The Economic Effects of Weather Modification Activities

Part III

Irrigated and Dryland Agriculture with Estimates of Production, Employment, and Income Effects on the Area Economy

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16. ABSTRACT
In this phase of the study of the economic effects of weather modification activities in the Big Spring-Snyder area, it has been estimated that a 10 percent increase in growing season precipitation could replace a total of 22,800 acre-feet of ground water that is now pumped annually from exhaustible ground water reserves and used for irrigation in the area. Such a savings in pumping requirements not only saves water, but also reduces irrigation costs amounting to $574,200 annually. The estimated effects on regional income are $370,000 annually due to reduced expenses for pumping irrigation water, and would free $364,000 of irrigation pump energy for other uses. The net effects of the additional rainfall in the dryland, irrigation, and non-farm support sectors of the Big Spring-Snyder area regional economy would be to create an expansion of $3.9 million in output and $2.3 million in payroll or personal income.

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THE ECONOMIC EFFECTS OF WEATHER MODIFICATION ACTIVITIES

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TABLE OF CONTENTS

Figures

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

THE ECONOMIC EFFECTS OF WEATHER MODIFICATION ACTIVITIES

Irrigated and Dryland Agriculture with Estimates of Production, Employment, and Income Effects on the Area Economy

Introduction

The Office of Atmospheric Resources Management, Bureau of Reclamation, and the United States Department of the Interior are responsible for establishing a verified, working technology and operational management framework capable of producing additional rain from cumulus clouds in the semi-arid Plains States.[1/] The experiment being used to attain the objectives of this program is termed the "High Plains Cooperative Experiment," or HIPLEX. Three field research sites have been selected within the High Plains Region east of the Continental Divide. These sites are located near Miles City, Montana; Goodland, Kansas; and Big Spring, Texas.

The Bureau of Reclamation, working through the Texas Department of Water Resources (TDWR), under a cooperative agreement, made funds available for carrying out specific projects in the Southern sector (Big Spring-Snyder area) of HIPLEX for the Federal Fiscal Year 1977 (FY 77).

A portion of the FY 77 funds was allocated for use by the Department of Water Resources staff to continue a study of the economic effects

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1/ Public Works Appropriation Act, P.L. 93-97.

of weather modification. The first phase of the study was conducted during FY 75 and consisted of an analysis of effects of additional rainfall upon dryland crop production in the Texas HIPLEX study area. In the second phase, completed during FY 76, estimates were made of the effects of additional rainfall on range production and included an analysis of the non-farm economic effects of weather modification activities on the Big Spring-Snyder regional economy. The third phase, described in this report, presents estimates of the potential farm and non-farm economic effects additional rainfall might have upon ground water pump irrigation in the study area.

The immediate goal of the HIPLEX program is to reduce scientific and management uncertainties in cloud seeding technology for the High Plains region for the purpose of augmenting normal precipitation in this semi-arid region of the United States. Currently, existing surface water resources are negligible and the ground water resources of the Texas HIPLEX study area and of the neighboring Ogallala aquifer area to the west and northwest of the Texas HIPLEX study area are being exhausted as withdrawals from the aquifer exceed recharge. Precipitation enhancement activities in other parts of the United States[2/] suggest that weather modification could offer a partial solution to the problem of supplementing existing water supplies in the moisture deficient High

[2/] U. S. National Oceanic and Atmospheric Administration, Weather and Climate Modification edited by W. N. Ness (New York: John Wiley & Sons, 1974), pp. 38, 67, 74. National Academy of Sciences, Weather & Climate Modification Problems and Progress, (Washington, D.C., 1973), pp. 3-7. "Policy Statement of the American Meteorological Society on Purposeful and Inadvertent Modification of Weather and Climate," Bulletin American Meteorological Society, Vol. 54, No. 7 (July 1973), pp. 694.

Plains region.

Increase in normal rainfall can be expected to have beneficial economic effects on the High Plains region. In accordance with the 1974 Bureau of Reclamation - State of Texas agreement, the Texas Department of Water Resources has conducted economic impact studies of the weather modification project in Texas.[3/] These studies have been directed toward developing information with which to estimate farm and non-farm economic value of a weather modification produced increase in rainfall to the area economy.

In order to estimate the economic impact of cloud seeding operations, it is necessary to estimate the quantity of increase in precipitation these seeding operations can be expected to produce in the study area. A recently concluded evaluation of a commercial cloud seeding precipitation augmentation program in the High Plains region of Texas suggests a small percentage of observed precipitation may be attributable to cloud seeding.[4/] Rainfall analyses suggest that: (1) for the seven year period 1971-77, more rainfall was associated with the seeded than unseeded area; (2) rainfall increases in the Big Spring-Snyder target area for the seeded period were 25 percent greater than those of the control area; and, (3) in the case of 1977 being dry, the seeded area showed marked increases in rainfall over the unseeded area.[5/]

[3/] American Meteorological Society, Sixth Conference on Planned and Inadvertent Weather Modification, Boston, Massachusetts, October, 1977, p. 311.

[4/] Smith, T. B., Peace, R. L., and Howard, S. M., Radar Evaluation of Big Spring Weather Modification Program, Altadena, California: Meteorology Research, Inc., August, 1977.

[5/] Girdzus, John. 1977 Weather Modification Program: Precipitation Enhancement, Colorado River Municipal Water District, 1977.

The reported precipitation data of each precipitation recording station in the study area show that mean April-October season, annual precipitation during the 1971-1978 cloud seeding period is significantly greater (from 21 percent to 54 percent) than mean annual precipitation for these stations during the same season during the 1940-1970 period (Table 2). However, the 1971-1978 cloud seeding period is too short to have produced enough data to allow researchers to state conclusively that cloud seeding can be expected to result in this magnitude of increased precipitation over long periods of time.

Studies of other precipitation augmentation programs conducted in the Continental United States, especially the Northern Great Plains region, have demonstrated that seeded areas at one project received 5 to 10 percent more rainfall[6/] and that another project area received about 10 percent more rainfall when seeded during the growing season.[7/] On the basis of these studies and on the basis of precipitation data from the cloud seeding study area (Table 2), it appears that potential effects of cloud seeding upon growing season (April-October) mean annual precipitation could be as much as 10 percent. Thus, the thrust of the present study is to compute estimates of potential annual production, income, and employment effects of a 10 percent increase in precipitation rates in the Texas HIPLEX area. Estimates are also made of the potential annual reductions in ground water withdrawal for irrigation, if precipitation during the growing season is increased by 10 percent through weather modification.

An earlier study of crop production demonstrated that crop yields

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6/ American Meteorological Society, _op_. _cit_., p. 395.

