reduction in groundwater depletions (265 acre-feet). In the Texas subregion, both surface water and groundwater depletions are reduced considerably by the additional constraint. Comparing Alternatives IV and V, the surface water depletions are reduced 12.96 percent by 1980, 27.6

Table 30. Comparison of agricultural sectors value of production and water depletions for Alternative III and a modified Alternative IV*

	1970 Base Period		1980		1990		2000		2010		2020	
	Value of Production ($ 000)	Water Depletions (ac-ft)	Value of Production ($ 000)	Water Depletions (ac-ft)	Value of Production ($ 000)	Water Depletions (ac-ft)	Value of Production ($ 000)	Water Depletions (ac-ft)	Value of Production ($ 000)	Water Depletions (ac-ft)	Value of Production ($ 000)	Water Depletions (ac-ft)
ALTERNATIVE III												
New Mexico Subregion												
AG 1	1,709	71,470	1,709	71,470	1,709	71,470	1,709	71,470	1,709	71,470	1,709	71,470
AG 2	5,507	93,784	5,609	95,521	5,508	93,801	5,508	93,801	5,508	93,801	5,508	93,801
AG 3	15,005	47,416	15,085	47,669	15,149	47,871	15,005	47,416	15,005	47,416	15,005	47,416
AG 4	18,110	10,100	20,650	11,517	23,187	12,931	23,947	13,355	23,947	13,355	23,947	13,355
AG 5	2,810	33	3,115	36	3,391	40	3,639	43	3,870	45	4,100	48
Total	43,141	222,803	46,168	226,213	48,944	226,114	49,808	226,085	50,039	226,088	50,269	226,091
Texas Subregion												
AG 1	2,403	89,440	2,404	89,477	2,404	89,477	2,404	89,477	2,404	89,477	2,404	89,477
AG 2	7,005	119,295	7,134	121,492	7,083	120,623	7,033	119,772	7,005	119,295	7,006	119,312
AG 3	4,106	15,028	4,322	15,819	4,538	16,609	4,750	17,385	4,852	17,758	4,830	17,678
AG 4	17,702	12,034	17,801	12,101	17,900	12,168	17,996	12,234	18,092	12,299	18,188	12,364
AG 5	2,200	26	2,544	30	2,880	34	3,215	38	3,550	42	3,886	45
Total	33,416	235,823	34,205	238,918	34,805	238,912	35,398	238,905	35,903	238,871	36,314	238,877
MODIFIED ALTERNATIVE IV*												
New Mexico Subregion												
AG 1	1,709	71,470	1,692	70,740	1,641	68,647	1,591	66,525	1,538	64,310	1,493	62,453
AG 2	5,507	93,784	5,609	95,521	5,508	93,801	5,508	93,801	5,508	93,801	5,508	93,801
AG 3	15,005	47,416	15,085	47,669	15,149	47,871	15,005	47,416	15,005	47,416	15,005	47,416
AG 4	18,110	10,100	20,650	11,517	23,187	12,931	23,947	13,355	23,947	13,355	23,947	13,355
AG 5	2,810	33	3,115	36	3,391	40	3,639	43	3,870	45	4,100	48
Total	43,141	222,803	46,151	225,483	48,876	223,290	49,690	221,140	49,868	218,927	50,053	217,073
Texas Subregion												
AG 1	2,403	89,440	2,404	89,477	2,404	89,477	2,404	89,477	2,404	89,477	2,404	89,477
AG 2	7,005	119,295	7,233	123,180	7,267	123,760	7,303	124,372	7,360	125,344	7,459	127,023
AG 3	4,106	15,028	4,322	15,819	4,538	16,609	4,750	17,385	4,852	17,758	4,830	17,678
AG 4	17,702	12,034	17,801	12,101	17,900	12,168	17,996	12,234	18,092	12,299	18,188	12,364
AG 5	2,200	26	2,544	30	2,880	34	3,215	38	3,550	42	3,886	45
Total	33,416	235,823	34,304	240,608	34,989	242,048	35,668	243,504	36,258	244,920	36,767	246,589

*Agricultural production shifts to next higher-valued enterprise not permitted.

Table 31. Comparison of value of production from agricultural sectors for Alternatives III and IV

Sector	Value of Production											
	1970 Base Period		1980		1990		2000		2010		2020	
	New Mexico	Texas	New Mexico	Texas	New Mexico	Texas	New Mexico	Texas	New Mexico	Texas	New Mexico	Texas
	(1,000 dollars)											
	ALTERNATIVE III											
Agriculture												
1	1,709	2,403	1,709	2,404	1,709	2,404	1,709	2,404	1,709	2,404	1,709	2,404
2	5,507	7,005	5,609	7,134	5,508	7,083	5,508	7,033	5,508	7,005	5,508	7,006
3	15,005	4,106	15,085	4,322	15,149	4,538	15,005	4,750	15,005	4,852	15,005	4,830
4	18,110	17,702	20,650	17,801	23,187	17,900	23,947	17,996	23,947	18,092	23,947	18,188
5	2,810	2,200	3,115	2,544	3,391	2,880	3,639	3,870	3,870	3,550	4,100	3,886
Total	43,141	33,416	46,168	34,205	48,944	34,805	49,808	35,398	50,039	35,903	50,269	36,314
	ALTERNATIVE IV											
Agriculture												
1	1,709	2,403	1,678	2,346	1,531	2,200	1,385	2,054	1,238	1,907	1,200	1,850
2	5,507	7,005	5,642	7,360	5,776	7,713	5,910	8,067	6,043	8,421	5,929	8,593
3	15,005	4,106	15,086	4,322	15,166	4,538	15,246	4,754	15,325	4,969	15,406	5,185
4	18,110	17,702	20,652	17,801	23,192	17,900	25,733	17,999	28,273	18,098	30,813	18,196
5	2,810	2,200	3,118	2,551	3,420	2,902	3,723	3,252	4,025	3,602	4,298	3,947
Total	43,141	33,416	46,176	34,380	49,085	35,253	51,997	36,126	54,904	36,997	57,646	37,771

Table 32. Comparison of agricultural sectors value of production for Alternative IV and V and agricultural production purchases required under Alternative V, Rio Grande Region

	Value of Production and Purchases											
	1970 Base Period		1980		1990		2000		2010		2020	
Sector	New Mexico	Texas	New Mexico	Texas	New Mexico	Texas	New Mexico	Texas	New Mexico	Texas	New Mexico	Texas
	(1,000 Dollars)											
	ALTERNATIVE IV											
Agriculture												
1	1,709	2,403	1,678	2,346	1,531	2,200	1,385	2,054	1,238	1,907	1,200	1,850
2	5,507	7,005	5,642	7,360	5,776	7,713	5,910	8,067	6,043	8,421	5,929	8,593
3	15,005	4,106	15,086	4,322	15,166	4,538	15,246	4,754	15,325	4,969	15,406	5,185
4	18,110	17,702	20,652	17,801	23,192	17,900	25,733	17,999	28,273	18,098	30,813	18,196
5	2,810	2,200	3,118	2,551	3,420	2,902	3,723	3,252	4,025	3,602	4,298	3,947
Total	43,141	33,416	46,176	34,380	49,085	35,253	51,997	36,126	54,904	36,997	57,646	37,771
	ALTERNATIVE V											
Agriculture												
1	1,709	2,403	1,678	1,456	1,532	300	1,387	300	1,242	300	1,098	300
2	5,507	7,005	5,641	7,359	5,775	7,690	5,907	4,962	6,039	2,235	6,170	500
3	15,005	4,106	15,085	4,322	15,165	4,538	15,244	4,753	15,324	4,969	15,402	621
4	18,110	17,702	20,641	17,801	23,169	17,900	25,676	17,998	28,182	18,096	30,651	18,194
5	2,810	2,200	3,117	2,541	3,418	2,878	3,718	3,115	4,018	3,351	4,314	3,611
Total	43,141	33,416	46,162	33,479	49,059	33,306	51,932	31,128	54,805	28,951	57,635	23,226
	PRODUCTION PURCHASES REQUIRED*											
Agriculture												
1				890	-1	1,900	-2	1,754	-4	1,607	102	1,550
2			1	1	1	23	3	3,105	4	6,186	-241	8,093
3			1		1		2	1	1		4	4,564
4			11		23		57	1	91	2	162	2
5			1	10	2	24	5	137	7	251	-16	336
Total			14	901	26	1,947	65	4,998	99	8,046	11	14,545

*Difference between value of production for Alternative IV and value of production for Alternative V. Provides an estimate of the value of purchases required as a result of the groundwater constraint.

Table 33. Comparison of water requirements for Alternatives IV and V by subregion, Rio Grande Region

Year	Alternative IV						Alternative V					
	Surface Water Depletions		Groundwater Depletions*		Groundwater Withdrawals*		Surface Water Depletions		Groundwater Depletions*		Groundwater Withdrawals*	
	(ac-ft)	Change from 1970 (%)	(ac-ft)	Change from 1970 (%)	(ac-ft)	Change from 1970 (%)	(ac-ft)	Change from 1970 (%)	(ac-ft)	Change from 1970 (%)	(ac-ft)	Change from 1970 (%)
						NEW MEXICO SUBREGION						
1970	166,594	--	64,012	--	111,253	--	166,594	--	64,012	--	111,253	--
1980	168,999	1.44	65,300	2.01	113,977	2.45	168,978	1.43	65,294	2.00	113,968	2.44
1990	167,978	.83	65,300	2.01	113,977	2.45	167,980	.83	65,147	1.77	114,283	2.72
2000	166,987	.24	64,992	1.53	114,588	3.00	166,971	.23	65,003	1.55	114,605	3.01
2010	165,951	- .39	64,828	1.27	114,875	3.26	165,965	- .38	64,857	1.32	114,924	3.30
2020	164,949	- .99	64,986	1.52	115,728	4.02	164,950	- .99	64,721	1.11	115,260	3.60
						TEXAS SUBREGION						
1970	176,038	--	112,580	--	290,830	--	176,038	--	112,580	--	290,830	--
1980	179,771	2.12	124,849	10.90	331,729	14.06	156,475	-11.11	114,996	2.15	313,147	7.67
1990	181,150	2.90	136,124	20.91	370,755	27.48	131,150	-25.50	115,002	2.15	330,942	13.79
2000	182,542	3.69	147,403	30.93	409,788	40.90	96,754	-45.04	115,022	2.17	351,776	20.96
2010	183,904	4.47	158,670	40.94	448,800	54.32	62,374	-64.57	114,999	2.15	372,372	28.04
2020	185,285	5.25	170,173	51.16	488,429	67.94	28,144	-84.01	115,089	2.23	394,310	35.58

*Includes municipal and rural water requirements

percent by 1990, 47.0 percent by 2000, 66.08 percent by 2010, and 84.81 percent by 2020 (Table 33). The groundwater depletions are reduced by 7.89 percent by 1980, 15.52 percent by 1990, 21.97 percent by 2000, 27.52 percent by 2010, and 32.37 percent by 2020 (Table 33). The demands for groundwater by the municipal and industrial sectors in the Texas subregion require the surface water depletions be reduced and transferred to groundwater.

In all of the previous scenarios, interregional transfers of water between the regions were not permitted. If a surface water constraint is imposed as in Alternative II, Scenario I, and if interregional transfers of water were permitted, additional shifts in water use and regional production are expected to occur. The water use in the Texas subregion is expected to shift from a predominate surface supply to primarily a groundwater supply. Production in the Texas subregion would be expected to be primarily in the industrial sectors, with minor agricultural production expected. In the New Mexico subregion, the surface water use is expected to increase due to the transfer of surface water from the Texas subregion into the New Mexico subregion. The agricultural production of the New Mexico subregion is expected to increase substantially, since the bulk of the production would be expected in this subregion. The industrial production is not expected to increase in the New Mexico subregion above earlier scenario levels. For the region as a whole, the interregional transfers of water are expected to permit the economy to approach an unconstrained state. In general, the New Mexico subregion has a comparative advantage in agricultural production if it is not constrained by surface water supplies, and the Texas subregion certainly would be expected to have an advantage in industrial production. By permitting interregional water transfers, the total regional economy would be expected to approach unconstrained levels, with increased interregional trade flows occurring.

For each alternative, several components were examined either individually or in concert with each other. The purchase of additional water necessary to satisfy demands was permitted in many cases to meet projected future needs. When imports (purchase of water) were not permitted, purchaes of agricultural production occurred to satisfy the increased processing demands. In others, groundwater mining was permitted to meet projected water requirements. With full consumptive use of surface water supplies in the Rio Grande Region--Alternatives III and IV--considerable groundwater mining would be expected by 2020. In fact, an additional 134,000 acre-feet of water per year must be withdrawn from the groundwater aquifers to support the anticipated production. The ability of the groundwater aquifers to sustain this level of withdrawal was not evaluated in this study. Similarly, importation plans and/or water salvage possibilities in lieu of groundwater mining were not examined. Additional research and assessments would be necessary for evaluation of these alternatives.

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APPENDIX A

STRUCTURE OF THE REGIONAL ECONOMY (INPUT-OUTPUT FRAMEWORK)

This section describes the economic structure of the regional economy in an input-output (interindustry) framework. Input-output (I-O) analysis involves the modeling of dollar flows through a given economy. This enables inferences to be made concerning the interdependence of the various economic activities within the economy.

Two I-O models, one for El Paso and Hudspeth counties in Texas and one for Dona Ana and Sierra counties in New Mexico, provide the base data on the economic structure of the subregions. These two models are linked together in terms of interregional trade flows to form an overall integrated model of the total (four county) economy.

The Sectors

To construct an I-O model, it is necessary first to group similar economic activities into sectors. There can be as many or as few sectors as is necessary to include all of the business transactions in the economy. The degree of aggregation or disaggregation of the sectors depends, of course, on the purpose of the study. For example, since the focus of this study is on water use and management, the irrigated crops subsectors of the agricultural sector are disaggregated more than is usual in most I-O models.

Sector titles, sector gross output and sector output as a percentage of total output for the Texas and New Mexico models are presented in Table A-1. The individual sectors having the greatest gross output in El Paso and Hudspeth counties, Texas, are construction, petroleum, and textiles and apparel. Agriculture (sectors 1 through 5) makes up 2.4 percent of total output of the subregion. Manufacturing industries (sectors 9 through 20) comprise 38 percent of gross output. Wholesale and retail trade (sectors 30 through 33) and service industries (sectors 34 through 39) contribute 16 and 19 percent, respectively (Table A-2).

In Dona Ana and Sierra counties, New Mexico, the individual sectors having the greatest gross output are construction; FIRE (finance, insurance, and real estate); livestock, dairy and poultry; and other irrigated crops (fruits and nuts). In this subregion, agriculture (sectors 1 through 5) makes up 21.1 percent of total output of the subregion. Manufacturing industries (sectors 9 through 20) comprise 7.8 percent of gross output. Wholesale and retail trade (sectors 30 through 33) and service industries (sectors 34 through 39) contribute 14.3 and 26.1 percent, respectively (Table A-2).

National I-O models utilize a four digit Standard Industrial Classification (SIC) in delineating sector categories [*U. S. Office of Management and Budget*, 1967]. The SIC code identifies particular kinds of business activities included in the sector. With regional economies being specialized, all SIC categories are not represented. For this reason, many of these categories are either aggregated into a larger sector or are omitted. The sectors of this study and the related SIC codes are presented in Table A-3.

The Transactions Table

The transactions table of an I-O model provides a picture of input flows to an industry from various sectors and the distribution of that industry's output to other sectors. Inputs that are required by an industry, but are not available within the local economy, are recorded as imports to

Table A-1. Economic sectors, gross output and sector output as percent of total output for the Rio Grande Region, 1967

Sector Number	Sector Title	Texas[a] Gross Output ($1,000)	Texas[a] Percent of Total (%)	New Mexico[b] Gross Output ($1,000)	New Mexico[b] Percent of Total (%)
1	Grain & Hay	2,400.0	.17	1,700.0	.83
2	Cotton	7,000.0	.50	5,500.0	2.70
3	Other Irrigated Crops	4,100.0	.29	15,000.0	7.37
4	Livestock, Dairy, Poultry	17,700.0	1.25	18,000.0	8.84
5	Agri. Service & Supply	2,200.0	.16	2,800.0	1.38
6	Mining	4,700.0	.33	4,500.0	2.21
7	Construction	178,500.0	12.62	37,000.0	18.17
8	Maintenance & Repair	19,400.0	1.37	3,800.0	1.87
9	Food Processing	84,400.0	5.97	6,400.0	3.14
10	Textiles & Apparel	166,800.0	11.80	2,000.0	.98
11	Lumber	6,500.0	.46	---	---
12	Furniture	2,200.0	.16	---	---
13	Boxes & Paper Containers	600.0	<.01	---	---
14	Printing & Publishing	12,600.0	.89	1,900.0	.93
15	Chemicals	5,600.0	.40	---	---
16	Petroleum	176,200.0	12.46	---	---
17	Rubber & Leather	7,700.0	.54	---	---
18	Glass, Stone, Clay, Cement	15,400.0	1.09	1,200.0	.59
19	Primary & Fabri. Metals	41,700.0	2.95	300.0	.15
20	Machinery	17,200.0	1.22	4,200.0	2.06
21	Railroad Transportation	12,400.0	.88	1,500.0	.74
22	Intercity Freight	23,600.0	1.67	900.0	.44
23	Trucking & Warehousing	1,200.0	.01	900.0	.44
24	Air Transportation	8,300.0	.59	23.0	.01
25	All Other Transportation	3,300.0	.23	777.0	.38
26	Communication Service	29,200.0	2.07	5,100.0	2.50
27	Gas Utility	36,500.0	2.58	100.0	.05
28	Electric Utility	28,000.0	1.98	7,600.0	3.73
29	Water Utility	7,300.0	.52	100.0	.05
30	General Wholesale	105,300.0	7.45	6,900.0	3.39
31	General Retail	103,600.0	7.33	18,500.0	9.09
32	Auto Dealers	11,900.0	.84	2,200.0	1.08
33	Gas Service Stations	3,700.0	.26	1,500.0	.74
34	Eating & Drinking Places	10,000.0	.71	2,200.0	1.08
35	FIRE*	71,400.0	5.05	31,500.0	15.47
36	Lodging	12,600.0	.89	3,700.0	1.82
37	Personal Services	38,100.0	2.69	13,700.0	6.73
38	Professional Services	134,700.0	9.53	2,100.0	1.03
		1,414,000.0		203,600.0	

*FIRE includes the activities of finance, insurance and real estate--includes all banks and related activities.

[a]El Paso and Hudspeth counties.

[b]Dona Ana and Sierra counties.

Table A-2. Major groupings of economic sector output as percent of total output for the Rio Grande Region, 1967

Groupings	Sectors	Percent of Total Output (%) Texas[a]	Percent of Total Output (%) New Mexico[b]
Agriculture	1-5	2.37	21.12
Mining	6	.33	2.21
Construction	7-8	13.99	20.04
Manufacturing	9-20	37.94	7.85
Transportation	21-25	3.38	2.01
Utilities	26-29	7.15	6.33
Wholesale-Retail	30-33	15.88	14.30
Services	34-38	18.87	26.13

[a]El Paso and Hudspeth counties

[b]Dona Ana and Sierra counties

Table A-3. Economic sectors and SIC codes for study area I-O models

Sector Number	Sector Title	Related SIC Codes*
1	Grain & Hay	0113, 0313
2	Cotton	0112
3	Other Irrigated Crops	0122, 0123, 0119
4	Livestock, Dairy, Poultry	0235, 0135-36, 0132, 0133-34
5	Agri. Service & Supply	5962, 69, 0712-15, 19, 22-23, 0729, 31, 41
6	Mining	1311, 12, 81-82, 89, 1411, 22-23, 29, 42, 46, 52, 56, 59, 76-77, 92, 99, 101-103, 05-06, 08-09
7	Construction	1511, 1611, 21
8	Maintenance & Repair	1700
9	Food Processing	2011, 13, 15, 21-24, 26, 42, 51-52, 31-38, 91-99, 61-63, 7-72, 82, 84, 86-87, 2121
10	Textiles & Apparel	2211, 21, 31, 41, 51, 53, 56, 59, 2261-62, 69, 71-72, 79, 81, 84, 91, 93-95, 97-99, 2311, 21-23, 27-29, 31, 35-37, 99, 41-42, 51-52, 61, 63, 69, 2371, 81, 84-87, 89, 91-97, 99
11	Lumber	2421, 26, 29, 31-33, 41-45, 91, 99
12	Furniture	2511-12, 14-15, 19, 21-22, 41-42, 91, 99
13	Boxes & Paper Containers	2641-47, 49
14	Printing & Publishing	2651-55, 2721, 31-32, 41, 51-53, 61, 71, 82, 89, 91, 93-94, 99
15	Chemicals	28121-24, 32-34, 91-99, 28211-17, 19, 2841-44, 51, 61, 91-93, 95, 99
16	Petroleum	2911, 51-52, 92, 99
17	Rubber & Leather	3069, 79, 3111, 31, 41-42, 51, 61, 71-72, 99
18	Glass, Stone, Clay, Cement	3221, 29, 31, 51, 53, 55, 59, 61-62, 69, 81, 91-92, 95-97, 99, 74-75, 01, 93, 71-73, 41
19	Primary & Fabri. Metals	3312, 13, 15-17, 31-33, 39, 41, 62, 69, 91-92, 99, 3441-44, 46, 49, 71, 79
20	Machinery	3532-36, 61-62, 64-67, 69, 81-82, 86, 89, 99, 3611-13, 21-22, 24, 29, 41-42, 44, 31-36, 39, 51, 61-62, 71, 74, 79, 93-94, 52, 99, 91, 3713-15, 11, 3811, 41-43, 51, 31, 61, 71, 3941-42, 49, 11, 13-14, 31, 51-53, 55, 61-64, 82-84, 87, 91, 93, 95, 99
21	Railroad Transportation	4011, 13, 21, 41
22	Intercity Freight	4131-32, 4213, 31
23	Trucking & Warehousing	4212, 14, 21-23, 24-26
24	Air Transportation	4511, 21, 82-83
25	All Other Transportation	4612-13, 19, 4111, 19, 21, 40-42, 50, 71-72, 4742, 82-84, 89, 4721
26	Communication Services	4811, 21, 32-33, 99
27	Gas Utility	4922-23, 32, 9149, 9249, 9349
28	Electric Utility	4911, 31, 9151, 9251, 9351
29	Water Utility	9102, 9202, 9302, 4941, 52-53, 59, 61
30	General Wholesale	5012-14, 41-49, 52-54, 59, 4731, 5081-85, 87-88, 92, 22, 28-29, 33-34, 36-37, 39, 63-65, 72, 74, 77, 91, 93-99
31	General Retail	5211, 52, 21, 31, 41, 51, 5311, 31, 99, 5411, 21, 31, 41, 51, 62, 99, 5611, 21, 31, 41, 51, 61, 71, 81, 99, 5712-15, 19, 22, 32-33, 5912, 21, 32-33, 42-43, 52-53, 91-92, 99, 71, 82, 84, 93-97, 99, 41, 51
32	Auto Dealers	511, 21, 31, 7549, 31, 34-35, 38-39, 42
33	Gas Service Stations	554
34	Eating & Drinking Places	5812-13
35	FIRE	6011-59, 6112-61, 6312-99, 6411, 6211-81, 6512-61, 6611, 6711-99
36	Lodging	7011, 21, 41, 31-32
37	Personal Services	3111, 8931, 7211-18, 31, 41, 51, 61, 71, 99, 7813-18, 21, 7395, 7221, 7331-32, 39, 7311-13, 19, 7832-33, 7911, 29, 32-33, 41-43, 45, 49, 7523, 25, 7512-13, 19, 7622-23, 29, 7631, 41, 92, 94, 99
38	Professional Services	8011, 21, 31, 41, 61, 71-72, 92, 99, 8211, 8221-22, 31, 41-42, 99, 8911, 7361, 7391, 8921, 7341-42, 49, 51, 92-94, 96-99, 73, 8999, 8411, 21, 8611, 21, 31, 41, 51, 61, 71, 99, 8811

*Source: *U. S. Office of Management and Budget, Standard Industrial Classification Manual.*

the economy. At the same time, all output of an industry that is not internally consumed, is exported. Thus, the transactions table of an I-O model shows linkages between sectors in terms of "purchases from" and "sales to" related industries.

The transactions table is made up of three major components--processing sectors, final demand and final payments sectors. Each processing sector (those sectors within the region that produce goods and services) is listed in the transactions table both as a row and as a column to indicate the sales and purchases among sectors. The processing sectors make up the internal or endogenous part of the table.

The household sector is not always included in the processing or endogenous portion of I-O models. However, households do provide (sell) labor and management skills to other processing sectors and consume (purchase) the products of the other sectors. Thus, the household sector was considered endogenous in this study so that the effect of changes in household activity (purchasing and selling) could be reflected in the model.

Final demand and final payments sectors complete the transactions table. Final demand sectors are depicted as columns, while final payments are shown as rows. Final demand sectors include those sales of goods and services produced by the processing sectors that are not internally consumed by other processing sectors. These include purchases by government, exports, net inventory change and capital formation. Government is frequently disaggregated into federal, state, and local as in the present model.

Methodology

The basic transactions matrices for this study were developed by compressing and scaling down an earlier I-O study of West Texas, *Upper Rio Grande Valley-Texas Interindustry Study* [George and Richards, 1972]. Also, the irrigated crop sectors were disaggregated from the single sector reported in the earlier study. A brief discussion of these procedures follows for the development of the El Paso and Hudspeth county model. The New Mexico portion of the Model (Dona Ana and Sierra counties) was obtained simply by assuming the same structure (direct requirements matrix) as for the Texas model and multiplying the appropriate New Mexico sector outputs.

Compressing and Scaling Down

The number of sectors in the *Upper Rio Grande Valley-Texas Interindustry Study* was greater than that desired for this study. The larger 10-county model included 67 endogenous sectors, whereas for the two-county model only 39 sectors were desired. Using existing computer programs, a compress route was applied to the data used in the 10-county regional model. The purpose of this was to generate a regional (10-county) model with the desired number of sectors. The data obtained from this program were then used along with the control totals to generate an I-O model for El Paso and Hudspeth counties.

A program developed by Mustafa and Jones (1971) was employed to generate a 37 endogenous sector[1] model for the two-county region. This program takes the control totals (sector output) for a regional model (El Paso-Hudspeth) and scales down the transactions matrix by applying location quotients to the larger (10 county--Upper Rio Grande) model.[2] Specifically, the program provides a method for estimating subregional interindustry transactions, technical and interdependence coefficients and sector multipliers from a larger input-output model and other secondary data. The program may be adapted for use in estimating regional input-output models for any region, number of sectors, or base year. The base year need not be the same as that of the larger input-output table [Mustafa and Jones].

Disaggregation of Irrigated Crops

The original 10-county study had all irrigated crops as a single sector. Thus, when the transactions table for the El Paso-Hudspeth counties model was generated, it contained 37 sectors with irrigated food and feed grain, cotton, and vegetables, fruits, nuts and other irrigated crops aggregated into one sector. To complete the 39 x 39 table, row 1 and column 1 had to be disaggregated into three rows and columns.

The general procedure for disaggregation was as follows:

1. For the column (i.e., purchases by irrigated agriculture from other sectors), an allocation was made based on the purchasing pattern exhibited in the High Plains Study [Osborn and McCray, 1972]. The allocation logic was as follows:

   Step 1. The average direct requirement coefficient ($\bar{X}_i$) for all irrigated crop categories (3) in the High Plains was calculated as

$$\bar{X}_i = \frac{\sum_{j=1}^{3} X_{ij}}{3}$$

where

X_{ij} = direct requirement ($purchases/$output) by the j^{th} irrigated crop from the i^{th} sector

i = 1, 2, ..., 39

j = 1, 2, 3

   Step 2. The individual crop direct requirement as a proportion of the average (W_{ij}) was calculated as

$$W_{ij} = \frac{X_{ij}}{\bar{X}_i}$$

where

$0 \leq W_{ij} < 1$ and $\sum_{j=1}^{3} > 1$

   Step 3. The direct requirements coefficient (C_{ij}) for the three desired irrigated crop subsectors for the El Paso-Hudspeth model were estimated by multiplying the composite ("average") direct requirement coefficient ($\bar{C}_i$) for El Paso-Hudsepth by the appropriate W_{ij} based on the High Plains coefficients; i.e., $C_{ij} = W_{ij}\ \bar{C}_i$

   Note: The assumption of step 1 through 3 is that a composite ("average") figure can be disaggregated if, for a "comparable situation," the composite and its component parts are known.

[1]Subsequently the irrigated crop sector was disaggregated into three sectors yielding the desired 39 sector model (see next section).

Step 4. The C_{ij} was then used to disaggregate the column entries (purchases by all irrigated crops from other sectors) into the desired three subsectors by

$$C_{ij} P_i = P_{ij}$$

where

P_i = purchases by all irrigated crops from the i^{th} sector

P_{ij} = estimated purchases by j^{th} irrigated crop from the i^{th} sector.

Step 5. Since the procedure does not guarantee that $\sum_{j=1}^{3} P_{ij} = P_i$ the three new column entries (P_{ij}'s) were adjusted to force the equality by increasing or reducing each P_{ij} in proportion to their respective control totals (i.e., in proportion to their relative share of total irrigated crop output).

II. For the row (i.e., sales by irrigated crops to other sectors) the allocation was judgemental. The sales pattern by irrigated agriculture to other sectors was not consistent in many instances between the High Plains and Upper Rio Grande Studies. The Upper Rio Grande model shows sales (generally of relatively small magnitude) to numerous sectors not shown in the High Plains model. Allocation of sales by irrigated crops are shown in Table A-4.

Table A-4. Disaggregation of sales by irrigated crops sector to irrigated crop subsectors.

		Percent of Total Sales Allocated to:		
Sales by Irrigated Crops to:	Basis of Allocation	Food & Feed Grains	Cotton	Vegetables Fruits, Nuts & Other
4. Livestock	High Plains[a]	80.0	---	20.0
5. Agri. Service & Supply	Proportional[b]	17.8	51.9	30.3
9. Food Processing	Proportional[b]	17.8	51.9	30.3
10. Textiles & Apparel	High Plains[a]	---	100.0	---
11. Lumber	Judgemental[c]	---	---	100.0
12. Furniture	Judgemental[c]	---	---	100.0
13. Boxes & Paper Containers	Judgemental[c]	---	---	100.0
14. Printing & Publishing	Judgemental[c]	---	---	100.0
15. Chemicals	Judgemental[c]	---	---	100.0
16. Petroleum	Judgemental[c]	---	---	100.0
17. Rubber & Leather	Judgemental[c]	---	---	100.0
18. Glass, Stone, Clay, Cement	Judgemental[c]	---	---	100.0
19. Primary & Fabri. Metals	Judgemental[c]	---	---	100.0
20. Machinery	Judgemental[c]	---	---	100.0
30. General Wholesale	Proportional[b]	17.8	51.9	30.3
31. General Retail	High Plains[a]	20.0	---	80.0
38. Professional Services	Judgemental[c]	---	---	100.0
39. Households	Judgemental[c]	---	---	100.0

[a]Based on percentage of individual irrigated crop sales of total sales to that particular sector from the High Plains model.

[b]Based on percentage of individual irrigated crop output (sales) of total irrigated crop output for El Paso and Hudspeth counties.

[c]The only conceivable irrigated crop that might be sold directly from agriculture to these sectors would seemingly be vegetables, fruits and nuts.

Data Sources

Data concerning sector outputs (Table A-1) were obtained, for the most part, from published federal and state government sources. Because of the time and cost involved, little primary data were collected. Control totals (sector output) from the chosen sectors were developed for El Paso and Hudspeth counties in Texas and Dona Ana and Sierra counties in New Mexico.

Data for the agricultural sectors (sectors 1-5) were taken from the *1969 Census of Agriculture* (1970). The Census lists total sales of all irrigated crops, then breaks out irrigated cotton and vegetables, fruits, nuts and miscellaneous other crops. To arrive at the total for sector 1--food and feed grains, the value for cotton and vegetables, fruits, nuts and other irrigated crops was subtracted out. These values were then entered as the totals for the respective sectors 2 and 3. Sector 4--livestock, dairy and poultry--was taken directly from the Census with a minor adjustment to be included in agricultural services and supply.

For agricultural service and supply--sector 5, a disclosure problem was encountered; i.e., limited number of firms in the sector.[2] Based on the state data, seven percent of the total of sectors 1, 2, 3, and 4 was used as the value for sector 5.

Sector output for mining (sector 6) was taken from the *1967 Census of Mineral Industries* (1965).

Construction information was available from the *1967 Census of Manufactures* (1970). For the purpose of this study, all construction activity, with the exception of maintenance and repair, was aggregated into one sector (sector 7). Maintenance and repair is a separate sector (sector 8). Data for sectors 5-25 (manufacturing and transporation activities) were also taken from the *1967 Census of Manufactures*. In cases where statistical data were not available due to disclosure problems, numbers of employees in the study region were multiplied by corresponding output per employee from state level data. In those cases where numbers of employees were not published, knowledgeable people in the region were consulted to obtain an estimate of employee numbers.

Communication and utilities (sectors 26-29) were valued as reported by the *1967 Business Statistics*. All wholesale trade was aggregated into one sector (sector 30). Total sales was taken from the *1967 U. S. Census of Wholesale, Retail and Selected Service* (1970). Total sales were deflated to obtain an estimate of value added.[4]

The control totals for sectors 35 (FIRE--finance, insurance, and real estate), 36 (lodging), 37 (personal service) and 38 (professional services), were all taken from the *1967 Census of Wholesale, Retail and Selected Services*.