7/ _Ibid_.

are affected by variations in rainfall during various times of the year, and that regional output and income are increased with increases in rainfall.[8/] The effects of additional rainfall on range production, as range produced forage affects the livestock industry, were discussed in the second phase report.[9/]

The objective of this study is to estimate the potential effects that additional precipitation from weather modification through cloud seeding in the study or target area could be expected to have on irrigated farming, and the subsequent non-farm economic impact on the region. A regional input-output model is used to estimate the economy-wide effects of additional rainfall. The specific objectives are to:

1. Determine the potential response of groundwater pump irrigation requirements and irrigation costs to a 10 percent increase in the quantity of precipitation received during the growing season,

2. Determine direct farm income effects on irrigation farms when the hypothesized 10 percent increase in precipitation replaces an equivalent quantity of irrigation water,

3. Determine the total economic effects which might occur in the Big Spring-Snyder area if 10 percent additional rainfall is available for dryland crop and rangeland production, and if in addition such precipitation replaces an equivalent quantity of irrigation water obtained from ground water supplies and applied to present irrigated acreages.

8/ Texas Water Development Board, The Economic Effects of Weather Modification Activities, Part I - Crop Production, November, 1975.

9/ Texas Water Development Board, The Economic Effects of Weather Modification Activities, Part II - Range Production and Interindustry Analysis, March, 1978.

Study Area

The study area is a 14-county region of Texas. The study area counties are: Borden, Coke, Dawson, Fisher, Garza, Glasscock, Howard, Kent, Lynn, Mitchell, Martin, Nolan, Scurry and Sterling (Figure 1).

Physical Characteristics

The terrain is characterized by plains in the west, sloping downward to rolling hills in the east. Soils in the area are generally red or brown sandy loams several feet thick. This type of soil easily supports crop production when sufficient water is available.

Precipitation in the area varies from an annual norm of about 14 inches in the southwest to about 22 inches in the east. Mean monthly temperatures range from a low of 40°F in January to a high of 82°F in July.

The study area encompasses 12,678 square miles, or 8,113,920 acres. Approximately 90 percent of the area land is used for farming and ranching. Since 1970, average annual data show approximately 4.6 million acres utilized as pasture or rangeland and over 2.2 million acres as cropland. During the same period, the number of acres irrigated comprised 8.5 percent of the region's total cropland.[10/]

Five surface water facilities on the Colorado River and its tributaries are located in or near the study area. These are: Lake J. B. Thomas, Lake Colorado City, and E. V. Spence Reservoir on the Colorado River, and Champion Creek and Oak Creek Reservoirs on the tributaries.

10/ U. S. Department of Commerce, Bureau of the Census, 1974 Census of Agriculture, Volume 1; Part 43, Texas, State and County Data. U. S. Government Printing Office, Washington, D. C.; June, 1977.

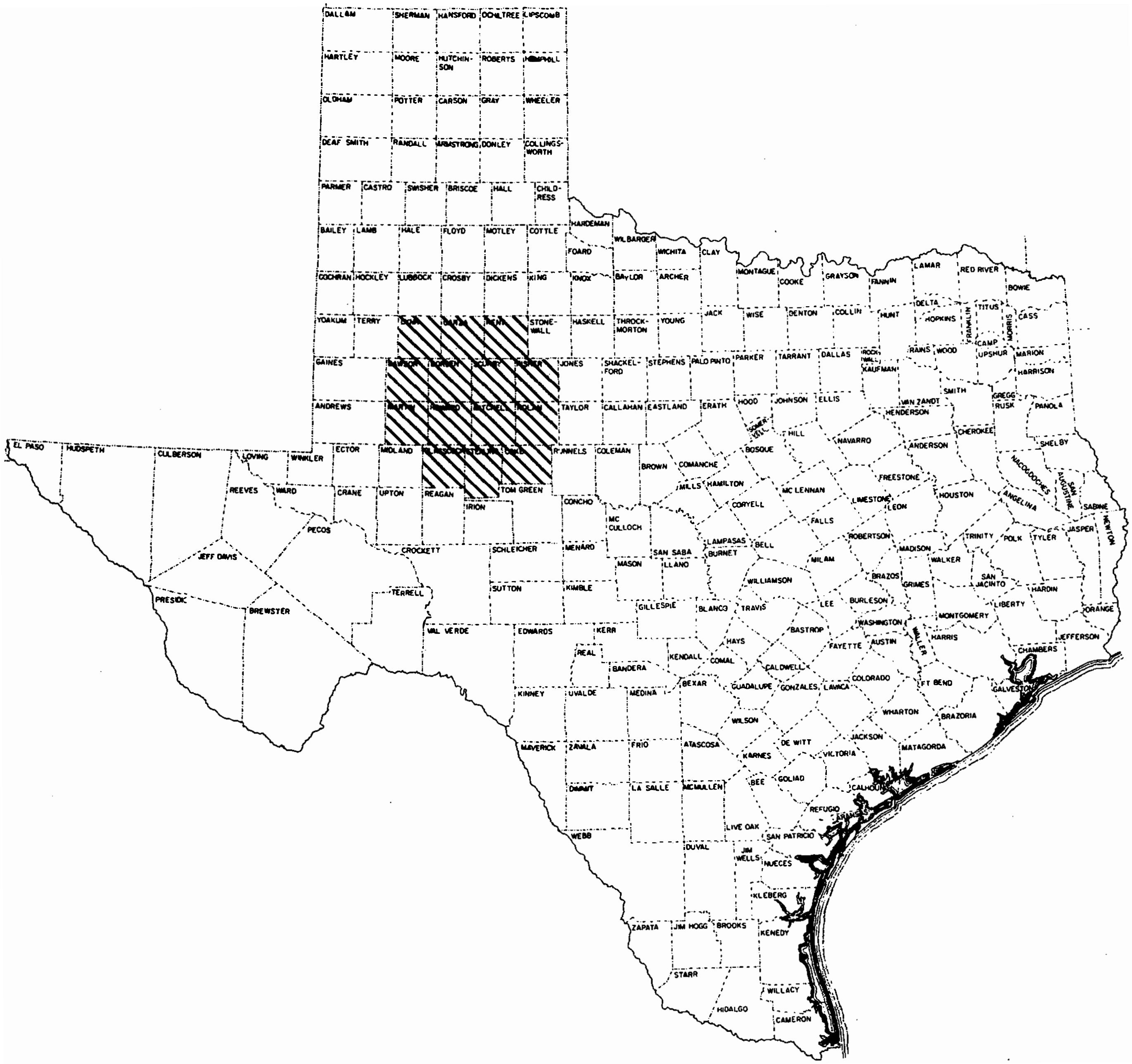

Figure 1. Location of the Big Spring-Snyder Weather Modification Study Area

These surface water facilities provide water to the major cities and industries served by the Colorado River Municipal Water District.