Since households was an endogenous sector in the George-Richards model, a control total had to be developed for Sector 39. The *1967 Census of Population* (1970) showed that of the 428,771 people residing in the 10 counties, 361,683 lived in the counties of this study, or 84.35 percent. Since the households sector represents purchases by (products bought) and payments to (wages) residents, 84.35 percent of the 10-county regional total was used.

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[2]The Census does not report information when only a few firms are involved to avoid possibly disclosing confidential information of an individual firm.

[3]The wholesale and retail trade sectors resell products they have purchased, so the total sales value would be incorrect as a control total. An estimate of value added is the desired figure. The deflators used were: wholesale .1950; retail .3183; auto dealers .1226; gas service stations .1288; eating and drinking places .3404.

APPENDIX B

SOCIO-ECONOMIC MODEL

The socio-economic model is essentially an interregional linear programming model for the Rio Grande Region. The basic mathematics of the model are presented below with a description of each set of model constraints.

The objective function for the model can be represented by the following equation:

$$\text{Maximize} \sum_{i=1}^{2}\sum_{j=1}^{38} X_{ij}V_{ij} - \sum_{i=1}^{2}\sum_{k=1}^{3} PR_{ik}CPR_{ik} - \sum_{i=1}^{2}\sum_{\substack{i'=1 \\ i\neq i'}}^{2}\sum_{k=1}^{3} TR_{ii'k}CTR_{ii'k}$$

$$- \sum_{i=1}^{2}\sum_{\ell=1}^{5} PPOL_{i\ell}CPPOL_{i\ell} - \sum_{i=1}^{2}\sum_{\substack{i'=1 \\ i'\neq 1}}^{2}\sum_{\ell=1}^{5} TPOL_{ii'\ell}CTPOL_{ii'\ell}$$

$$- \sum_{i=1}^{2} UE_iCUE_i - \sum_{i=1}^{2} PL_iCPL_i - \sum_{i=1}^{2}\sum_{\substack{i'=1 \\ i'\neq i}}^{2} TL_{ii'}CTL_{ii'} -$$

$$- \sum_{i=1}^{2}\sum_{m=1}^{2}\sum_{n=1}^{2} PW_{imn}CPW_{imn} - \sum_{i=1}^{2}\sum_{i'=1}^{2}\sum_{m=1}^{2}\sum_{n=1}^{2} TW_{ii'mn}CTW_{ii'mn}$$

$$- \sum_{i=1}^{2}\sum_{j=1}^{4} PAG_{ij}CPAG_{ij} - \sum_{i=1}^{2}\sum_{\substack{i'=1 \\ i'\neq 1}}^{2}\sum_{j=1}^{4} TAG_{ii'j}CTAG_{ii'j}$$

Definition and description of symbols:

i	=	the number of the subregion;
i'	=	the number of the subregion from which the particular "resource" is being transferred;
j	=	the number of the sector;
k	=	the type of recreation;
ℓ	=	the type of pollution;
m	=	the type of water;
n	=	the "measure" of water (as defined for the model);
i	=	1 New Mexico subregion--Dona Ana and Sierra counties 2 Texas subregion--El Paso and Hudspeth counties 3 any area outside of 1 and 2
j	=	1-38 see Table 2 (Chapter III) for classification and description of the production sectors
k	=	1 Boating (primarily pleasure) 2 Water skiing 3 Fishing (both warm and cold water)

ℓ = 1 Biological Oxygen Demand (BOD)
2 Chemical Oxygen Demand (COD)
3 Suspended Solids (SS)
4 Dissolved Solids (DS)
5 Nutrients (Both P and N compounds)

m = 1 Surface
2 Ground

n = 1 diversions or new water intake
2 depletion or water consumption

X_{ij} = The level of activity in thousand-dollar units of a particular sector j within subregion i.

V_{ij} = The value added per unit (thousand-dollar units) of a particular sector j ($V_{1j} \approx V_{2j}$ due to the construction of the input-output table from which the V_{ij}'s are derived).

PR_{ik} = The amount of additional recreational "use" in activity occasion in subregion i of type k to satisfy demands.

CPR_{ik} = The cost of a unit (activity occasion) of additional recreational "use" in subregion i of type k.

$TR_{ii'k}$ = The amount in activity occasions of recreational "use" transferred to subregion i from subregion i' of type k (this includes export and import of activity occasions to and from areas outside of the Rio Grande Region).

$CTR_{ii'k}$ = The cost per unit (activity occasion) of transferred recreational "use" to subregion i from subregion i' of type k.

$PPOL_{i\ell}$ = The amount of pollution in pounds in subregion i of type ℓ that must be "purchased" from the system to meet standards.

$CPPOL'_{i\ell}$ = The cost per unit (pounds) of "purchased" pollution in subregion i of type ℓ.

$TPOL_{ii'\ell}$ = The amount of pollution in pounds transferred from subregion i to subregion i' of type ℓ to meet standards in subregion i.

$CTPOL_{ii'\ell}$ = The cost per unit (pounds) of transferred pollution from subregion i to subregion i' of type ℓ.

UE_i = The amount of labor in employees in subregion i that remains unemployed within the system.

CUE_i = The cost per unit (employee) of unemployed labor in subregion i.

PL_i = The amount of additional labor in employees needed from the outside in subregion i to satisfy its demand.

CPL_i = The cost per unit (employee) of "additional" labor.

$TL_{ii'}$ = The amount of labor in employees transferred to subregion i from subregion i' to meet its demand.

$CTL_{ii'}$ = The cost per unit (employee) of transferring labor to subregion i from subregion i' to meet its demands.

PW_{imn} = The amount of water in acre-feet purchased in subregion i of type m and "measure" n.

CPW_{imn} = The cost per unit (acre-feet) of purchased water in subregion i of type m and "measure" n.

$TW_{ii'mn}$ = The amount of water in acre-feet transferred from subregion i to subregion i' of type m and measure n (this includes transfer within the same subregion).

$CTW_{ii'mn}$ = The cost per unit (acre-feet) of transferred water to subregion i from subregion i' of type m and "measure" n.

PAG_{ij} = The amount of additional agricultural production in subregion i of type j needed to satisfy final demands.

$CPAG_{ij}$ = The cost per unit (thousand dollar) of "purchasing" or acquiring agricultural production of type j in subregion i.

$TAG_{ii'j}$ = The amount of agricultural production of type j transferred to subregion i from subregion i'.

$CTAG_{ii'j}$ = The cost per unit (thousand dollar) of agricultural production of type j transferred to subregion i from subregion i'.

The objective function maximizes value added within the Rio Grande Region subject to several separate cost components. Typically, value added per unit (V_{ij}) measures the payment to households as wages, payments to governments as taxes, and payments to businesses as profits. The goal, therefore, is to maximize this "net addition" to the region. The cost components serve as mechanisms to encourage the system as represented by this socio-economic model to use as little as possible of any of the "resources" or activities that these cost components reflect.

The cost component (CPR_{ik}) places a relatively high price in the initial model on the generation of any additional recreational capacity within a subregion. This serves to minimize any building of recreational facilities to satisfy demands until (a) all present resources are utilized and (b) maximum transfers between and among the subregions have taken place. The cost component ($CTR_{ii'k}$) serves to place a price on the system for "transferring" excess recreational capacity in one subregion to satisfy demands in another. This cost is much less than the cost associated with generating capacity, insuring all recreational capacity within the available area is utilized to satisfy all demands before construction starts on further capacity. However, there is still a cost because a certain decrease in use will occur if one has to travel to other subregions to use their facilities.

The cost component ($CPOL_{i\ell}$) assigns a price to the system of cleaning up the streams once the standards and carrying capacities have been violated. Therefore, every unit of pollution that is generated over some amount that will just meet the proposed standards must be treated as a cost. The cost component ($CTPOL_{ii'\ell}$) is assigned to transferring excess pollution-carrying capacity among the subregions. This cost, as in recreation, is much less than the cost of cleaning up a subregion's stream and will vary depending upon several stream flow characteristics and the actual point of pollution within one subregion in relation to another subregion.

The cost (CUE_i) is assigned to the system for "allowing" unemployment within a subregion. Unemployment insurance, welfare payments, etc., are just a few of the elements considered in the cost to the region as a whole. If labor is needed from outside the system, a very high price (CPL_i) is charged for acquiring such labor. The high price assigned reflects the relative difficulty of actually being able to aquire labor from outside the region on short notice. Purchased labor should only be evident if mistakes have been made in calculating labor use and coefficients initially. It is much more likely that labor would shift from one subregion to the other rather quickly in the region, and thus a much lower cost to the system (CTL_i) is assigned. Even with the greater probability of inter-regional moves, there will still be disruptions and various losses that must be reflected in this cost component.

There is a definite price (CPW_{imn}) charged to the system from any additional water made available for use within a subregion. This availability could be water salvage, intrabasin purchases and transfers, purchases of groundwater supplies, or the acquisition of water rights. The component ($CTW_{ii'mn}$) places a price upon the transfer of water from one subregion to another. There is a definite loss or gain of water when its use is transferred down or up-stream. In addition there is some cost in substituting ground for surface water in one subregion or between subregions. For surface transfers, there is a loss of pollution-carrying capacity and recreational use to the subregion initiating the transfer.

Within any transfer mechanism there are legal constraints and costs. Therefore, a cost is assigned to the system for transferring this important resource from subregion to subregion.

Water and land limit the expansion capabilities of agricultural production in the region. The component ($CPAG_{ij}$) assigns a price to all units of agriculture acquired from outside the region to satisfy regional demands. A relatively high price ensures that production capacity is utilized before any agricultural products are "purchased." The cost component ($CTAG_{ii'j}$) allows excess production capacity to be transferred from one subregion to the other to satisfy output demands. Such transfers necessarily will place certain losses and foregone welfare increases upon the system, which are accounted for in this component.

Many of the cost components reflected in the outright "purchase" or "transfer" of specific "resources" and activities within the region may at times be set arbitrarily high to allow examination of alternative policies where such "purchases" or "transfers" would adversely influence the analysis.

The objective function is thus concerned with maximizing value added subject to these costs.

(1) Under-utilization of the labor force (unemployment).

(2) Transferring

(a) Pollution-carrying capacity of a stream.

(b) Excess recreational capacity.

(c) Excess water.

(d) Excess labor in one subregion.

(e) Excess agricultural production capability.

(3) Maintaining stream standards.

(4) Creating additional recreational use capacity.

(5) Adding additional water to each subregion.

(6) Acquiring additional labor from outside the system.

The actual value of the objective function is not really important: only the relative differences when various transfers, movements, and additions of resources are hypothesized in differing scenarios when solving the model. In addition, differential pricing in the cost components can be considered and weighed by using the mechanism of the objective function to assign relative weights to all activities.

Model Constraints

Production Constraints

$$\sum_{i=1}^{2}\sum_{j=1}^{38} a_{ij}X_{ij} + \underset{\text{for } j = 1, \ldots, 4}{PAG_{ij}} + \underset{\text{for } j = 1, \ldots, 4}{TAG_{ii'j}} \geq \sum_{d^*=1}^{3} FD_{i^*j^*d^*}$$

for all i^*, j^* $\quad i^* = 1, 2 \quad j^* = 1, \ldots, 38$

a_{ij} = Coefficient in the I-A matrix for each subregion i and each sector j.

X_{ij} = Amount of production (activity) in subregion i of sector j.

PAG_{ij} = Amount of additional agricultural production (sector j) to satisfy demands that must come from outside of subregion i.

$TAG_{ii'j}$ = Amount of subregion i' excess agricultural production capability (sector j) acquired by subregion i to satisfy its demands.

$FD_{i^*j^*d^*}$ = Represents the actual calculated final demand figure for all sectors within the region; where j* represents the sector number associated with the actual constraint, and i* the subregion. FD is composed of three components: (1) regional final consumption including households, state and local governments, (2) federal government purchases, and (3) exports.

*Asterisks will be used to denote the constraint side of the equation.

Each sector must produce a specified amount of product for final consumption. This constraint equation insures that the specific final demand is met for each production sector by each subregion's associated production sector. The a_{ij}'s serve to fix a technical relationship between and among all the sectors and were derived from an inter-regional input-output table. This constraint simply states that each and every production activity will have to be at least as great as a predetermined final demand for that activity, with final demand being composed of three components: regional final consumption, government purchases, and exports. Where sufficient production capacity does not exist in sectors 1 through 4 (agriculture), excess production capability will be transferred from subregion i' to subregion i if such excesses exist, or output will be "purchased" from outside the region. The PAG_{ij}'s are primarily designed to allow feasibility solutions when agricultural production cannot be met internally. These activities allow one to judge magnitudes of need in the region. $TAG_{ii'j}$'s may also be used to access magnitudes of shortages or excess possibilities under various policy alternatives (such as shifting cropping patterns in one area or another).

Labor Constraint

$$\sum_{j=1}^{38} \ell_{ij}X_{ij} + UE_i + \sum_{e=1}^{32} S_{ei} - PL_i - TL_{ii'} = LA_{i*} \qquad \text{for all } i^* \quad i^* = 1, 2$$

ℓ_{uj} = Labor coefficients per unit of output for each subregion i and each sector j.

X_{ij} = Amount of production (activity) in subregion i of sector j.

UE_i = Unemployment (actual number of persons) in subregion i.

S_{ei} = Type of service employment within each subregion i--consists of two categories: (1) miscellaneous nonagricultural and (2) government workers.

PL_i = Amount of labor "purchased" from outside the region to satisfy demand.

$TL_{ii'}$ = Amount of excess labor in subregion i' transferred to subregion i to satisfy its demand.

LA_{i*} = Labor availability within each subregion i*.

Each production activity per unit requires a certain amount of labor to produce it. The ℓ_{ij}'s were derived for each sector within each individual subregion from survey data adjusted by reported ESC employment estimates. These ℓ_{ij}'s are computed on covered and reported wage and salary workers plus an estimate of non-covered employment. The ESC also makes estimates of the number of people in certain employment groupings for each county. The two types of service employment were developed from these estimates to insure all employment would be accounted for within the model. Unemployment was added as a separate item with a cost in the objective function to account for all the labor availability and is computed as a residual within the model. Thus, the sum of all labor used by the 38 production sectors, plus a given amount of "service" type of employment, plus any unemployment that exists must be equal to the labor available for each subregion. If the LA_{i*}, labor availability within region i, is not sufficient to satisfy demands (with unemployment absorbed in the production sectors), then excess labor (if existing) from subregion i' can be transferred. This allows unemployment from one subregion to migrate to where it is needed. As a last resort, labor may be acquired from outside the region in sufficienct quantities to just offset the excess demand.

Recreation Constraint

$$\sum_{j=1}^{38} r_{ijk}X_{ij} - PR_{ik} - \sum_{\substack{i'=1 \\ i\neq i'}}^{3} TR_{ii'k} + r_{ik}UE_i + \sum_{e=1}^{2} r_{iek}S_{ei} \leq RCP_{i*k*}$$

for all i*, k* $\quad$ i* = 1, 2, 3 $\quad$ k* = 1, 2, 3

r_{ijk} = Recreation coefficient related to employment--represents the recreation "demanded" of type k by each employee and his family employed in sector j within subregion i.

X_{ij} = Amount of production (activity) in subregion i of sector j.

PR_{ik} = The amount of recreation "use" required in subregion i of type k to meet the "demand" created within the system (represents the amount not presently available within the subregion or "transferable" to the subregion).

$TR_{ii'k}$ = The amount of recreation available in subregion i' that was utilized by subregion i of type k to satisfy its excess demands (demand exceeds available regional capacity).

r_{ik} = Represents the recreation "demanded" of type k by each unemployed person and his family in subregion i.

UE_i = Amount of unemployment within subregion i.

r_{iek} = Represents the recreation "demanded" of type k by each person and his family within the two service groups e in subregion i.

S_{ei} = Amount of service type e (two possible) of employment in subregion i.

RCP_{i*k*} = Recreational capacity (utilization ratios of full capacity rates) within subregion i* of type k*.

Given a certain assumed capacity for each type of recreational activity, a constraint is placed upon the system. "Transfers" or movements from one subregion to another are allowed once the capacity within a certain subregion is reached. In addition, a mechanism is provided whereby the system is allowed to generate new recreational capacity at a cost (PR_{ik}). The recreational coefficients were derived from data developed by the OBRRC in the early 1960's. These coefficients were developed for each employment type which was classified into several different groupings. Because the report used only a survey for people 12 years old and over, the coefficients also assume only the population 12 years and older within each subregion. Family size per employee is also based upon the 12 years and older population when aggregating the various employment type coefficients to arrive at an aggregate coefficient that will represent employees and his "family" in a particular sector j within a subregion i.

The transfers are allowed to take place among subregions to insure that all recreational capacity is utilized before new recreational capacity is allowed to be generated. A transfer here implies that someone in subregion 2 will travel to subregion 1 to enjoy boating where unused capacity exists instead of building a reservoir within subregion 2. In addition, some recreational demand within subregion i could be expected to be satisfied by capacity outside the region itself as a matter of normal activity. Therefore, subregion 3 represents other areas outside the Rio Grande Region that are available for this "export" of recreational demand. On the same note, some of the recreational capacity located in subregion i can normally be expected to be utilized by people from subregion 3--the import side of the relationship.

Although the unemployed have fewer resources and money, the still "demand" a certain amount of recreation. Therefore, coefficients were developed for this segment of the labor force and their families. The service employment coefficients were derived also to insure all the labor force and associated families were represented in this constraint.

Capacity for each recreational activity within the model was developed by using certain standards for each activity, compiling a maximum use estimate, and deriving probable maximum utilization rates for each given the subregion and activity. The "import" and "export" demands were based upon some percentage of the total regional demand or capacity.

Regional Recreational Counter:

$$\sum_{j=1}^{38} r_{ijk}X_{ij} + r_{ik}UE_i + \sum_{e=1}^{2} r_{iek}S_{ei} - C'R_{i*k*} = 0 \qquad \text{for all } i^*, k^*$$

$$i^* = 1, 2, 3, \quad k^* = 1, 2, 3$$

where all the coefficients and activities except $C'R_{i*k*}$ have the same definition and value as in the recreation constraint.

$C'R_{i*k*}$ = The amount of recreation activity consumed of type k* in subregion i* by all users within subregion i*.

This counter was added to record the amount of a recreational activity actually consumed by the "demanders" that reside within a particular subregion itself. Because of the allowance of transfer and purchase mechanisms, many users in other subregions could be using recreational activities in this particular subregion i*. Thus, this counter equation was established to keep track of recreational "demand" generated within, and consumed by, the subregion.

Water Constraint

$$\sum_{j=1}^{38} w_{ijmn}X_{ij} + \sum_{k=1}^{3} W_{ikmn}PR_{ik} + \sum_{p=1}^{2} w_{ipmn}P_{ip} - \sum_{i'=1}^{2} TW_{ii'mn} - PW_{imn} \leq WA_{i*m*n*}$$

for all i*, m*, n* $\qquad i^* = 1, 2 \quad m^* = 1, 2 \quad n^* = 1, 2$

w_{ijm} = Water coefficient per unit of output in subregion i of sector j of either surface (m = 1) and/or ground (m = 2) type, and either diversion (n = 1) or depletion (n = 2) "measure."

X_{ij} = Amount of production (activity) of sector j in subregion i.

W_{ikmn} = Water coefficient for each subregion i or recreational activity k of type m and "measure" n.

PR_{ik} = The amount of recreational activity of type k in subregion i generated (created) to satsify regional "demands."

w_{ipmn} = Water coefficient of type m and "measure" n per unit of population, either urban (p = 1) or rural (p = 2) in subregion i.

P_{ip} = The population, urban and rural, in subregion i.

$TW_{ii'mn}$ = The amount of water transferred to subregion i from subregion i' (where i can equal i') of type m and "measure" n.

PW_{imn} = The amount of water "purchased" by subregion i of type m and "measure" n to satisfy its demands.

WA_{i*m*n*} = Water availability in subregion i* of type m* and "measure" n*.

The agricultural and recreational activities constitute the only surface water use in the model as it is presently set up. The surface coefficients for agriculture were derived from consumptive use data supplied by the NMSU Agricultural Economics Department (Table B-1), and modified slightly for the Texas portion of the region.

Groundwater users in the model constitute all production sectors, including a portion of agriculture, and the urban and rural population (Table B-1). These coefficients were derived from various sources; the basic ones were national use studies, studies on water use from other states, and the New Mexico State Engineer Office.

At present a transfer mechanism is incorporated within this water constraint to allow the traditional surface flows between subregions. In addition, this transfer mechanism allows ground to surface exchanges not only within the same subregion i, but also between the subregions.

Table B-1. Water depletion and diversion coefficients by subregion and production sector for surface and groundwater, Rio Grande Region

Sector			Units	Water Depletion Coefficients New Mexico[a]	Water Depletion Coefficients Texas[b]	Water Diversion Coefficients New Mexico[a]	Water Diversion Coefficients Texas[b]
Surface Water Coefficients							
			Acre-feet per thousand dollars				
AG	Gr & hay	1	output	29.3900	26.1600	69.3400	40.2500
	Cotton	2	"	12.8500	12.8500	30.3000	19.7700
	Other irr	3	"	2.3800	2.7600	5.6100	4.2500
	Lvstk	4	"	0.5461	0.6682	1.0611	1.2980
Groundwater Coefficients							
AG	Gr & hay	1	"	12.4300	11.0600	20.8400	17.0200
	Cotton	2	"	4.1800	4.1800	6.9100	6.4300
	Other irr	3	"	0.7800	0.9000	1.2900	1.3850
	Lvstk	4	"	0.0116	0.0116	0.0193	0.0225
	Services	5	"	0.0117	0.0117	0.0195	0.0195
MIN		6	"	0.0234	0.0234	0.0585	0.0585
CON	Const	7	"	0.0176	0.0176	0.0440	0.0440
	Man & rep	8	"	0.0176	0.0176	0.1760	0.1760
MAN	Food	9	"	0.0052	0.0052	0.0520	0.0520
	Text & ap	10	"	0.0064	0.0064	0.0640	0.0640
	Lumber	11	"	*	0.0064	*	0.0640
	Furn	12	"	*	0.0064	*	0.0640
	Boxes etc	13	"	*	0.0028	*	0.0280
	Print	14	"	0.0028	0.0028	0.0280	0.0280
	Chem	15	"	*	0.0374	*	0.3740
	Petro	16	"	*	0.0374	*	0.3740
	Rubber	17	"	*	0.0081	*	0.0810
	Stone	18	"	0.0064	0.0064	0.0640	0.0640
	Pr & fab	19	"	0.0019	0.0019	0.0190	0.0190
	Mach	20	"	0.0019	0.0019	0.0190	0.0190
TRP	Rail	21	"	0.0025	0.0025	0.0063	0.0063
	Incity Ft	22	"	0.0025	0.0025	0.0063	0.0063
	Truck	23	"	0.0025	0.0025	0.0063	0.0063
	Air	24	"	0.0025	0.0025	0.0063	0.0063
	Other	25	"	0.0025	0.0025	0.0063	0.0063
COM		26	"	0.0588	0.0588	0.1470	0.1470
UT	Gas	27	"	0.0588	0.0588	0.1470	0.1470
	Elect	28	"	0.0588	0.0588	0.1470	0.1470
	Water	29	"	0.0588	0.0588	0.1470	0.1470
TR	Gen whsl	30	"	0.0049	0.0049	0.0123	0.0123
	Gen retl	31	"	0.0049	0.0049	0.0123	0.0123
	Auto	32	"	0.0091	0.0091	0.0228	0.0228
	Ser Sta	33	"	0.0091	0.0091	0.0228	0.0228
	Eat & dr	34	"	0.0091	0.0091	0.0228	0.0228
FIRE		35	"	0.0098	0.0098	0.0245	0.0245
SER	Lodg	36	"	0.0121	0.0121	0.0303	0.0303
	Pers	37	"	0.0121	0.0121	0.0303	0.0303
	Prof	38	"	0.0123	0.0123	0.0308	0.0308
Municipal			Acre-feet per 1,000 persons	85.00	85.00	170.00	170.00
Rural			"	42.00	42.00	85.00	85.00

*There was no production from these sectors in the New Mexico subregion in 1967-1970 and is assumed that there will be no production in the future.

[a]Dona Ana and Sierra counties.

[b]El Paso and Hudspeth counties.

As with any transfers of water, losses and gains to the system will occur because of the nature of water movement. Water "moved" upstream will actually increase because of the elimination of some portion of the evaporation, seepage and other non-beneficial uses. The same is true in the opposite direction where the total quantity released for use downstream will decrease before being utilized by the next subregion.

Groundwater may be substituted for surface flows (and vice versa, but this is generally not the case in the Southwest) within the same subregion. It may also be substituted indirectly in either the downstream or upstream subregion fairly easily by proper specification of the transfer mechanism.

The purchase of water allows the system to easily consider inter-basin transfers; salvage, reclamation, and development of water supply; and the quantity of shortages and excesses in any one subregion.

Regional Water Counter:

$$\sum_{j=1}^{38} w_{ijmn}X_{ij} + \sum_{k=1}^{3} w_{ikmn}PR_{ik} + \sum_{p=1}^{2} w_{ipmn}P_{ip} - C'W_{i*m*n*} = 0$$

for all i^*, m^*, n^* $\quad i^* = 1, 2 \quad m^* = 1, 2 \quad n^* = 1, 2$

where all the coefficients and activities, except $C'W_{i*m*n*}$, have the same definition and value as in the water constraint.

$C'W_{i*m*n*}$ = The amount of water of type m^* and "measure" n actually consumed by the users within a particular subregion i^*.

This counter was added to record the quantity of water actually used by the production sectors and other water-using activities within a particular subregion i. Because of the allowance of transfer and purchase mechanisms, users in one subregion within the Rio Grande Region may be using subregion i's water. Thus, the counter mechanism was established to keep track of water used solely by activities within the subregion.

This counter mechanism also helps in the computation of actual transfers and purchases consumed by activities in any subregion i.

Pollution Constraint

$$\sum_{j-1}^{38} P_{ij\ell}X_{ij} + \sum_{p=1}^{2} P_{ip\ell}P_{ip} - PPOL_{i\ell} - \sum_{\substack{i'=1 \\ i'\neq 1}}^{2} TPOL_{ii'\ell} \leq POLCP_{i*\ell*}$$

for all i^*, ℓ^* $\quad i^* = 1, 2 \quad \ell^* = 1, 5$

$P_{ij\ell}$ = Pollution coefficient for sector j in subregion i of type ℓ where: 1 = BOD, 2 = COD, 3 = SS, 4 = DS, and 5 = Nutrients.

X_{ij} = Amount of production (activity) of sector j in subregion i.

$P_{ip\ell}$ = Pollution coefficient of type ℓ for either urban (p = 1) or rural (p = 2) population in subregion i.

P_{ip} = Urban or rural population in subregion i.

$PPOL_{i\ell}$ = Amount of pollution "purchased" (cleaned or treated) of type ℓ by the system to maintain stream standards in subregion i.

$TPOL_{ii'\ell}$ = Amount of pollution capacity of type ℓ that is "transferred" to subregion i from subregion i'.

$POLCP_{i*\ell*}$ = Pollution carrying capacity of the stream in subregion i^* for type ℓ^*.

Assuming the stream serves as a carrier of wastes, the amount of total use by all users in subregion i cannot exceed a certain standard (ambient converted to residual loadings). The coefficients were derived from data from Resources for the Future (RfF) and the Environmental Protection Agency (EPA), which in turn utilized many and varied sources, and therefore represent many different opinions of the magnitude of the prevalent pollution. Although the vast majority of the 38 production sectors in each subregion are served by municipal sewer systems, a net contribution was still estimated for each where data were available. Of course, the manufacturing sectors are the most complete at this time.

Although the data to construct pollution coefficients are limited for the commercial and trade sectors (the vast majority of which discharge only to municipal systems), an effort was made to devise average effluent discharges that could be used within the model.

When excess pollution capacity exists within a subregion, it is allowed to be "transferred" to another subregion. The transfer mechanism does have a cost when used by other subregions. If stream standards are above the present quality, one subregion may be able to pollute the stream further given that the standards are again met when measured in the receiving subregion. The transfer of pollution-carrying capacity may involve the transfer of water resources, depending upon the formulation.

A mechanism was incorporated within this constraint to allow the system, through each individual subregion, more pollution from the users of the stream as long as each subregion is allowed to "clean up" or "treat" the excess over the standards. A uniform treatment process applicable to all types ℓ of pollution for any and all quantities treated is assumed within the model.

Pollution-carrying capacity of each segment of the stream (regional boundaries) can be estimated by converting stream standards into residual loadings and treating them as maximums. Of course, within each subregion the actual extent of the pollution will depend on the actual place where the effluent enters the waterway as well as certain characteristics of the stream flow at the time. In the present model, due to the lack of appropriate secondary sources of data, only very general averages are used.

Regional Pollution Counter:

$$\sum_{j=1}^{38} P_{ij\ell}X_{ij} + \sum_{p=1}^{2} P_{ip}P_{ip} - C'POL_{i^*\ell^*} = 0$$

for all i^*, ℓ^* $\quad i^* = 1, 2 \quad \ell^* = 1, 5$

where all the coefficients and activities, except $C'POL_{i^*\ell^*}$ have the same definition and value as in the pollution constraint.

$C'POL_{i^*\ell^*}$ = The amount of pollution-carrying capacity of type ℓ actually required by the users within a subregion i^* that reside in subregion i^*.

This counter was added to record the amount of pollution-carrying capacity, by type ℓ actually needed and used by users within a particular subregion i^*. Because of the allowance of transfer and purchase mechanisms, users in other subregions may make use of unused capacity within subregion i^*. Thus, the counter mechanism was established to keep track of pollution requirements within the subregion where all the users reside within the same subregion.

Population Constraint

P_{ip} = $POP_{i^*p^*}$ for all i^*, p^* $\quad i^* = 1, 2 \quad p^* = 1, 2$

P_{ip} = A counter mechanism (coefficient of variable in the model = 1) to force each subregion to incorporate the reported urban and rural population within the system (p = 1, urban; p = 2, rural).

$POP_{i^*p^*}$ = The number of urban (p = 1) and rural (p = 2) population within subregion i.

This constraint was designed so that the model would be forced to just meet the reported population figures. Since the urban and rural populations both use some of the "resources" with the model, this equation insures that their use is adequately accouted for. Two examples are the water requirements and the residual discharge of each person within a subregion. The procedure used above in the population constraint was the most efficient to insure that the requirements and needs of the population were incorporated into the model.

<u>Service Employment (Labor) Constraint</u>

$S_{ie} = SER_{i*e*}$ for all i*, e* i* = 1, 2 e* = 1, 2

S_{ie} = A counter mechanism to force each subregion i to employ a given amount of labor of type e.

SER_{i*e*} = The actual calculated figure for each type e* of service employment in subregion i*.

Since the labor coefficients were derived using survey data modified to match ESC employment estimates, only covered and reported employment (plus an estimate of non-covered in that sector) within each subregion were used for the production sector derivation. A significant amount of estimated labor still existed which was taken care of by this constraint. Each subregion is forced to employ a given number of people in the two types of subsidiary services: government and miscellaneous nonagricultural, which includes many varied skill types.

<u>Outside Labor Constraint</u>

$PL_i \leq PLCP_{i*}$ for all i* i* = 1, 2

PL_i = Amount of labor actually needed over and above what is available within a subregion i and from transfers from subregion i'.

$PLCP_{i*}$ = The maximum amount of labor outside the system that would reasonably be expected to be available.

The main purpose of this constraint was to allow the system to "purchase" labor from outside the subregion if mistakes had been made in the calculation and estimation of the labor coefficients. A very high price is placed upon the activity of "purchasing" outside labor to insure that the system utilizes all available labor to it before looking elsewhere to satisfy the excess demands.

<u>Outside Water Constraint</u>

$PW_{imn} \leq PWCP_{i*m*n*}$ for all i*, m*, n* i* = 1, 2 m* = 1, 2 n* = 1, 2

PW_{imn} = The amount of water needed from outside subregion i (after transfer within the region has been exhausted) to satisfy demands for type m and "measure" n.

$PWCP_{i*m*n*}$ = The amount of outside transfer availability to a particular subregion i* of type m and "measure" n.

This constraint allows for purchase, <u>inter</u> and <u>intra</u>-basin transfers, and reclamation of waters not presently available to subregion i. Water salvage of any kind is implicitly incorporated within this equation. This constraint allows the model to test for the effects of additional water into a particular subregion. Any number of additional acre-feet with varying costs may be added with the mechanism and procedure set up by this constraint.

<u>Outside Agriculture Constraint</u>

$PAG_{ij} \leq PAGCP_{i*j*}$ for all i*, j* i* = 1, 2 j* = 1, 2, 3, 4

PAG_{ij} = The amount of agricultural output in sector j needed from outside subregion i (after all production transfers within the region have been exhausted) to satisfy demands.

$PAFCP_{i*j*}$ = The amount of outside agricultural production in sector j* that would be available to subregion i* at any point in time.