Ground water is the major source of irrigation water in the study area. Some of the ground water is high in soluble salts and can be used for irrigating salt tolerant crops only. Shallow and weak wells are characteristic of the area. These conditions substantiate the need to increase rainfall, thereby saving ground water of usable quality for later use.

Population and Agriculture

The population of the study area declined from 194,056 in 1960 to 128,587 in 1970, but increased about 1 percent from 1970 to 1975, according to recent estimates.[11/] Approximately 50 percent of the region's population is concentrated in the Cities of Big Spring, Snyder, Lamesa, and Sweetwater. Population in the study area is projected to remain comparatively stable through 1980 and increase to 137,600 and 145,600 in the years 1990 and 2000 respectively.[12/]

The region's total farmland area remained relatively constant from 1969 to 1974 at 7.3 million acres. Between 1969 and 1974 average farm size increased from 1,058 acres to 1,398 acres, while the total number of farms in the area decreased from 6,952 to 5,274. Harvested acreage for the region was over 860,000 acres in 1974 with more than 20 percent

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[11/] U.S. Department of Commerce, Bureau of the Census. "1973 (Revised) and 1975 Population Estimates, and 1972 (Revised) and 1974 Per Capita Income Estimates for Counties and Incorporated Places in Texas" in <u>Current Population Reports: Population Estimates and Projections</u>, Series P-25, No. 691; Issued April, 1977.

[12/] Population Projections for the State of Texas by Counties, Texas Department of Water Resources, December, 1978.

of this acreage irrigated. The annual market value of all agricultural commodities produced in the study area has remained comparatively stable at $104.0 million since 1970. The sale of livestock, poultry, and their products accounted for more than half of this farming revenue in 1969 and over 80 percent in 1974. Almost 28 percent of the labor and proprietor's income in the study area is produced by the farm sector.[13]

[13] U.S. Department of Commerce, Bureau of the Census, 1974 Census of Agriculture - Texas, Volume 1, Part 43.

Estimating Irrigation Cost Response To Increased Precipitation from Weather Modification

Purpose

If weather modification activities increase precipitation during the growing season, then farmers can reduce irrigation by an equivalent quantity, thereby reducing production costs and increasing net farm income, these things equal. The purpose of this section of the analyses is to estimate potential irrigation water savings, irrigation cost reduction, and increased net farm incomes from a 10 percent increase in rainfall during the study area growing season. The analyses is based on the following assumptions:

1. Any savings in the cost of irrigated agricultural production, such as a decrease in the cost of energy to pump irrigation water will be considered additional net income to farmers of the area;
2. Weather modification activities do not cause changes in the farmer's production activities, except to reduce the irrigation water input obtained from ground water supplies and increase the percentage obtained from rainfall,
3. Precipitation occurs during the growing season and is available for crop production.

Methodology

In order to appropriately reflect the variation in precipitation rates within the study area and thereby take this variation into account in the analyses, the present study used historical rainfall data for each of the fourteen counties. The precipitation that falls during April-October is the most beneficial to crop production. This seven month growing season was the time interval chosen for analyses, since this is the time period during which cloud seeding is done. Historical monthly rainfall data were used to determine the average amount of rainfall received during this period each year in the study area. A projected 10 percent increase in annual growing season precipitation for each county was calculated and multiplied by each county's average annual irrigated acreage in the years 1971-1975 to determine the extent to which the additional rainfall could be expected to replace ground water pumpage in each county. The summation of these county estimates is approximately the total amount by which ground water pump irrigation requirements could be reduced in the study area without appreciably affecting total water available for crop production. The irrigation cost savings to farmers were estimated as the sum of the reduced energy requirements of the irrigation pumps and distribution systems and the associated reductions in well repair and lubrication and hired labor. The estimation technique is partial crop enterprise budgeting.

The additional farm income from irrigation cost savings and dryland crop output produced as a result of increased growing season rainfall will have substantial business effects on the local economy. An input-output model developed for the study area was used to estimate these related non-farm economic effects.

Data

Precipitation

Historical precipitation data from each of the 30 precipitation stations that have recorded monthly rainfall in the study area were obtained from the National Climatic Center, Environmental Data Service, and the National Oceanic and Atmospheric Administration. The periods of rainfall records vary considerably (Table 1). The period 1940-1970 was selected as the base period from which average annual growing season rainfall (April-October) was calculated. Only those precipitation stations lying within close proximity of the irrigated crop acreage in each respective county were used to calculate average growing season rainfall. County highway maps showing the location of irrigation wells in each county (based on information supplied from water well driller's logs maintained by TDWR) were used to discern the approximate location of the county's irrigation wells. Since the irrigated crop acreage within a particular county lies in extremely close proximity to the location of the county's irrigation wells, rainfall data recorded at precipitation stations not in the immediate vicinity of the respective county's irrigation acreage were excluded from the analysis to give a more accurate estimate of the rate of rainfall which would have a direct bearing on crop yields (Figure 2).[14/]

Since most of the irrigated crop acreage in Mitchell and Nolan Counties is concentrated between Stations 1903 and 7743, the average rates of April-October rainfall for the two stations (15.14 and 16,90, respectively) were averaged to derive the applicable growing season rate of rainfall, 16.02 inches, for both counties (Table 1 and Figure 2). For those stations where precipitation data were recorded on an intermittent basis from 1940-1970, an adjustment factor was used to incorporate the historic rainfall data from neighboring stations. It is emphasized that the rate of rainfall computed for each county is defined as the