This constraint allows the system to "purchase" additional agricultural production when such capacity is in short supply. Because production in the future will likely be limited by land and water resources available within the region, total demand generated by both the intermediate and final consumption aggregate activities may become greater than capacity. By allowing outside "purchases" to satisfy this excess demand, the model will be better able to reflect what actually may take place. Intermediate purchases by the production sectors will be shifted from regional output to imports and/or final demand decreased in any or all of its three major components: regional final consumption, government purchases, and exports.

The constraint also allows the model to interpret the PAG_{ij}'s as shifts in cropping patterns within sector j, adding another dimension of flexibility to the system.

Transfer Constraints

$TW_{ii'mn} \leq TWA_{i*i'*m*n*}$ for all i*, m*, and n* i* = 1, 2 i'* = 1, 2 m* = 1, 2 n* = 1, 2

$TW_{ii'mn}$ = The quantity of water of type m (surface or ground) and "measure" n (diversion or depletion) transferred from subregion i' to subregion i.

$TWA_{i*i'*m*n*}$ = The quantity of water allowed or available for transfer to subregion i from subregion i' of type m and "measure" n.

This type of constraint specifies the maximum allowed transfer from one subregion to another when $i \neq i'$, and within one subregion when $i = i'$ (such as ground to surface). In the initial model the majority of transfer constraints are of this form, making specification of specific quantities relatively easy.

However, when quantities to be transferred are tied to the activity level of the "resource" itself within the subregion, a different specification of the equation becomes necessary:

(1) $TW_{ii'mn} - f_{ii'mn}WA_{i*m*n*} \leq 0$ where $f_{ii'mn}$ is the percentage (in decimal form) of water available that is to be the maximum unit allowed or

(2) $TW_{ii'mn} - f_{ii'mn}C'W_{i*m*n*} \leq 0$ where $f_{ii'mn}$ still represents the percentage, but here it is tied to actual use within the consuming subregion i, or by replacing i* with i'* with the "producing" subregion i'.

Although other forms were utilized for testing various scenarios and policy alternatives, the above two general specifications were the most common.

Final Demand Constraint

$$\sum_{d=1}^{3} FD_{dij} = FD_{i*j*} \quad \text{for all } i*, j* \qquad i* = 1, 2 \quad j* = 1, \ldots, 38$$

FD_{dij} = The amount of final consumption of type d (regional, government, and exports) for sector j in subregion i.

FD_{i*j*} = Pre-specified final demand for all sectors j* and subregion i*.

In the initial model, this constraint had the above form which forced the three components of final demand to not only equal a prespecified total, but also to sum individually to that total. This allows examination of each component separately, but only to the extent that each must move in the same direction and in the exact same percentage amount.

A more useful formulation for policy alternatives was to allow specification of each component separately on an autonomous basis, or to tie only regional final consumption in some fashion to the population of each subregion. This allowed much more flexibility in analyzing potential changes in the regional economy.

APPENDIX C

ECONOMIC ANALYSIS OF PRESENT WATER USE

Introduction

Economic interpretations stemming from the development and exercise of the socio-economic model, along with some further evaluation concerned primarily with water use and its relationship to output, income, value added, and employment in the region are discussed in this Appendix. Principally, the amount of new water intake (diversions) and the amount of actual water consumed (depletions) in the production processes will be examined. Much of the information presented was constructed as basic input for the socio-economic model, while the remaining evaluation presented complements some of the results presented in Chapter IV where alternative growth scenarios were examined.

Definition of Economic Sectors

Although the economic sectors utilized within this study were previously defined in Chapter III, they are here for notational purposes. All 38 production industries defined are not present in New Mexico (subregion 1--Dona Ana and Sierra counties). The sector definitions, SIC code classifications, and abbreviations to be used in this chapter are presented in Table C-1.

Table C-1. Sector definitions, SIC code classifications, and abbreviations used in the socio-economic model, Rio Grande Region

Sector No.	Sector Classification		Description
1	AG	Gr & hay	Food and Feed Grain
2		Cotton	Cotton
3		Other irr	Vegetables, Fruits, Nuts and Other Irrigated Crops
4		Lvstk	Livestock, Dairy, Poultry
5		Services	Agricultural Service and Supply
6	MIN		Mining
7	CON	Const	Construction
8		Man & rep	Maintenance and Repair
9	MAN	Food	Food Processing
10		Text & ap	Textiles and Apparel
11		Lumber	Lumber
12		Furn	Furniture
13		Boxes etc	Boxes and Paper Containers
14		Print	Printing and Publishing
15		Chem	Chemicals
16		Petro	Petroleum
17		Rubber	Rubber and Leather
18		Stone	Glass, Stone, Clay, Cement and Concrete
19		Pr & fab	Primary and Fabricated Metals
20		Mach	Machinery
21	TRP	Rail	Railroad Transportation
22		Incity Ft	Intercity Freight
23		Truck	Trucking and Warehousing
24		Air	Air Transportation
25		Other	All Other Transporation
26	COM		Telephone, Telegraph, Radio and TV
27	UT	Gas	Gas Utility
28		Elect	Electric Utility
29		Water	Water Utility
30	TR	Gen whsl	General Wholesale
31		Gen retl	General Retail
32		Auto	Auto Dealers
33		Ser Sta	Gas Service Stations
34		Eat & dr	Eating and Drinking Places
35	FIRE		Finance, Insurance, and Real Estate
36	SER	Lodg	Lodging
37		Pers	Personal Services
38		Prof	Professional Services

Diversions and Depletions

An estimate was made of the major beneficial diversions and depletions (excludes all uses attributable to stream and reservoir evaporation, fish and wildlife support, and flood and sediment control) for both subregions. In Tables C-2 and C-3, these estimates are summarized for the aggregate (basic) "sector" classifications. Agriculture is by far the largest user of water for both subregions, even though in the Texas subregion other users do compose a significant percentage of the total. Both diversions and depletions within the whole region in the agricultural sector are primarily from surface water supplies in any "normal" year (80 percent surface, 20 percent ground). In low water years the percentage pumped is increased to make up for deficiencies, and correspondingly decreased in high water years. The remaining users are supplied for the most part from groundwater supplies (although the city of El Paso in the Texas subregion does obtain a portion of its supply from surface waters of the Rio Grande). For groundwater sources, only a portion of the difference between diversion (pumpage) and depletion is returned to the groundwater aquifer in the immediate area; whereas the agricultural sectors return their unused portion (after non-beneficial depletions have been considered) of surface water diversions to the stream and drainage ditches. Thus for surface water users, the consumptive use (both beneficial and non-beneficial) is the more appropriate measure of water use in the region. For groundwater users, pumpage is probably the better measure for use of the groundwaters. Part of the pumpage from the groundwater basin in both New Mexico and Texas is drawn from the river. Therefore, in actuality, surface water use is somewhat more than the estimates presented in the tables.

Table C-2. Estimated total diversions[a] by major sectors in the Rio Grande Region

Major Sector	New Mexico Subregion (acre-feet)	New Mexico Subregion (percent)	Texas Subregion (acre-feet)	Texas Subregion (percent)	Region[b] (acre-feet)	Region[b] (percent)
1. Agriculture[c]	482,189	96.51	367,707	66.36	849,896	80.66
a. Surface	388,759		275,638		664,397	
b. Ground	93,430		92,069		185,499	
2. Mining	265	0.05	275	0.05	540	0.05
3. Industrial	2,960	0.59	100,717	18.18	103,677	9.84
4. Communication, Utilities, and Transporation	1,922	0.38	15,031	2.71	16,953	1.61
5. Commercial Trade and Services	1,807	0.36	10,556	1.91	12,363	1.17
6. Municipal[d, e]	8,647	1.73	58,640	10.58	67,287	6.39
7. Rural	1,828	0.38	1,172	0.21	3,000	0.28
Total	499,618	100.00	554,098	100.00	1,053,716	100.00

[a]Diversions estimated by using water use coefficients were derived from several state and federal agencies published and unpublished data, as well as from several other studies for states located in the West and Southwest.

[b]Total of New Mexico and Texas subregions--includes only Dona Ana and Sierra counties in New Mexico, El Paso and Hudspeth counties in Texas.

[c]Includes stock pond evaporation and irrigated pasture--first number is total of ground and surface. The mix of ground/surface supplies for New Mexico is based upon long-term normal patterns in the past. For any one year the mix may and will differ considerably depending upon surface supply availability. A similar long-term mix has been assumed for Texas, although in actuality the percent of acreage irrigated from surface supplies is somewhat higher. Not enough information was available, however, to compute this mix for Texas.

[d]Includes the public and governmental sectors.

[e]All water assumed to be from ground sources, although the city of El Paso obtains a small proportion of its needs from surface supplies. Water that is obtained indirectly from surface supplies through pumpage of the near surface aquifer for all sectors is ignored here, with all groundwater assumed to come from groundwater storage only.

Table C-3. Estimated total depletions[a] by major sector in the Rio Grande Region

Major Sector	New Mexico Subregion (acre-feet)	(percent)	Texas Subregion (acre-feet)	(percent)	Region[b] (acre-feet)	(percent)
1. Agriculture[c]	222,803	96.62	235,823	81.71	458,626	88.33
a. Surface	166,594		176,038		342,632	
b. Ground	56,209		59,785		115,994	
2. Mining	106	0.04	110	0.04	216	0.04
3. Industrial	785	0.34	12,428	4.30	13,213	2.54
4. Communications, Utilities, and Transporation	769	0.33	6,012	2.08	6,781	1.30
5. Commercial Trade and Services	723	0.31	4,222	1.46	4,945	0.95
6. Municipal[d, e]	4,324	1.87	29,320	10.15	33,644	6.48
7. Rural	1,097	0.49	703	0.26	1,800	0.36
Total	230,607	100.00	288,618	100.00	519,225	100.00

[a]Depletions estimated by utilizing depletion to diversion ratios and by using information derived from several state and federal agencies published and unpublished data, as well as from several other studies completed for states located in the West and Southwest.

[b]Total of New Mexico and Texas--includes only Dona Ana and Sierra counties in New Mexico, El Paso and Hudspeth counties in Texas.

[c]Includes stock pond evaporation and irrigated pasture--first number is total of ground and surface. The mix of ground/surface supplies for New Mexico is based upon long-term normal patterns in the past. For any one year the mix may and will differ considerably depending upon surface supply availability. A similar long-term mix has been assumed for Texas, although in actuality the percent of acreage irrigated from surface supplies is somewhat higher. Not enough information was available, however, to compute this mix for Texas.

[d]Includes the public and governmental sectors.

[e]All water assumed to be from ground sources, although the city of El Paso obtains a small proportion of its needs directly from surface supplies. Water that is obtained indirectly from surface supplies through pumpage of the near surface aquifer for all sectors is ignored here, with all groundwater assumed to come from groundwater storage only.

Agriculture accounts for approximately 88 percent of the water depletions within the region. The remainder goes to primarily the municipal and commercial sectors in New Mexico, and the municipal and industrial sectors in Texas. Non-agricultural uses do account for a significant portion of the water depletions within Texas, while in New Mexico their effect is almost inconsequential. About 75 percent of the water depletions within the region is from surface supplies, while the remainder comes from the groundwater basin. This percentage is somewhat higher for New Mexico and lower for Texas. This does not take into account equilibrium questions and the portion of groundwater that is actually derived from surface water supplies. Along most portions of the river in both New Mexico and Texas, agricultural shallow aquifer wells pump groundwater that is in reality from the stream flow itself.

Production and New Water Use in the Region

Table C-4 presents water intake use or diversion requirements for each of the 38 production sectors in both New Mexico and Texas subregions. The estimate of dollar value of output in each of these "industries" for each subregion is derived from the output estimates made earlier. Adjustments for inventory changes have been made so the estimates presented in Table C-4 differ slightly from those

Table C-4. Production and new water use by sector and subregion, Rio Grande Region

Sectors			New Mexico Subregion: Output[a] (dollars)	Rank[b]	Water Intake Coefficient[c] (acre-feet/$1,000 output)	Rank[b]	Estimated Total Use (acre-feet)	Rank[b]	Texas Subregion: Output[a] (dollars)	Rank[b]	Water Intake Coefficient[c] (acre-feet/$1,000 output)	Rank[b]	Estimated Total Use (acre-feet)	Rank[b]
AG	Gr & hay	1	1,709	21	90.1800	1	154,118	2	2,403	34	57.2700	1	137,620	2
	Cotton	2	5,507	10	37.2100	2	204,915	1	7,005	27	26.2000	2	183,531	1
	Other irr	3	15,005	5	6.9000	3	103,534	3	4,106	30	5.6350	3	23,138	5
	Lvstk	4	18,110	4	1.0804	4	19,567	4	17,702	16	1.3205	4	23,375	4
	Services	5	2,810	16	.0195	23	55	20	2,200	36	.0195	34	43	35
MIN		6	4,528	12	.0585	12	265	12	4,705	31	.0585	22	275	27
CON	Const	7	37,024	1	.0440	14	1,629	5	178,500	2	.0440	24	7,854	7
	Man & rep	8	3,800	14	.1760	5	669	9	19,389	15	.1760	7	3,412	13
MAN	Food	9	6,514	9	.0520	13	339	11	85,417	7	.0520	23	4,442	9
	Text & ap	10	1,656	22	.0640	10	106	15	164,382	3	.0640	13	10,520	6
	Lumber	11	**		**				6,180	28	.0640	13	396	23
	Furn	12	**		**				2,213	35	.0640	13	142	31
	Boxes etc	13	**		**				597	38	.0280	28	17	37
	Print	14	1,908	20	.0280	18	53	21	12,661	19	.0280	28	355	25
	Chem	15	**		**				5,594	29	.3740	5	2,092	14
	Petro	16	**		**				183,928	1	.3740	5	68,789	3
	Rubber	17	**		**				7,252	26	.0810	12	587	22
	Stone	18	1,240	25	.0640	10	79	18	15,712	18	.0640	13	1,006	20
	Pr & fab	19	249	29	.0190	24	5	30	41,067	9	.0190	35	780	21
	Mach	20	4,195	13	.0190	24	80	17	17,163	17	.0190	35	326	26
TRP	Rail	21	1,500	24	.0063	28	9	27	12,384	21	.0625	17	77	33
	Incity Ft	22	900	27	.0063	28	6	28	23,631	14	.0625	17	148	30
	Truck	23	901	26	.0063	28	6	28	1,218	37	.0625	17	8	38
	Air	24	22	32	.0063	28	*	32	8,297	24	.0625	17	52	34
	Other	25	777	28	.0063	28	5	30	3,306	33	.0625	17	21	36
COM		26	5,101	11	.1470	6	750	8	29,196	12	.1470	8	4,292	10
UT	Gas	27	100	30	.1470	6	15	25	35,633	11	.1470	8	5,238	8
	Elect	28	7,601	7	.1470	6	1,117	6	28,045	13	.1470	8	4,123	12
	Water	29	100	30	.1470	6	15	25	7,302	25	.1470	8	1,073	19
TR	Gen whsl	30	6,903	8	.0123	26	85	16	105,290	5	.0123	37	1,290	16
	Gen retl	31	18,500	3	.0123	26	227	13	103,599	6	.0123	37	1,269	17
	Auto	32	2,201	17	.0228	20	50	22	11,900	22	.0228	31	271	28
	Ser Sta	33	1,502	23	.0228	20	34	24	3,702	32	.0228	31	84	32
	Eat & dr	34	2,199	18	.0228	20	50	22	9,999	23	.0228	31	227	29
FIRE		35	31,507	2	.0245	19	772	7	71,352	8	.0245	30	1,748	15
SER	Lodg	36	3,690	15	.0303	16	112	14	12,532	20	.0325	25	379	24
	Pers	37	13,673	6	.0303	16	414	10	37,908	10	.0325	25	1,147	18
	Prof	38	2,097	19	.0308	15	64	19	134,647	4	.0308	27	4,140	11

*Less than one acre-foot.

**No production from these industries was recorded for the base year.

[a]Estimated for 1967 in thousand-dollar units.

[b]Where a tie exists (same number) the equivalent rank is assigned to each with the following sequence incremented by the slots skipped.

[c]The amount of new water in acre-foot units needed to produce $1,000 of final product. Derived from various sources. Where the information was not sufficient to make a distinction between categories of sectors, they were assumed to be equivalent for purposes of water intake--thus several sectors have equivalent coefficients. Because most of the water intake coefficients were constructed from secondary data sources, they do not differ for New Mexico or Texas in all but the agricultural sectors.

developed earlier. Because Texas dominates the industrial and commercial sectors in most instances for the region, the majority of rankings for production output is not appreciably different from those presented for Texas. Output estimates and their relative ranks are reported in Table C-4. Direct agricultural production plays a very significant role in New Mexico's economy and a lesser role in Texas where the commercial and industrial sectors contribute the larger proportion. However, the overall agricultural base in both New Mexico and Texas has contributed much to each's growth over the last several decades. Figure C-1 illustrates the production magnitudes involved for all sectors.

An estimate[1] of a water-intake coefficient (diversion requirement for agriculture) was derived from various sources. Information and data on water use were extracted from several state and federal agency published and unpublished reports; from several studies in the states of Arizona, California, Utah, and Colorado, and from national manufacturing census and studies. This coefficient is the amount of new water needed to produce $1,000 of final product in a specific industry or sector. These estimates appear in column 4 and 10 of Table C-4 along with their relative rankings in columns 5 and 11. Presently the majority of agricultural water intake is from surface supplies (approximately 80 percent), while the remaining sectors' intake is from groundwaters. Additional water intake in the future by the agricultural sectors will have to come from the groundwater basin due to the present full appropriation of surface water rights. Agriculture uses water (intake or diversion) in quantities of ten to over two hundred times as great as that for all other users in the production of a $1,000 unit of final product. This supports the recognized fact that a tremendous amount of water is needed to keep agricultural production at the present levels it enjoys today. However, conservation techniques, new irrigation practices, and a shifting to higher-valued crops would help to reduce the impact water shortages.

Total water use was derived and these estimates appear in columns 6 and 12 of Table C-4 along with their relative rankings in columns 7 and 13. In New Mexico a tremendous gap in magnitude exists between the agricultural sectors and the remaining production "industries." The gap in Texas is of similar magnitude, but here several industrial sectors display a relatively large use of new water.

Production and Consumptive Water Use

The consumptive water use (depletion in agriculture) coefficients were derived from the same data sources as those used for new water intake coefficients. This coefficient is the quantity of water that is actually consumed in the production process in obtaining a $1,000 unit of final output in a specific industry. It represents the difference between new water intake (diversions in agriculture) and total amount returned to the system.

Consumptive use of water is sometimes a rather nebulous concept, especially in the agricultural and mineral industries. In most estimates today for the industrial and commercial sectors, consumptive use has been fairly narrowly defined as that quantity of water used or required in the technological production process (plus some amount for normal operations of the business such as water for drinking and sanitation). In the mineral industries these estimates are not nearly as well specified. Within

[1]The information in this Appendix has been estimated from many secondary and tertiary data sources. Even though many of the estimated numbers and results presented have several decimal places attached to them, they should not and cannot be construed as a presentation of the accuracy of any of these estimates themselves. But rather, they are used to point out the differences in magnitudes and to help portray the types of economic interpretation that can come from this sort of analysis. These estimates of the coefficients and multipliers should serve as tools supplying additional information in the planning process of future water use and evaluation, as well as helping to point out the economic direction future water use should take.

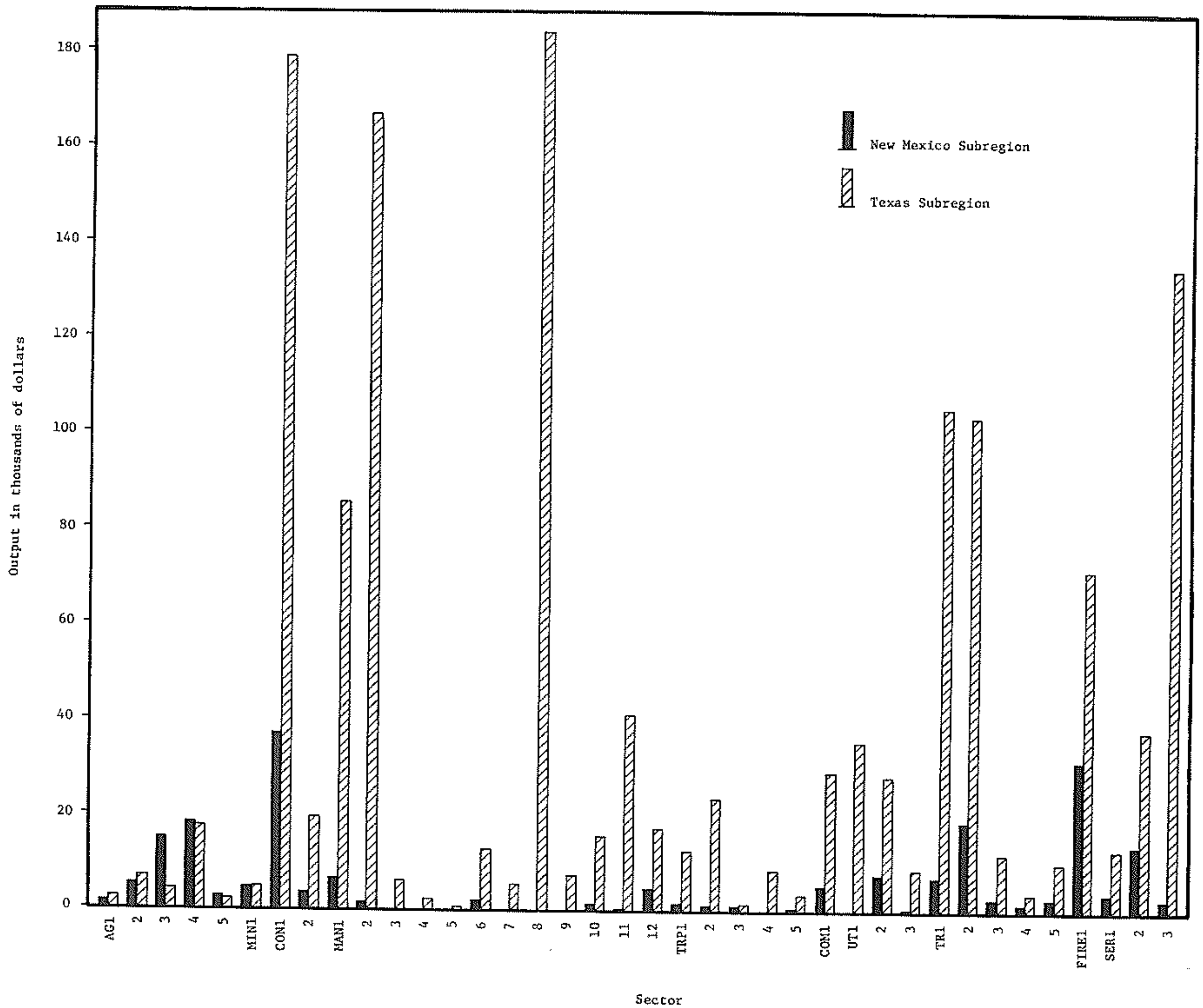

Figure C-1. Production by sector and subregion, Rio Grande Region the agricultural industries they include some measure of the consumptive irrigation requirement (CIR) plus an accounting of incidental losses. This assumes that the water not consumptively used by above definitions is available for other beneficial use by other economic activities. The consumptive use estimates utilized are assumed to only include that quantity actually consumed on the "premises" of any business.

The consumptive use estimates appear in columns 2 and 6 of Table C-5 along with their relative rankings in columns 3 and 7. Because of the lack of specific industry data that is appropriate when used on an aggregate basis for many of the sectors defined, classes of industrial and/or commercial sectors were assumed to have similar or equivalent consumptive use patterns (i.e., the same ratio of water consumption to new water intake). Presently agricultural water consumption is primarily from surface supplies, while the remaining sectors' consumption is from groundwaters. Any additional water consumed by agriculture must come from either the groundwater basin due to the present full appropriation of the surface rights, or an increase in irrigation efficiency from those same surface supplies. This, however, ignores the interdependent relationship of the ground and surface water "basins."

The differences between agricultural and industrial/commercial consumptive use coefficients are of the same magnitudes as for the new water intake coefficients. To produce a $1,000 unit of final product in the agricultural "industries" requires between ten and over three hundred times the quantity of water as that required in some of the commercial and trade "industries." Agricultural production currently requires (depletes) an enormous amount of water from both the limited surface and groundwater supplies. Total consumptive water requirements for each industry were also derived. These particular estimates appear in columns 4 and 8 of Table C-5 along with their relative rankings in columns 5 and 9. The large gap between the agricultural and industrial/commercial sectors is still apparent. Also the relative rankings of some of the industrial/commercial sectors are different from those presented in Table C-4 for new water intake.

Output Per Acre-Foot of New Water Intake

Table C-6 presents output, income, and value added per acre-foot of new water intake in a slightly different manner. Because of the way the new water intake coefficients were constructed (one of the factors in computing estimated total use) both the New Mexico and Texas subregions have equivalent dollar outputs and rankings except for three of the four agricultural sectors--Food and Feed Grain (AG1), Vegetables, Fruits, Nuts, and Other Irrigated Crops (AG3), and Livestock, Dairy, and Poultry (AG4). In some instances, only the Texas subregion estimates are presented since six sectors in the New Mexico subregion have no production and therefore no coefficients associated with them. New Mexico's agricultural differences are presented as footnotes.

Agriculture is considerably below the other sectors, and transporation and trade "industries" are far above all others in the production of final output per acre-foot of new water intake. The transportation and trade "industries" appear to be the logical choices for additional allocation of water due to their extremely high output to water ratios. However, many other factors play a role (and in many instances a far more dominant one) in the determination of the best economic use of any additional water supplies. The demand for the final product would dictate that unless production increased in certain other sectors first, there would in reality be no additional demand for either transporation or commercial trade industries. Thus more comprehensive evaluation is necessary for the allocation of additional water supplies that consider the total economic effects--both direct and indirect.

Table C-5. Production and consumptive water use by sector and subregion, Rio Grande Region

Sectors			New Mexico Subregion				Texas Subregion			
			Consumptive[a] Use Coefficient (acre-feet/$1,000 output)	Rank[b]	Estimated Total Use (acre-feet)	Rank[b]	Consumptive[a] Use Coefficient (acre-feet/$1,000 output)	Rank[b]	Estimated Total Use (acre-feet)	Rank[b]
AG	Gr & hay	1	41.8200	1	71,471	2	37.2200	1	89,439	2
	Cotton	2	17.0300	2	93,784	1	17.0300	2	119,295	1
	Other irr	3	3.1600	3	47,416	3	3.6600	3	15,028	3
	Lvstk	4	.5577	4	10,100	4	.6798	4	12,033	4
	Services	5	.0117	15	33	16	.0117	17	26	33
MIN		6	.0234	9	106	10	.0234	11	110	21
CON	Const	7	.0176	10	652	5	.0176	12	3,142	6
	Man & rep	8	.0176	10	67	12	.0176	12	341	18
MAN	Food	9	.0052	22	34	14	.0052	27	444	16
	Text & ap	10	.0064	20	11	21	.0064	23	1,052	11
	Lumber	11	**		**		.0064	23	40	28
	Furn	12	**		**		.0064	23	14	35
	Boxes etc	13	**		**		.0028	30	2	38
	Print	14	.0028	25	5	26	.0028	30	35	29
	Chem	15	**		**		.0374	9	209	19
	Petro	16	**		**		.0374	9	6,879	5
	Rubber	17	**		**		.0081	22	59	26
	Stone	18	.0064	20	8	22	.0064	23	101	23
	Pr & fab	19	.0019	31	*	31	.0019	37	78	25
	Mach	20	.0019	31	8	22	.0019	37	33	31
TRP	Rail	21	.0025	26	4	27	.0025	32	31	32
	Incity Ft	22	.0025	26	2	28	.0025	32	59	26
	Truck	23	.0025	26	2	28	.0025	32	3	37
	Air	24	.0025	26	*	31	.0025	32	21	34
	Other	25	.0025	26	2	28	.0025	32	8	36
COM		26	.0588	5	300	8	.0588	5	1,717	8
UT	Gas	27	.0588	5	6	24	.0588	5	2,095	7
	Elect	28	.0588	5	477	6	.0588	5	1,649	10
	Water	29	.0588	5	6	24	.0588	5	429	17
TR	Gen whsl	30	.0049	23	34	14	.0049	28	516	13
	Gen retl	31	.0049	23	91	11	.0049	28	508	14
	Auto	32	.0091	17	20	18	.0091	19	108	22
	Ser Sta	33	.0091	17	14	20	.0091	19	34	30
	Eat & dr	34	.0091	17	20	18	.0091	19	91	24
FIRE		35	.0098	16	309	7	.0098	18	699	12
SER	Lodg	36	.0121	13	45	13	.0121	15	152	20
	Pers	37	.0121	13	165	9	.0121	15	459	15
	Prof	38	.0123	12	29	17	.0123	14	1,656	9

*Less than one acre-foot.

**No production from these industries was recorded in the base year.

[a] The amount of water consumed in acre-foot units as a normal part of doing business needed to produce a $1,000 units of final product. Derived from various sources. Where the information was not sufficient to make a distinction between categories of sectors, they were assumed to be equivalent for purposes of water intake--thus several sectors have equivalent coefficients. Because most of the water intake coefficients were constructed from secondary data sources, they do not differ for New Mexico or Texas in all but the agricultural sectors.

[b] Where a tie exists (same number) the equivalent rank is assigned to each with the following sequence incremented by the slots skipped.

Table C-6. Output, income, and value added per acre-foot of new water intake for the Texas subregion[a]

Sector	Output[b] (dollars)	Rank[c]	Income[d] (dollars)	Rank[c]	Value Added[e] (dollars)	Rank[c]
AG1	12*	38	4*	38	8*	38
2	27	37	9	37	17	37
3	125*	36	14*	36	31*	36
4	643*	35	88*	35	164*	35
5	51,282	10	12,428	17	17,464	16
MIN1	17,094	22	10,265	18	12,737	19
CON1	22,727	20	7,631	20	9,004	20
2	5,682	32	3,541	28	3,740	31
MAN1	19,231	21	5,825	22	6,608	22
2	15,625	23	5,487	24	6,179	24
3	15,625+	23	5,530+	23	6,169+	25
4	15,625+	23	4,043+	27	5,345+	27
5	35,714+	15	6,887+	21	8,418+	21
6	35,714	15	17,587	13	20,722	13
7	2,674+	33	719+	33	923+	33
8	2,674+	33	280+	34	479+	34
9	12,346+	27	4,677+	26	5,388+	26
10	15,625	23	4,678	25	6,489	23
11	52,632	8	15,877	15	18,237	15
12	52,632	8	21,518	11	26,487	11
TRP1	160,000	1	71,582	2	91,537	2
2	160,000	1	71,922	2	85,216	3
3	160,000	1	78,503	1	97,543	1
4	160,000	1	51,964	5	58,783	5
5	160,000	1	63,048	4	77,626	4
COM1	6,803	28	2,005	32	4,128	29
UT1	6,803	28	2,638	29	3,769	31
2	6,803	29	2,576	30	4,731	28
3	6,803	28	2,569	31	3,673	32
TR1	81,633	6	43,774	6	51,132	6
2	81,633	6	40,648	7	49,924	7
3	43,956	11	15,169	16	17,051	17
4	43,956	11	22,040	9	26,605	10
5	43,956	11	28,106	8	33,364	8
FIRE1	40,816	14	21,563	10	27,058	9
SER1	33,058	17	8,764	19	14,991	18
2	33,058	17	18,319	12	21,238	12
3	32,520	19	16,178	14	18,920	14

[a]New Mexico is equivalent except for those entries marked with an * and +; those with a + are 0 and with an * are 11, 5, and 7 for AG1; 145, 9, and 36 for AG3; 926, 126, and 237 for AG4 for output, income, and value added respectively for each.

[b]Rounded to the nearest dollar with New Mexico being equivalent except where noted in a.

[c]Where a tie exists (same number) the equivalent rank is assigned to each with the following sequence incremented by the slots skipped.

[d]Wages and salaries paid to households for the most part.

[e]In addition to income, includes taxes, business profits, and capital formation.

Income and Value Added Per Acre-Foot of New Water Intake

In addition to the output per acre-foot estimates, income per acre-foot of new water intake (Table C-6) was derived by calculating the household income (primarily salaries and wages) to final product ratio for each of the 38 sectors and then using this ratio to calculate the income coefficient by multiplying this ratio by the output coefficient.

Because of the way in which the new water intake coefficients were constructed, the New Mexico subregion is equivalent except for the same three agricultural sectors--AG1, AG3, and AG4; the differences presented in footnotes.

The estimates represent the amount of income (average) accruing to the population of each subregion from each acre-foot of new water intakes (or diversions) in that particular sector. The estimates of value added are somewhat larger because value added not only includes the income paid to households, but also taxes paid to all forms of government, plus depreciation and capital consumption. The transportation and trade sectors as a whole are significantly above the manufacturing and other commercial sectors although the commerical sectors generally are above the manufacturing sectors; and all of these major sector groups are substantially greater than the agricultural sector.

Output, Income, and Value Added Per Acre-Foot of Water Consumption

Table C-7 presents output income and value added per acre-foot of water consumption. Actual water consumption instead of new water intake is the basis for these estimates. As in Table C-6, the New Mexico subregion is not presented because all estimates except those denoted by an * (agriculture) and a + (six manufacturing sectors that did not exist in the New Mexico subregion) are equivalent to those estimated for Texas due to the methodology and water coefficient development schema.