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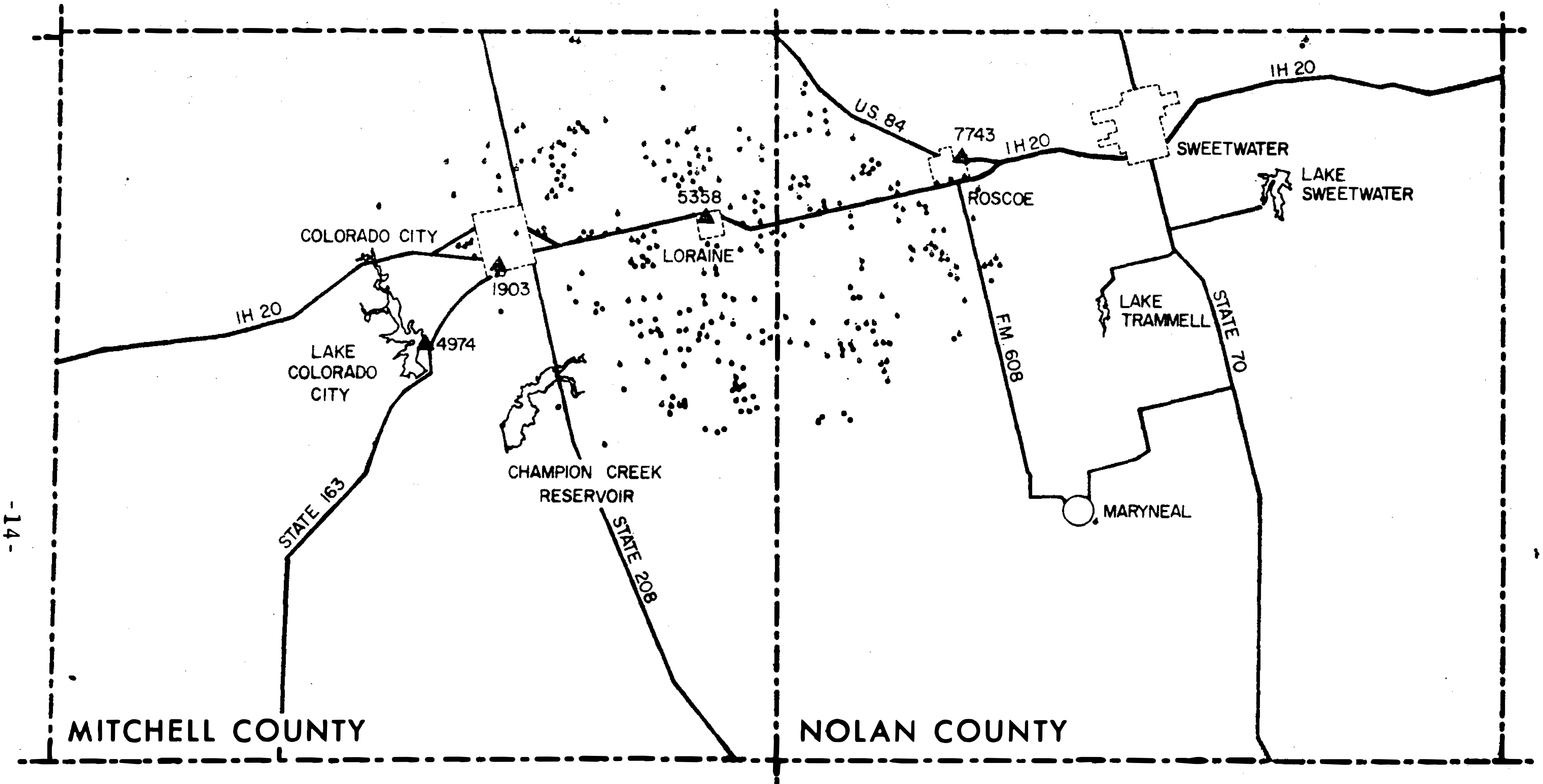
14/ Rainfall data from Station 5358 was excluded since records were not recent and only for the years 1947 to 1963.

TABLE 1. Precipitation Stations and Date of Precipitation Record in the Big Spring-Snyder Study Area.

County	Precipitation Station	Name of Precipitation Station	Period of Record
Borden	3411	Gail	1935-1970
Coke	6495	Oak Creek Lake	1962-1970
	7669	Robert Lee (LCRA 55)	1908-1970
	9501	Water Valley 10 NNE	1959-1970
Dawson	0034	Ackerly	1940-1970
	5013	Lamesa 1 SSE	1910-1970
Fisher	7678	Roby	1904-1970
	7782	Rotan	1925-1970
Garza	7206	Post	1910-1970
Glasscock	3445	Garden City 1 E	1912-1970
	3446	Garden City 16 E	1943-1963
Howard	0784	Big Spring Field Sta	1953-1963
	9786	Big Spring	1900-1970
	3253	Forsan	1949-1970
Kent	4570	Jayton	1910-1919
	4570	Jayton	1940-1970
	7146	Polar	1940-1970
Lynn	6504	O'Donnell	1940-1963
	8373	Slaton 5 SE	1946-1970
	8818	Tahoka	1913-1970
Martin	5158	Lenorah	1941-1970
Mitchell	1903	Colorado City	1900-1970
	4974	Lake Colorado City	1955-1966
	5358	Loraine	1947-1963
Nolan	7743	Roscoe	1935-1970
Scurry	4841	Knapp 2 SW	1931-1970
	8433	Snyder	1911-1970
Sterling	1511	Case Ranch 3 S	1940-1970
	1974	Cope Ranch	1940-1970
	8630	Sterling City	1926-1970
	8631	Sterling City 8 NE	1943-1963



▲ Precipitation Station

· Irrigation Well

FIGURE 2. LOCATION OF PRECIPITATION STATIONS AND IRRIGATION WELLS IN MITCHELL AND NOLAN COUNTIES.

mean of the average rates of April-October rainfall recorded each year at those stations lying within close proximity of the irrigated crop acreage in the respective county. The estimated 10 percent increase in rainfall in the study area was derived, for each county, by multiplying this average growing season rainfall rate by 10 percent (Table 2).

Irrigation

The average annual planted irrigated acreage for each county was obtained from data published by the Texas Crop and Livestock Reporting Service (TCLRS). The three principal irrigated crops are cotton, wheat, and grain sorghum. Data were available for the years 1971-1975.

Estimated Changes in Ground Water Requirements

To determine the extent to which additional rainfall could or might replace ground water used for irrigation, each county's average annual irrigated acreage was multiplied by its projected increase in rainfall, (i.e., if the average growing season rainfall is computed to be 12 inches, then each acre of irrigated land would receive an average of 12 acre-inches of water each year from rainfall). If cloud seeding activities increase rainfall in the study area by 10 percent, then approximately 273,900 acre-inches or 22,800 acre-feet of additional precipitation would fall on the region's irrigated land, and thereby reduce ground water requirements by this amount (Table 3), without reducing total water available for crop production. Over 84.0 percent of the estimated total effects upon reductions in ground water withdrawals would be in TCLRS Crop Reporting District 1-S (Figure 3), with 63.0 percent of the effects occurring in Dawson and Lynn Counties (Table 3).