Columns 4 and 6 of Table C-7 contain the income and value-added estimates, with their relative rankings appearing in columns 5 and 7. Because water consumption varies by industry with respect to new water intake, there is some change in these relative rankings when contrasted with those presented in Table C-6. The same care should be exercised here as previously in making any definitive interpretation of this information (derived from the estimate) for policy formulation. Those sectors which have the highest output, income, or value-added coefficient may depend upon other economic factors for their growth; and thus channelling more water into these sectors would prove "economically" infeasible until some of the other sectors were cultivated first. The commercial, industrial, and trade sectors are many times larger than the agricultural sectors.

Employment and Direct Employment Per Acre-Foot of New Water Intake

Table C-8 contains the estimated direct employment totals and coefficients per acre-foot of new water intake for each sector for both the Texas and New Mexico subregions. Column 2 summarizes the estimates on covered (and derived uncovered) production employment and column 3 contains the relative rankings.

For the New Mexico subregion, total employment in four of the five agricultural sectors rank relatively high when contrasted with the industrial/commercial sectors. This is not true in Texas, where only the livestock "industry" is ranked within the top half.

In the region, employment per acre-foot of new water intake (column 4) the commerical and trade sectors are generally greater than manufacturing, which is substantially greater than the agricultural sectors.

Table C-7. Output, income, and value added per acre-foot of water consumption by sector for the Texas subregion[a]

Sector	Output[b] (dollars)	Rank[c]	Income[d] (dollars)	Rank[c]	Value Added[e] (dollars)	Rank[c]
AG1	27*	38	5*	38	10*	38
2	59	37	13	37	23	37
3	273*	36	40*	36	90*	36
4	1,471*	35	201*	35	376*	35
5	85,470	22	20,712	27	29,107	27
MIN1	42,735	28	25,663	25	31,844	26
CON1	56,818	26	19,076	28	22,509	28
2	56,818	26	35,406	24	37,395	25
MAN1	192,308	12	58,243	13	66,079	15
2	156,250	13	54,872	16	61,786	17
3	156,250+	13	55,299+	14	61,690+	18
4	156,250+	13	40,430+	22	53,450+	20
5	357,143+	8	68,875+	12	84,179+	11
6	357,143+	8	75,870	5	207,223	5
7	26,738+	29	7,189+	29	9,234+	32
8	26,738+	29	2,799+	34	4,790+	34
9	123,457+	17	46,768+	19	53,880+	19
10	156,250	13	46,782	18	64,894	16
11	526,316	1	158,771	6	182,370	7
12	526,316	1	215,179	1	264,868	1
TRP1	400,000	3	178,954	4	228,842	3
2	400,000	3	179,808	3	213,042	4
3	400,000	3	196,256	2	243,856	2
4	400,000	3	129,952	8	147,005	8
5	400,000	3	157,618	7	194,063	6
COM1	17,007	31	5,012	33	10,321	30
UT1	17,007	32	6,595	30	9,423	31
2	17,007	33	6,439	31	11,826	22
3	17,007	34	6,423	32	9,182	33
TR1	204,082	10	109,435	9	127,830	9
2	204,082	10	101,621	10	124,811	10
3	109,890	18	37,921	23	42,627	23
4	109,890	18	55,099	15	66,512	14
5	109,890	18	70,265	11	83,411	12
FIRE1	102,041	21	53,906	17	67,645	13
SER1	82,645	23	21,910	26	37,478	24
2	82,645	23	45,799	20	53,094	21
3	81,301	25	40,446	21	47,300	22

[a]New Mexico is equivalent except for those entries marked with an * and +; those with a + are 0 and with an * are 24, 11, and 15 for AG1; 316, 21 and 78 for AG3; 793, 244 and 458 for AG4 for output, income, and value added respectively for each.

[b]Rounded to the nearest dollar with New Mexico being equivalent except where noted in a.

[c]Where a tie exists (same number) the equivalent rank is assigned to each with the following sequence incremented by the slots skipped.

[d]Wages and salaries paid to households for the most part.

[e]In addition to income, includes taxes, business profits, and capital formation.

Table C-8. Total employment[a] and direct employment per acre-foot of new water intake by sector and subregion, Rio Grande Region

	Sector		New Mexico Subregion				Texas Subregion			
			Employment[a]	Rank[b]	Employment[c] (per acre-foot)	Rank	Employment[a]	Rank[b]	Employment[c] (per acre-foot)	Rank
AG	Gr & hay	1	96	21	.0006	32	97	36	.0005	38
	Cotton	2	621	9	.0030	31	567	22	.0022	37
	Other irr	3	903	5	.0087	30	177	34	.0054	35
	Lvstk	4	1,650	3	.0843	29	1,154	15	.04195	29
	Services	5	330	13	6.0256	9	185	33	4.3231	10
MIN		6	38	28	.1436	28	158	35	.5727	25
CON	Const	7	1,148	4	.7045	19	5,569	5	.7091	22
	Man & rep	8	100	20	.1494	27	708	18	.2074	32
MAN	Food	9	510	10	1.5057	15	9,276	3	2.0885	14
	Text & ap	10	41	26	.3891	24	5,704	4	.5422	26
	Lumber	11	*		*		262	29	.6625	23
	Furn	12	*		*		273	28	1.9281	16
	Boxes etc	13	*		*		15	38	.8786	20
	Print	14	71	24	1.3286	16	653	20	1.8429	17
	Chem	15	*		*		77	37	.0366	34
	Petro	16	*		*		368	26	.0053	36
	Rubber	17	*		*		223	20	.3790	30
	Stone	18	41	26	.5203	21	724	17	.7203	21
	Pr & fab	19	1	31	.1842	25	201	31	.2579	31
	Mach	20	307	14	3.8474	13	1,740	12	5.3368	9
TRP	Rail	21	138	19	14.7199	5	998	16	12.8960	6
	Incity Ft	22	94	22	16.7199	4	2,167	10	14.6719	4
	Truck	23	162	18	28.6879	1	191	32	25.1519	2
	Air	24	1	31	10.3199	7	469	24	9.0399	7
	Other	25	91	23	18.8319	3	341	27	16.4959	3
COM		26	362	12	.4829	23	1,816	11	.4231	28
UT	Gas	27	7	30	.4864	22	2,238	9	.4272	27
	Elect	28	204	17	.1829	26	662	19	.1605	33
	Water	29	10	29	.6537	20	615	21	.5728	24
TR	Gen whsl	30	223	16	2.6367	14	5,075	6	3.9347	11
	Gen retl	31	1,998	2	8.8163	8	16,669	1	13.1347	5
	Auto	32	66	25	1.3187	17	531	23	1.9604	15
	Ser Sta	33	835	6	24.4352	2	3,065	8	36.3868	1
	Eat & dr	34	253	15	5.0593	11	1,712	14	7.5253	8
FIRE		35	643	8	.8327	18	2,929	7	2.2531	13
SER	Lodg	36	448	11	4.0099	12	397	25	1.0479	19
	Pers	37	2,397	1	5.7950	10	1,736	13	1.5140	18
	Prof	38	787	7	12.2079	6	13,195	2	3.1869	12

*No production was recorded from these industries in the base year.

[a]As estimated from survey data adjusted to match ESC data on covered wage and salary workers (plus derived non-covered) within each sector's SIC codes.

[b]Where tie exists (same number) the equivalent rank is assigned to each with the following sequence incremented by the slots skipped.

[c]Based upon employment estimated in column 2 and total new water intake requirements from Table C-4.

Table C-9 contains the estimates of employment per acre-foot of water consumption, coefficients, and relative rankings. Although these coefficients are much larger, the relative rankings are similar when contrasted with those for the new water intake.

Table C-9. Direct employment per acre-foot of water consumption by sector and subregion, Rio Grande Region

Sector			New Mexico Subregion		Texas Subregion	
			Employment per Acre-Foot[a]	Rank[b]	Employment per Acre-Foot[a]	Rank[b]
AG	Gr & hay	1	.0013	32	.0011	38
	Cotton	2	.0067	31	.0048	37
	Other irr	3	.0191	30	.0118	36
	Lvstk	4	.1633	29	.0959	34
	Services	5	10.0427	14	7.2051	16
MIN		6	.3590	28	1.4316	29
CON	Const	7	1.7614	22	1.7727	27
	Man & rep	8	1.4943	24	2.0739	26
MAN	Food	9	15.0577	10	20.8846	9
	Text & ap	10	3.8906	18	5.4219	20
	Lumber	11	0		6.6250	18
	Furn	12	0		19.2812	10
	Boxes etc	13	0		8.7857	14
	Print	14	13.2857	12	18.4286	12
	Chem	15	0		.36663	33
	Petro	16	0		.0535	35
	Rubber	17	0		3.7901	22
	Stone	18	5.2031	17	7.2031	17
	Pr & fab	19	1.8421	21	2.5789	25
	Mach	20	38.4736	5	53.3684	3
TRP	Rail	21	36.8000	6	32.2400	7
	Incity Ft	22	41.8000	4	36.6800	5
	Truck	23	7.7200	1	62.8800	2
	Air	24	25.7999	8	22.6000	8
	Other	25	47.0800	3	41.2400	4
COM		26	1.2075	26	1.0578	31
UT	Gas	27	1.2159	25	1.0680	30
	Elect	28	.4575	27	.4014	32
	Water	29	1.6344	23	1.4320	28
TR	Gen whsl	30	6.5918	16	9.8367	13
	Gen retl	31	22.0408	9	32.8367	6
	Auto	32	3.2967	19	4.9011	21
	Ser Sta	33	61.0879	2	90.9670	1
	Eat & dr	34	12.6484	13	18.8132	11
FIRE		35	2.0816	20	5.6327	19
SER	Lodg	36	10.0248	15	2.6198	24
	Pers	37	14.4876	11	3.7851	23
	Prof	38	30.5203	7	7.9675	15

[a]Based upon employment estimates in column 2 from Table C-8 and water consumption estimates from Table C-5.

[b]Where a tie exists (same number) the equivalent rank is assigned to each with the following sequence incremented by the slots skipped.

Direct and Indirect New Water Intake Requirements

Within the socio-economic model, each industry buys and sells to the other industries within the same region (inter-regional effects were not included within this analysis). Not every sector, of course, needs to buy from and/or sell to each and every other sector, but it is enough just to have some of the interconnections within and between the sectors to change the earlier concept of total water requirements. The direct and indirect requirements, the total amount of new water intake required to produce $1,000 of the product in question for final consumption in each sector, are reported in Table C-10. This necessarily takes into account all of the water (indirect requirements) used by the "industries" it purchases its inputs from to produce that $1,000 of output. These are the indirect requirements, plus the direct requirements from Table C-4.

In any input-output scheme, the retail or wholesale trade sectors must make purchases from many "firms" in order to be able to sell commodities; such as from the service sectors to package and merchandise the product, transportation sectors to deliver the inputs and final commodities, the manufacturing sectors from where the products are purchased in either finished or semi-finished form, and so on. All of these purchases or inputs require some amount of new water intake for their production. Many of these inputs in turn required raw materials as well as other semi-processed resources in their production process which required water for their production. Thus the direct and indirect water requirement is the amount of water used by all the input and raw materials sectors, plus the amount of water needed to do $1,000 worth of business for final demand in each sector.

The relative rankings of the coefficients of direct and indirect new water intake use are listed in Table C-10. A comparison can be made with the direct new water intake requirements from Table C-4. By subtracting coefficients of Table C-4 (the direct new water intake coefficient) from coefficients of Table C-10 (the direct and indirect new water intake requirement) the amount of indirect water use by all the required inputs can be calculated.

Multiplier (New Water Intake)

The multiplier for new water intake is actually a ratio derived by dividing the total direct and indirect new water intake requirements by the direct coefficients from Table C-4. The multiplier is the total additional water required in a subregion necessary to increase production in a particular sector. The higher the multiplier, of course, the more new water needed by the entire system to produce a given increase in a specific sector in comparison to just the water intake needed by the initiating sector.

Three of the agricultural sectors have rather low multipliers, which indicate their relatively large direct new water intake requirements in contrast to the much smaller indirect requirement. Both the livestock and agricultural services sectors AG4 and AG5, have relatively high multipliers. This comes about because both of these sectors purchase inputs from the preceeding three agricultural sectors which have high water intake requirements. Some of the manufacturing sectors also have relatively low multipliers, while some of the commerical sectors experience quite high multipliers indicating the tremendous amount of indirect water required to support their production, even though the direct requirements are extremely low in comparison to many of the other sectors. Food processing and the general wholesale sector both purchase large quantities of agricultural products, thus pushing their indirect requirements well above their direct needs.

Table C-10. Direct and indirect new water intake requirements, water multiplier and weighted water multiplier by sector and subregion, Rio Grande Region

Sector		New Mexico Subregion						Texas Subregion					
		Direct and Indirect[a] Requirements (acre-feet/$1,000 output)	Rank	Multiplier[b]	Rank	Weighted[c] Multiplier (acre-feet)	Rank	Direct and Indirect[a] Requirements (acre-feet/$1,000 output)	Rank	Multiplier[b]	Rank	Weighted[c] Multiplier (acre-feet)	Rank
AG	Gr & hay	91.5226	1	1.0149	30	2,343.6201	4	57.7176	1	1.0039	37	9,378.1664	2
	Cotton	37.4969	2	1.0077	32	19,881.8827	1	26.2707	2	1.0027	38	20,140.5398	1
	Other irr	6.9940	4	1.0136	31	10,023.4879	3	5.7539	3	1.0211	36	2,397.1984	7
	Lvstk	8.1917	3	7.5821	4	14,604.7547	2	4.4374	4	3.3604	12	9,000.3940	3
	Services	.0988	14	5.1159	8	13.8600	18	.0870	22	4.4609	10	13.7260	36
MIN		.0632	17	1.0807	25	21.7214	16	.0715	27	1.2222	29	26.7300	31
CON	Const	.0546	19	1.2415	22	202.1272	7	.0783	25	1.7797	20	1,397.7416	9
	Man & rep	.1806	8	1.0261	28	39.0341	14	.1906	10	1.0828	33	132.8459	15
MAN	Food	1.5669	5	30.1334	1	882.8662	5	.8876	4	17.0691	2	7,041.3287	4
	Text & ap	.2225	7	3.4773	11	43.0736	13	.1604	13	2.5060	15	2,592.8296	6
	Lumber	*		*		0		.0895	21	1.3988	26	15.1616	35
	Furn	*		*		0		.1063	19	1.6613	24	19.5299	32
	Boxes etc	*		*		0		.1015	20	3.6257	11	3.6307	37
	Print	.0454	23	1.6228	17	6.8221	22	.0466	32	1.6630	23	48.2461	27
	Chem	*		*		0		.4221	6	1.1285	32	128.0064	16
	Petro	*		*		0		.3897	7	1.0421	35	6,163.3857	5
	Rubber	*		*		0		.1113	18	1.3742	27	77.8040	22
	Stone	.0948	15	1.4819	21	.8873	30	.1134	17	1.7716	21	18.2624	33
	Pr & fab	.0225	32	1.1825	24	.6374	31	.0298	38	1.5690	25	112.8509	19
	Mach	.0383	26	2.0145	15	14.3101	17	.0432	34	2.2748	16	62.2104	26
TRP	Rail	.0367	27	5.8688	5	3.1832	24	.0695	28	11.1234	5	35.2245	29
	Incity Ft	.0328	29	5.2555	7	1.8919	26	.0400	36	6.4000	7	63.9085	25
	Truck	.0339	28	5.4224	6	2.6970	25	.0371	37	5.9289	8	.1653	38
	Air	.0242	31	3.8681	10	.0543	32	.1281	15	20.5020	1	67.6051	24
	Other	.0263	30	4.2145	9	1.7925	27	.0856	23	13.6891	4	18.0331	34
COM		.1568	11	1.0669	27	50.9180	11	.1590	14	1.0818	34	276.2320	13
UT	Gas	.1504	12	1.0234	29	1.3261	29	.1790	11	1.2174	30	361.6822	12
	Elect	.1574	10	1.0707	26	77.3148	10	.1712	12	1.1644	31	250.3408	14
	Water	.1743	9	1.1854	23	1.5587	28	.2015	8	1.3705	28	104.9242	20
TR	Gen whsl	.3320	6	27.1059	2	162.7863	8	.1994	9	16.2783	3	1,713.4169	8
	Gen retl	.1224	13	9.9905	3	221.6324	6	.0843	24	6.8819	6	861.2845	10
	Auto	.0571	18	2.5084	12	10.4701	19	.0653	29	2.8684	13	72.8554	23
	Ser Sta	.0468	21	2.0550	14	3.9066	23	.1199	16	5.2686	9	31.3493	30
	Eat & dr	.0419	24	1.8397	16	8.6097	21	.0444	33	1.9517	18	41.7942	28
FIRE		.0384	25	1.5657	18	87.7352	9	.0412	35	1.6815	22	120.7043	18
SER	Lodg	.0711	16	2.3499	13	24.3411	15	.0764	26	2.5257	14	82.5218	21
	Pers	.0471	20	1.5568	19	49.2765	12	.0556	31	1.8396	19	127.0085	17
	Prof	.0463	22	1.5065	20	8.9030	20	.0638	30	2.0757	17	735.7651	11

*No production for these industries was recorded in the base year.

[a]The quantity of new water intake, both direct and indirect, per thousand dollar increases in final demand output by this particular sector.

[b]The direct and indirect new water intake divided by the direct new water intake.

[c]Based upon a 10 percent change in final demand multiplied by the direct and indirect new water intake requirement.

Weighted Multiplier (New Water Intake)

The weighted multiplier of Table C-10 is the amount of total new water (both direct and indirect) required to meet a 10 percent increase in final demand for that particular sector. Final demand is in many cases substantially less than output in any one sector and represents household and government (local, state, and federal) consumption plus exports of the final product. Of the total output only a portion is supplied to final demand (whether it be for domestic consumption or export), the remainder going to supply the production processes of all other industries that serves as inputs; i.e., the metal sector delivers much of its product to other industries as an input into their production as opposed to households or governments for their consumption. Thus, final demand is both exports and final consumption by either households or the government.

A 10 percent increase in final demand is probably a better test of changes in future demand than using any constant dollar increase in product output for all sectors. In this case, by using a 10 percent change to weight the change in new water intake demand (although any other consistent percentage change can be used), a more reasonable estimate of what might take place in the near future is obtained. Generally a change in exports, household or government consumption (or purchasing patterns) is used when measuring future growth possibilities. Effects on total new water intake for a given change in one or more of the components making up final demand (household and government consumption plus exports) can be obtained by the "weighted multiplier" of Table C-10. If exports are forecasted to increase 20 percent and this represents a 10 percent change in overall final demand (exports are equal to household and government consumption originally), then the "weighted multiplier" represents the total new water intake needed by the subregion to meet this increase in exports. By converting any percentage change of an individual component into a final demand change, total new water requirements can be computed.

The "weighted multiplier" gives a more realistic picture of possible new water intake than the direct and indirect new water intake requirements. This requirement was calculated for a $1,000 change in total final demand so certain sectors have more potential than others for growth. In the short run, all sectors could not be expected to increase final demand output by $1,000, but some sectors with a much larger production base could be expected to increase their final demand output by substantially more. In addition, with percentage decreases in final demand for various sectors, the "weighted water multipliers" provide the amount of additional water that would then be made available to the subregion from the decrease in production.

Because of the generally dominant role that final demand exhibits in the overall agricultural output or total production, a 10 percent change is significant. This tends to overshadow the other sectors, but real increases in agricultural production will be severely limited in the future because of basic water and land constraints, as well as agricultural technology in the Southwest. Thus, the 10 percent change in many of the other sectors has a much better probability of occurring in the relatively near future.

The relative differences between the manufacturing, commercial, and trade sectors' "weighted multipliers" and their direct and indirect requirements are significant. The 10 percent change in final demand has a substantial effect whereas the direct and indirect new water intake requirements are rather low for each $1,000 increase in final demand output for the most part. The agricultural sectors dominate the "weighted multipliers" due to their large production base in both subregions, new water intake requirements, and substantial final demand portion of their total production. In the near future, changes in real agricultural demand is expected to be far outpassed by the majority of the other economic sectors.

Direct and Indirect Requirements, Multiplier, and Weighted Multipler--Water Consumption

Analagous to the three previous sections, Table C-11 presents the estimates of direct and indirect water consumption requirements, the appropriate multiplier (direct and indirect divided by direct water consumption), and a "weighted multiplier" representing the change in total water consumption due to a 10 percent change in final demand in the originating sector. There are changes in the relative rankings for all three categories when contrasted with the new water intake estimates for these categories. For some of the sectors, the multipliers are less than those in Table C-10.

Direct and Indirect (a) Income and (b) Employment Per Direct and Indirect Acre-Foot of New Water Intake

Table C-12 presents possibly the most comprehensive method of analyzing new water intake from an economic point of view. Every production sector generates income payments to households in terms of wages, salaries, profits, etc. Each "industry" or sector doesn't produce the same percent of income to the households per unit of production. The more labor intensive the production process, usually, the higher the payments made to the household. Good examples are the personal and professional services sectors, and the printing and publishing sector in the manufacturing area.

At the same time as producing direct income payments to households (whether small or large), each sector by purchasing inputs from other sectors in the production of its output is responsible for generating some indirect income (income paid to households by the input sectors from their sales to the purchasing sector). Table C-12 presents estimates of generated income resulting from an increased acre-foot of new water intake to the initiating sector. This new water is actually total water to the region, with the initiating sector taking a portion of it to increase its production, while the remainder is used by the other "inputting" sectors to supply the initiating sector.

In addition to the income generated to the households, the production process of each sector also generates employment. Table C-8 presented estimates of employment for each sector and subregion. An employee coefficient per unit of output was used to develop the total employment change (excluding some miscellaneous non-agricultural wage earners and government workers) per acre-foot of direct and indirect new water intake. Table C-12 also presents the estimated total change in employment (ESC covered wage and salaried employment plus an estimate of noncovered workers) per acre-foot of direct and indirect new water intake for each sector. In the New Mexico subregion if 100 acre-feet of new water is added to the system and the eating and drinking establishments (TR5) initiated the production increase (and thus increasing its purchases of inputs) through expanded tourism, about 30 additional persons would be employed, some in the TR5 sector, and the remainder in the sectors that supply the inputs.

This employment change does not take into account any change in government employment and some miscellaneous non-agricultural employment excluded from one of the 38 production sectors. Any spin-off or secondary employment by these two components has been excluded from the analysis. Thus, in most instances the employment change in Table C-12 underestimates the true effect if <u>all</u> employment could be accounted for. Of course, each sector could be expected to influence these two missing components in a different fashion and magnitude.

The increase in income that could be expected given a change in new water intake to each subregion can be estimated from Table C-12 as well as the increase in employment (excluding those two components discussed earlier) that could be expected given a change in new water intake to each subregion. With the increase in income and employment, both the direct to the initiating sector and indirect to the remaining interdependent sectors are incorporated. For the machinery sector, MAN12, if an additional

Table C-11. Direct and indirect water consumption requirements, water multiplier and weighted water multiplier by sector and subregion, Rio Grande Region

Sector			New Mexico Subregion: Direct and Indirect Requirements (acre-feet/$1,000 output)	Rank[b]	Multiplier[c]	Rank[b]	Weighted[d] Multiplier (acre-feet)	Rank[b]	Texas Subregion: Direct and Indirect Requirements (acre-feet/$1,000 output)	Rank[b]	Multiplier[c]	Rank[b]	Weighted[d] Multiplier (acre-feet)	Rank[b]
AG	Gr & hay	1	42.4411	1	1.0149	30	1,086.7882	4	37.3558	1	1.0036	37	4,347.5767	2
	Cotton	2	17.1606	2	1.0077	32	9,099.0470	1	17.0706	2	1.0024	38	9,214.7218	1
	Other irr	3	3.2026	4	1.0135	31	4,589.8117	3	3.7316	3	1.0196	36	1,093.6862	5
	Lvstk	4	3.8531	3	6.9089	5	6,869.5329	2	2.3745	4	3.4929	12	4,091.6944	3
	Services	5	.0480	13	4.1045	10	6.6719	16	.0371	14	3.1690	14	5.8506	32
MIN		6	.0254	15	1.0868	25	8.7378	15	.0282	17	1.2058	31	10.5481	28
CON	Const	7	.0211	17	1.1987	23	78.0616	7	.0240	22	1.3642	27	428.5755	9
	Man & rep	8	.0190	18	1.0792	26	4.1054	18	.0208	24	1.1817	32	14.4975	23
MAN	Food	9	.7014	5	134.8804	1	395.1758	5	.3872	5	74.4564	1	3,071.4621	4
	Text & ap	10	.0780	7	12.1830	3	15.0912	13	.0490	11	7.6568	5	792.1981	6
	Lumber	11	*		*		0		.0111	35	1.7365	24	1.8822	36
	Furn	12	*		*		0		.0199	26	3.1027	15	3.6476	33
	Boxes etc	13	*		*		0		.0269	18	9.6184	3	.9632	37
	Print	14	.0098	30	3.4884	13	1.4665	23	.0094	36	3.3648	13	9.7618	29
	Chem	15	*		*		0		.0460	12	1.2287	29	13.9362	24
	Petro	16	*		*		0		.0398	13	1.0630	35	628.7349	8
	Rubber	17	*		*		0		.0163	31	2.0172	22	11.4209	27
	Stone	18	.0155	23	2.4284	15	.1454	30	.0184	27	2.8804	18	2.9692	35
	Pr & fab	19	.0028	32	1.4871	22	.0802	31	.0049	38	2.5648	19	18.4474	21
	Mach	20	.0078	31	4.1135	9	2.9220	21	.0083	37	4.3946	11	12.0181	25
TRP	Rail	21	.0125	26	4.9905	7	1.0827	24	.0168	30	6.7240	8	8.5171	30
	Incity Ft	22	.0132	25	5.2978	6	.7628	26	.0153	33	6.1331	9	24.4972	20
	Truck	23	.0123	27	4.9014	8	.9751	25	.0133	34	5.3340	10	.0595	38
	Air	24	.0101	28	4.0441	12	.0227	32	.0225	23	8.9938	4	11.8628	26
	Other	25	.0101	28	4.0506	11	.6891	27	.0171	29	6.8266	7	3.5972	34
COM		26	.0625	10	1.0622	28	20.2775	11	.0630	10	1.0719	34	109.4784	13
UT	Gas	27	.0601	11	1.0223	29	.5299	29	.0714	8	1.2134	30	144.2075	12
	Elect	28	.0628	9	1.0688	27	30.8703	10	.0681	9	1.1581	33	99.5918	14
	Water	29	.0668	8	1.1369	24	.5980	28	.0748	7	1 .2720	28	38.9526	17
TR	Gen whsl	30	.1512	6	30.8597	2	74.1320	8	.0890	6	18.1649	2	764.8010	7
	Gen retl	31	.0546	12	11.1476	4	98.9200	6	.0357	15	7.2959	6	365.2414	10
	Auto	32	.0241	16	2.6461	14	4.1479	17	.0263	20	2.8911	17	29.3726	19
	Ser Sta	33	.0181	21	1.9840	17	1.5087	22	.0264	19	2.8963	16	6.8934	31
	Eat & dr	34	.0171	22	1.8824	18	3.5239	20	.0175	28	1.9182	23	16.4309	22
FIRE		35	.0151	24	1.5379	20	34.4713	9	.0160	32	1.6313	26	46.8409	15
SER	Lodg	36	.0285	14	2.3561	16	9.7623	14	.0296	16	2.4442	20	31.9441	18
	Pers	37	.0188	19	1.5534	19	19.6733	12	.0204	25	1.6834	25	46.4900	16
	Prof	38	.0188	19	1.5307	21	3.6185	19	.0249	21	2.0221	21	286.6995	11

*No production in these industries was recorded in the base year.

[a]The quantity of water consumption required, both direct and indirect, per thousand dollar increase in final demand output by this particular sector.

[b]Where a tie exists (same number) the equivalent rank is assigned to each with the following sequence incremented by the slots skipped.

[c]The direct and indirect water consumption divided by the direct water consumption.

[d]Based upon a 10 percent change in final demand multiplied by the direct and indirect water consumption requirement.

Table C-12. Direct and indirect income and employment effects per acre-foot of direct and indirect water intake by the initiating sector by sector and subregion, Rio Grande Region

Sector			New Mexico Subregion				Texas Subregion			
			Income Change (dollars)	Rank	Employment Change[a]	Rank	Income Change (dollars)	Rank	Employment Change[a]	Rank
AG	Gr & hay	1	.73	32	.0010	32	1.37	38	.0007	38
	Cotton	2	1.81	31	.0040	31	2.94	37	.0026	37
	Other irr	3	7.96	30	.0095	30	15.02	36	.0079	36
	Lvstk	4	8.07	29	.0143	29	23.53	35	.0175	34
	Services	5	613.96	19	1.3780	12	1,383.23	16	1.2303	13
MIN		6	818.34	17	.1752	25	1,391.75	15	.5687	20
CON	Const	7	1,042.76	15	.7100	17	1,468.13	14	.5755	19
	Man & rep	8	295.86	25	.1875	24	561.42	31	.2609	29
MAN	Food	9	36.41	28	.0579	28	115.93	34	.1352	32
	Text & ap	10	240.03	26	.1329	27	614.89	29	.2529	30
	Lumber	11	*		*		1,369.38	17	.6881	17
	Furn	12	*		*		1,267.28	19	1.4360	11
	Boxes etc	13	*		*		1,188.94	21	.4004	25
	Print	14	1,234.63	12	.9600	14	2,240.81	7	1.3182	12
	Chem	15	*		*		259.81	32	.0549	33
	Petro	16	*		*		245.15	33	.0115	35
	Rubber	17	*		*		964.90	24	.3635	27
	Stone	18	734.86	18	.5185	19	1,198.82	20	.6601	18
	Pr & fab	19	2,330.89	2	.2982	22	3,382.30	2	.3696	26
	Mach	20	1,551.42	7	2.3205	10	2,582.71	5	2.6585	5
TRP	Rail	21	1,716.14	6	2.9797	8	1,839.41	10	1.4664	10
	Incity Ft	22	1,873.77	5	3.7493	6	2,894.28	3	2.7329	4
	Truck	23	2,079.31	4	5.7116	3	3,503.84	1	4.8843	2
	Air	24	2,295.45	3	2.9643	9	1,019.67	23	.5353	21
	Other	25	2,466.09	1	5.3316	4	1,582.62	13	1.4970	9
COM		26	356.25	21	.5140	20	638.32	25	.4400	23
UT	Gas	27	349.38	22	.4984	21	626.73	26	.4377	24
	Elect	28	346.19	23	.980	23	620.79	27	.1940	31
	Water	29	345.57	24	.5952	18	619.30	28	.5089	22
TR	Gen whsl	30	178.61	27	.1439	26	562.01	30	.3256	28
	Gen retl	31	471.29	20	.9799	13	1,288.97	18	2.0584	6
	Auto	32	1,113.13	14	.8494	15	1,926.27	9	1.0587	15
	Ser Sta	33	1,258.10	10	12.0991	1	1,064.73	22	7.0271	1
	Eat & dr	34	1,399.15	9	3.0799	7	2,449.90	6	4.1559	3
FIRE		35	1,518.73	8	.8115	16	2,623.19	4	1.6456	8
SER	Lodg	36	937.72	16	1.9356	11	1,667.03	12	.7379	16
	Pers	37	1,239.18	11	4.0284	5	2,020.35	8	1.1036	14
	Prof	38	1,169.76	13	8.2607	2	1,834.71	11	1.8721	7

*No production in these industries was recorded for the base year.

[a]This column only presents changes based upon ESC covered wage and salary employment plus the estimated non-covered employment for each sector. It excludes those categories such as miscellaneous non-agricultural and government workers.

5,000 acre-feet of new water intake was in some way added to the available supplies in the New Mexico subregion for the increased production in MAN12, an additional $7.75 million of income would be generated within the New Mexico subregion. This income comes not only from the increased sales of MAN12 itself, but also from the increased sales of the suppliers of inputs to MAN12. Analysis of specific employment increases brought about by increased production from an initiating sector can be examined with Table C-12. Determination of the quantity of new water intake needed by a subregion to ensure a specific employment increase can be made. If TR5 (eating and drinking establishments) was initiating an increase in its production to account for a 1,000 increase in employment (both direct to TR5 and indirect to the remaining sectors), an additional 324.7 acre-feet of new water intake would be required in the New Mexico subregion (a portion of which goes to TR5 for its production and the remainder to its suppliers for their production). However, if SER1 (the lodging industry) was initiating the increase due to expanded tourism, an additional 516.67 acre-feet of new water intake would be needed.

All estimates should be used with care since some of the higher ranked sectors (in regard to increasing income and employment to the subregion when they are initiating the process) are also the same sectors economic information indicates are the least likely to increase their production (primarily from increased export or government consumption) autonomously. In other words, any increase in these sectors will come from increased demands for their products or services by other production sectors (this is more true for the Texas subregion than for the New Mexico subregion due to its higher "industrialization"). TRP3 (trucking and warehousing) is an excellent example, with the fourth highest income potential and the third highest employment potential, but as a portion of the transporation industry it is highly unlikely that this specific sector will or could increase its production without first an increase in the business activities of other sectors in the subregion. TR5 (eating and drinking establishments) however, is influenced by a variety of economic variables and conditions that may very well be entirely stimulated from outside the region. Expanded tourism would translate itself very easily into an increased demand for its production rather "autonomously" without really depending upon any business increase within a subregion.