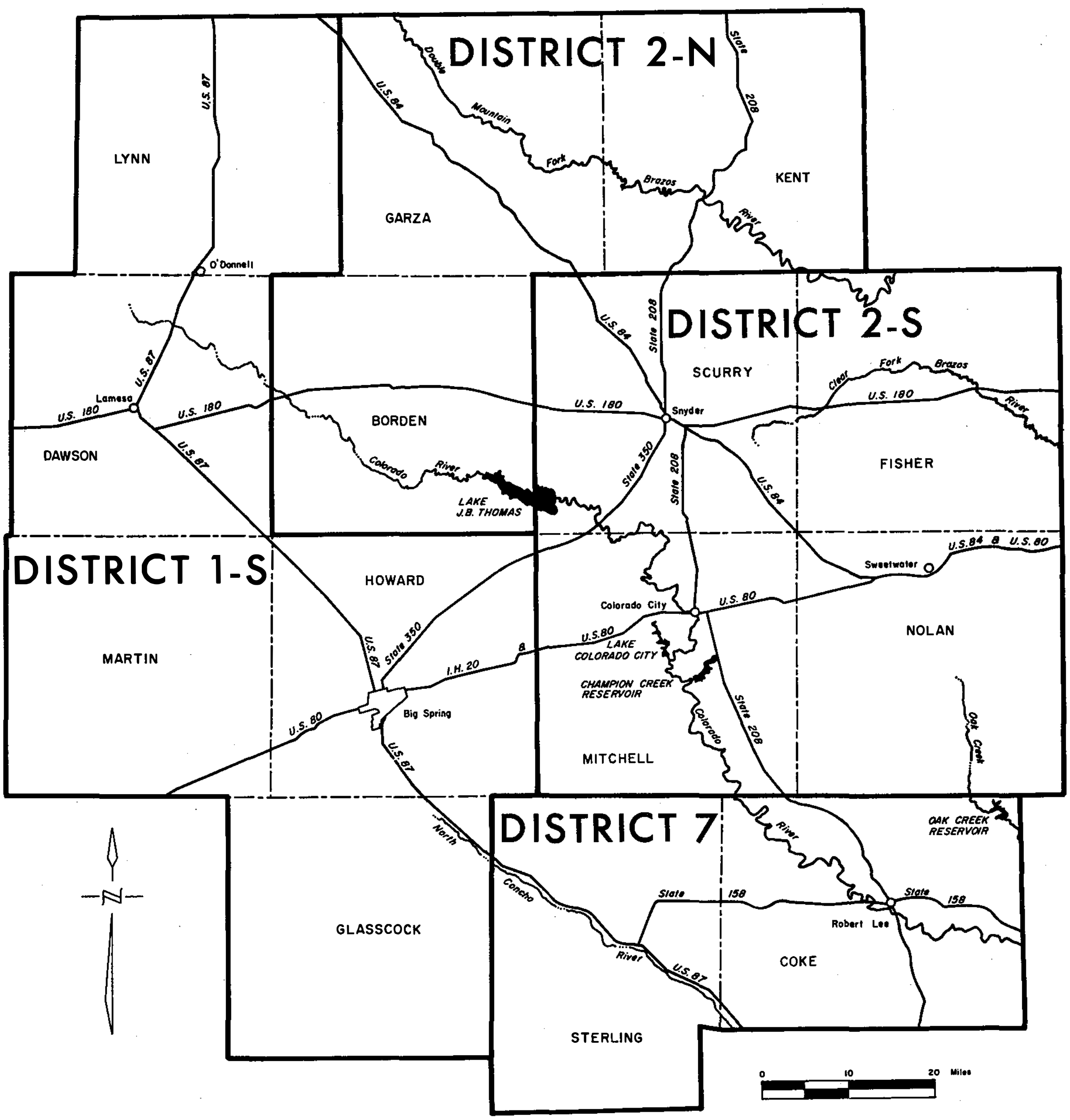


Figure 3. Big Spring-Snyder Study Area Crop Reporting District

Table 2. Average April-October Rainfall and Estimated Additional Rainfall from Weather Modification; HIPLEX Study Area -- 1940-1975 and 1971-1978.

District/County	Precipitation Station Number	1940-1970 Average Annual Apr.-Oct. Rainfall[a] Recorded at Station (Inches)	1940-1970 Average Annual Apr.-Oct. Rate of County Rainfall (Inches)	Ten Percent Increase in Rate of Apr.-Oct. County Rainfall (Inches)	1971-1978 Average Annual Apr.-Oct. Rainfall[a] Recorded at Station (Inches)	1971-1978 Average Annual Apr.-Oct. Rate of County Rainfall (Inches)	Difference over 1940-1970[d] Inches	Difference over 1940-1970[d] %
District 1-S								
Dawson	0034	10.87	11.71	1.2	17.05	16.89	+ 5.18	44
	5013	12.54			16.73			
Glasscock	3253	13.64[b]	12.77	1.3	18.01	16.92	+ 4.15	32
	3445	11.90[b]			15.83			
	3446	12.78[b]			-			
Howard	786	12.45[b]	13.05	1.3	17.94	17.97	+ 4.92	37
	3253	13.64[b]			18.01			
Lynn	8773	15.06[b]	14.78	1.5	17.74	17.83	+ 3.05	21
	8818	14.49[b]			17.92			
Martin	5158	11.79	11.79	1.2	14.98	14.98	+ 3.19	27
District 2-N								
Borden	3411	11.84	11.84	1.2	18.77	18.77	+ 6.93	59
Garza	7206	15.12[b]	15.09	1.5	19.13	18.43	+ 3.34	22
	8373	15.06[b]			17.74			
Kent	4570	14.58	14.58	1.5	19.36	19.36	+ 4.78	33
District 2-S								
Fisher	7678	15.26	16.08	1.6	21.01[c]	20.57	+ 4.49	28
	7782	16.89			20.13			
Mitchell	1903	15.14	16.02	1.6	21.09[c]	21.44	+ 5.42	34
	7743	18.46			21.80			

(continued)

Table 2. Average April-October Rainfall and Estimated Additional Rainfall from Weather Modification; HIPLEX Study Area -- 1940-1975 and 1971-1978 (continued).

District/County	Precipitation Station Number	1940-1970		Ten Percent Increase in Rate of Apr.-Oct. County Rainfall (Inches)	1971-1978		Difference over 1940-1970[d]	
		Average Annual Apr.-Oct. Rainfall[a] Recorded at Station (Inches)	Average Annual Apr.-Oct. Rate of County Rainfall (Inches)		Average Annual Apr.-Oct. Rainfall[a] Recorded at Station (Inches)	Average Annual Apr.-Oct. Rate of County Rainfall (Inches)	Inches	%
District 2-S								
Nolan	1903	15.14	16.02	1.6	21.09[c]	21.44	+ 5.42	34
	7743	16.90			21.80			
Scurry	4841	13.49	14.44	1.4	19.18	20.74	+ 6.30	44
	8433	15.38			22.31			
District 7								
Coke	7669	13.19	13.19	1.3	20.37	20.37	+ 7.18	54
Sterling	1511	12.74 [b]	13.31	1.3	18.07	17.83	+ 4.52	34
	3446	12.78 [b]			-			
	8630	14.54			17.59			
	8631	13.17 [b]			-			

[a] Unless otherwise noted, average annual April-October rainfall, 1940-1970.

[b] Average annual April-October rainfall, 1950-1979.

[c] 1971-1975 data.

[d] Positive difference between computed mean precipitation in 1940-1970 and 1971-1978 periods.

Table 3. Average Annual Irrigated Acreage, 1971-1975, and Estimated Annual Reduction in Ground Water Withdrawals if Weather Modification Increases Rainfall by 10 Percent.

District/County	1971-1975 Average Annual Irrigated Acreage (Acres)	Additional County Rainfall (Inches)	1971-1975 Average Annual Reduction In Groundwater Pumpage (Acre-Inches)
District 1-S	172,340		231,793
Dawson	52,640	1.2	63,168
Glasscock	16,090	1.3	20,917
Howard	14,010	1.3	18,213
Lynn	73,250	1.5	109,875
Martin	16,350	1.2	19,620
District 2-N	12,023		17,579
Borden	1,517	1.2	1,820
Garza	9,236	1.5	13,854
Kent	1,270	1.5	1,905
District 2-S	15,731		24,049
Fisher	3,455	1.6	5,528
Mitchell	3,307	1.6	5,291
Nolan	3,368	1.6	5,389
Scurry	5,601	1.4	7,841
District 7	377		490
Coke	349	1.3	454
Sterling	28	1.3	36
TOTAL BIG SPRING-SNYDER STUDY AREA	200,471		273,911

1/ 273,911 Acre-Inches = 22,826 Acre-Feet

A comparison of 1974 ground water pumpage with the estimated annual reduction in ground water requirements due to a weather modification induced 10 percent increase in precipitation indicates an approximate 10 percent reduction in ground water requirements for the entire study area (Table 4). Dawson, Howard, Borden, and Fisher Counties would experience an even greater reduction in ground water withdrawals (Table 4). This annual conservation of more than 22,800 acre-feet of ground water through weather modification activities would extend the life of the region's ground water reserves.

Both sprinkler and furrow irrigation methods are used in the study area. Since the sprinkler and furrow irrigation methods have different energy and labor requirements, changes in input requirements are computed from the potential reduction in ground water withdrawals that accrue to each method due to increased water from weather modification (Table 5).

A broad range of fuels (liquid petroleum gas, diesel fuel, gasoline, natural gas, and electricity) is used to drive the region's irrigation well power units. According to the Texas Agricultural Extension Service in Lubbock and the Colorado River Municipal Water District in Big Spring, over 80 percent of the wells in the study area are powered by electricity since the wells are relatively shallow (averaging 200 feet) and average yields are relatively low (75 gallons a minute).[15/] Consequently, the savings in pump energy requirements due to increased precipitation is estimated in terms of kilowatt hours of electricity.

[15/] Texas Agricultural Extension Service, Lubbock, Texas.

Table 4. Estimated Annual Reduction in Ground Water Pumpage as a Percentage of Actual 1974 Pumpage if Weather Modification Increases Rainfall by 10 Percent.

District/County	1974 Groundwater Pumpage (Acre-Inches)	Estimated Average Annual Reduction Groundwater Pumpage 1971-1975 (Acre-Inches)	Percent of 1974 Groundwater Pumpage (Percent)
District 1-S	2,289,684	231,793	10.1
Dawson	374,940	63,168	16.9
Glasscock	661,236	20,917	3.2
Howard	28,320	18,213	64.3
Lynn	867,288	109,875	12.7
Martin	357,900	19,620	5.5
District 2-N	220,284	17,579	8.0
Borden	7,320	1,820	24.9
Garza	188,004	13,854	7.4
Kent	24,960	1,905	7.6
District 2-S	176,448	24,049	13.6
Fisher	22,212	5,528	24.9
Mitchell	50,448	5,291	10.5
Nolan	32,472	5,389	16.6
Scurry	71,316	7,841	11.0
District 7	50,268	490	1.0
Coke[a/]	240	454	189.2
Sterling	50,028	36	.1
TOTAL BIG SPRING-SNYDER STUDY AREA	2,736,684	273,911	10.0

[a/] There were insufficient 1974 irrigation data for Coke County.

SOURCE: Texas Water Development Board, Inventories of Irrigation in Texas 1958, 1964, 1969, and 1974, Report 196, October, 1975.

Table 5. Estimated Annual Reduction in Ground Water Pumped for Sprinkler and Furrow Irrigation Methods in the Big Spring-Snyder Study Area by Crop Reporting District and County if Weather Modification Increases Rainfall by 10 Percent.

District/County	Sprinkler Irrigated Acreage (Percent)	Estimated Annual 1971-1975 Reduction Groundwater Irrigation (Acre-Inches)	Estimated Annual Reduction In: Sprinkler Irrigation (Acre-Inches)	Estimated Annual Reduction In: Furrow Irrigation (Acre-Inches)
District 1-S		231,793	103,111	128,682
Dawson	.995576	63,168	62,889	279
Glasscock	.174418	20,917	3,648	17,269
Howard	.682684	18,213	12,434	5,779
Lynn	.041141	109,875	4,520	105,355
Martin	1.000000	19,620	19,620	0
District 2-N		17,579	2,489	15,090
Borden	.014939	1,820	27	1,793
Garza	.049577	13,854	687	13,167
Kent	.931871	1,905	1,775	130
District 2-S		24,049	17,425	6,624
Fisher	.422866	5,528	2,338	3,190
Mitchell	.998284	5,291	5,282	9
Nolan	.684917	5,389	3,691	1,698
Scurry	.779724	7,841	6,114	1,727
District 7		490	321	169
Coke	.658436	454	299	155
Sterling	.598892	36	22	14
TOTAL BIG SPRING-SNYDER STUDY AREA		273,911	123,346	150,565

The following formula was used to determine the kilowatt hours of electricity required to pump 1 acre-inch (27,152 gallons), using a furrow irrigation system:

$$KWH = \frac{1.024(\text{Lift})}{\text{OPE}} \div 12$$

where:

KWH = the electrical energy requirement in kilowatt hours necessary to pump one (1) acre-inch of ground water,

1.024= kilowatts to lift one (1) acre-foot of water one vertical foot at 100 percent overall pumping efficiency,

Lift = vertical lift in feet, and

OPE = overall pumping efficiency expressed as a decimal.

The same equation can be used to derive the electrical energy requirements for a sprinkler irrigation system when the equation is modified to replace the lift variable with the term "well depth + 2.31 (PSI)," where PSI = pounds of pressure per square inch required to operate a sprinkler system.

Using average study area well depth of 200 feet, well yield of 75 gallons per minute, and overall pumping efficiency rate of 48 percent,[16/] approximately 35.52 kilowatt hours of electricity are required to pump and apply 1 acre-inch of ground water (27,152 gallons) when furrow irrigation is used. Based on a pressure requirement of 40 PSI for sprinkler systems[17/] 51.92 kilowatt hours of electricity would be required to pump

[16/] *Ibid.*

[17/] *Ibid.*

and apply 1 acre-inch of irrigation water through a sprinkler system.

Furrow irrigation labor requirements would decline by 0.25 hours per acre-inch and sprinkler irrigation labor requirements would decline by 0.10 hours per acre-inch of unused ground water.[18/] Thus, the total reduction in farm irrigation labor requirements associated with a 10 percent increase in precipitation is estimated at 49,976 hours annually.

Estimated Changes in Irrigation Costs

To estimate the savings in irrigation costs per acre-inch of reduced ground water irrigation, 1977 unit prices for electricity and labor were applied to the per acre-inch unit input requirements (Table 6).[19/] According to the Texas Agricultural Extension Service Staff in Lubbock, the price of 3.1 cents per kilowatt hour used is most representative of the price paid by farmers throughout the entire region. The per acre-inch repair and lubrication costs associated with furrow and sprinkler irrigation methods were also obtained from the Agricultural Extension Service. The differences in the input requirements per acre-inch of water use of the two distribution systems is due to the fact that sprinkler irrigation is more capital intensive while furrow irrigation is more labor intensive.

The total reductions in associated irrigation costs for the study area were derived by multiplying the estimated annual acre-inch decrease

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[18/] Obtained from Texas Agricultural Extension Service, Lubbock, Texas.

[19/] These calculations were made under the assumption that changes in the quantities of electricity and labor used will not affect the unit prices of either.

Table 6. Estimated Reductions (Dollars Per Acre-Inch) in Irrigation Costs if Weather Modification Increases Rainfall 10 Percent.

Sprinkler Irrigation	
Reduction in Cost of Fuel: 51.92 kwh/Acre-Inch @ 3.1¢/kwh	= $1.61/Acre-Inch
Reduction in Cost of Repair and Lubrication	= $ .52/Acre-Inch[1/]
Reduction in Labor Costs: .10 hr/Acre-Inch @ $2.25/hr[2/]	= $ .23/Acre-Inch
Total Reduction in Costs of Sprinkler Irrigation	= $2.36/Acre-Inch
Furrow Irrigation	
Reduction in Cost of Fuel: 35.52 kwh/Acre-Inch @ 3.1¢/kwh[1/]	= $1.10/Acre-Inch
Reduction in Cost of Repair and Lubrication	= $ .22/Acre-Inch[1/]
Reduction in Labor Costs: .25 hr/Acre-Inch @ $2.25/hr[2/]	= $ .56/Acre-Inch
Total Reduction in Costs of Furrow Irrigation	= $1.88/Acre-Inch

[1/] Obtained from the Texas Agricultural Extension Service in Lubbock, Texas.

[2/] Hourly wage rate currently paid for farm labor in the study area according to the Texas Employment Commission Office in Big Spring, Texas.

in sprinkler and furrow irrigation, in Table 5, by the appropriate per acre-inch fuel, repair, lubrication and labor costs derived in Table 6. Based on 1977 prices, annual irrigation costs in the study area could be reduced by approximately $574,159 (Table 7) if ground water irrigation withdrawals decline 22,800 acre-feet (274,000 acres-inches) in response to a 10 percent increase in growing season rainfall caused by weather modification activities in the study area. Of the total reduction in irrigation costs, declining electrical energy requirements would comprise 63.4 percent, decreased labor costs 19.6 percent, and reduced charges for irrigation well repair and lubrication 17.0 percent. The total savings in irrigation costs would be almost equally divided among sprinkler and furrow irrigation.

Summary

In this phase of the study, the quantity of water resulting from a 10 percent increase in April-October rainfall each year on irrigated acreage was estimated for the Big Spring-Snyder study area. The growing season rate of rainfall in each county was estimated as the mean of the April-October rainfall rates recorded from 1940-1970 at those precipitation stations lying within close proximity of the irrigated crop acreage in each county. Irrigated areas were identified from locations of recorded irrigation wells. Irrigated acres are known to lie in close proximity of irrigation wells. The electrical energy requirements necessary to pump the equivalent quantity of ground water were derived according to the extent of furrow and sprinkler irrigation practices in the study area. The subsequent savings in irrigation costs were estimated by mutliplying the projected decrease in furrow and sprinkler irrigation requirements,

Table 7. Estimated Annual Reduction in the Cost of Sprinkler, Furrow, and Total Irrigation in the Big Spring-Snyder Study Area (1977 Dollars).

	Reductions in Cost of Irrigation			
	Fuel Costs (Dollars)	R&L Costs[1/] (Dollars)	Labor Costs (Dollars)	Total Costs (Dollars)
	Sprinkler Irrigation			
District 1-S	166,009	53,618	23,716	243,343
District 2-N	4,007	1,294	573	5,874
District 2-S	28,054	9,061	4,008	41,123
District 7	517	167	74	758
Total Study Area	198,587	64,140	28,371	291,098
	Furrow Irrigation			
District 1-S	141,550	28,310	72,062	241,922
District s-N	16,599	3,320	8,450	28,369
District 2-S	7,286	1,457	3,709	12,452
District 7	186	37	95	318
Total Study Area	165,621	33,124	84,316	283,061
	All Irrigation (Furrow Plus Sprinkler)			
District 1-S	307,559	81,928	95,778	485,265
District 2-N	20,606	4,614	9,023	34,243
District 2-S	35,340	10,518	7,717	53,375
District	703	204	169	1,076
Total Study Area	364,208	97,264	112,687	574,159

1/ Repair & Lubrication Costs.

in acre-inches, by the appropriate per acre-inch costs in fuel, well repair and lubrication, and labor. The estimates are:

1. A 10 percent increase in April-October rainfall annually in the study area is equivalent to ground water furrow irrigation requirements of 150,565 acre-inches and sprinkler irrigation of 123,346 acre-inches or a total of 22,826 acre feet, and

2. Reduced irrigation requirements would reduce furrow irrigation costs (in 1977 dollars) by $283,061 annually, and sprinkler irrigation costs by $291,098 annually for a total reduction in costs of $574,159, based on 1977 input prices.

Estimated Potential Study Area Non-Farm Economy Effects of Weather Modification

The potential business and income effect the Big Spring-Snyder regional economy would be expected to experience as a result of reduction in irrigation input requirements, and lowered irrigation costs in the study area are estimated below. The potential economic impact of weather modification activities on the agricultural sector in general is also discussed in terms of the potential non-farm business effects on the local economy.

There are a number of economic effects usually associated with changes in economic activity within a region caused by forces either internal or external to the region. One of the most comprehensive methods of measuring the effects of changes in regional economic activity is input-output analysis. This procedure was developed by Wassily W. Leontief, and was first applied by Leontief in his analysis of the interdependence of the sectors of the American economy for the period 1919 to 1929.[20/] Since that time, additional research has expanded the usefulness of this procedure, and many interindustry studies, both for the United States as a whole and for smaller areas, including areas of Texas, have been conducted. These latter studies will be used in this analysis.

The purpose of this part of the study is to determine the direct, indirect, and total output effects, as well as the household income

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20/ Leontief, W. W., The Structure of the American Economy, 1919-1929, Oxford University Press, New York, 1941.

effect, which could be expected if efforts to increase growing season rainfall by 10 percent in the Big Spring-Snyder area, through weather modification activities, should succeed. The reduction in irrigation costs presented in the preceding section of this study will serve as the basis for quantifying the direct effects. An input-output model developed for the study will be used to estimate the other economic effects.[21/]

The specific objectives of this part of the study are as follows:

1. To estimate the indirect output and household income effects caused by the initial reduction in the costs of ground water pump irrigation and the concurrent expansion of household farm income;

2. To estimate the potential net economic effects accruing to the study area's economy as a result of a 10 percent increase in April-October rainfall annually;

3. To present the total estimated economic effects of weather modification including the irrigation effects listed above, estimated dryland crop and livestock production, and total economic effects occurring in the regional economy as a result of the expansion in dryland crop and livestock production and the reduction in ground water pump irrigation.

Assumptions underlying the analytic model are: (1) the amount of any one input required in a production process is related proportionately to the total output of the sector; and (2) the type of businesses comprising any sector are relatively homogeneous, i.e., the mix of input requirements shown for a sector is representative of that sector.

The input-output model expresses a quantitative measure of the structure of the economy and estimates the magnitude of interindustry effect which can be expected to occur as a result of changes in each

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21/ A mathematical description of the input-output model developed for the study area is in Appendix C of the report entitled "Economic Effects of Weather Modification Activities, Part II - Range Production and Interindustry Analysis."

respective sector. The model of the Big Spring-Snyder area economy contains 32 processing or business sectors, five final payments or income receiving sectors, and six final demand or consuming sectors (Table 8 and Appendix A).

Estimated Economic Effects of Weather Modification

Regional Output and Household Income Effects

As estimated in the previous section, the savings in irrigation costs would increase direct irrigation farm income by $574,159. If this additional farm income is spent on goods and services, total regional output would increase by $1,007,161 (Table 9) and total regional income would expand by $688,480 (Table 10). The increase in farm household income through lower irrigation costs would account for 57.0 percent of the total increase in regional output and 83.4 percent of the total regional growth in household income.

Irrigation Costs

The total reduction in ground water pump irrigation requirements, valued in terms of the associated reduction in irrigation costs, is the potential direct input effect on irrigated agriculture of an increase in rainfall due to weather modification activities. It is assumed that the output from irrigated acreage would remain unchanged. The reduction in regional irrigation costs by $574,159 would mean direct economic output in the study area would decline by the same amount, because farmers would spend $364,208 less on fuel; $97,264 less for well repair and lubrication, and $112,687 less for irrigation labor (Table 9). Since

Table 8. Economic Sectors of the Big Spring-Snyder Study Area.

Sector Number	Sector Name
1	Irrigated Crops
2	Dryland Crops
3	Livestock
4	All Other Agriculture
5	Crude Petroleum and Natural Gas
6	Natural Gas Liquids, Oil & Gas Field Services
7	Construction
8	Meats & Dairies
9	Milling & Feeds
10	Foods & Beverages
11	Textile Products
12	Wood Products, Printing & Publishing
13	Chemicals, Petroleum Products, Plastic, Leather, Glass Products
14	Clay, Stone, Cement Products
15	Other Manufacturing
16	Local & Long Distance Trucking, Storage and Arrangement
17	Other Transportation
18	Communications
19	Gas Services
20	Electrical Services
21	Water & Sanitary Services
22	Wholesale Farm Products
23	Wholesale Petroleum Products
24	Other Wholesale
25	Lumber Yards, Hardware, etc.
26	Auto Dealers, Repair, Service Station
27	Other Retail
28	Finance, Insurance, Real Estate
29	Amusement & Recreation
30	Medical Services
31	Educational Services
32	All Other Services
Final Payments	Households
	Federal Government
	State Government
	Local Governments
	Imports
Final Demand	Households
	Federal Government
	State Government
	Local Governments
	Exports and Inventory Change
	Capital Formation

Table 9. Estimated Economic Impact on Regional Output in the Big Spring-Snyder Area if Weather Modification Increases Rainfall 10 Percent.

	Direct	Indirect	Total
Increase in Output Due to Increased Household Spending by Farmers	$ 574,159	$ 433,002	$1,007,161
Less Decrease in Output Due to:			
Decrease in Payments to Farm Labor	112,687	84,983	197,670 [b/]
Decrease in Fuel Purchases	364,208	300,974	665,182 [c/]
Decrease in Repair & Lubrication Purchases	97,264	69,602	166,866 [d/]
Subtotal Decrease in Output	574,159	455,559	1,029,718
Equals:			
Net Output Effect	0 [a/]	-22,557	-22,557
Plus:			
Net Output Effect of Increased Dryland Crop and Livestock Production	1,605,250	2,278,850	3,884,100
Equals:			
Estimated Net Output Effect of Weather Modification Activities	$1,605,250	$2,256,293	$3,861,543

a/ It was assumed that the decrease in payments by farmers to factors of production would represent increased net income to farmers and that all of the increased income would be spent on household consumption. Therefore, the direct decrease in irrigation farm spending is exactly offset by direct increases in farm household income.

b/ Table B-4, Households Sector Multiplier - 1.75415.

c/ Table B-4, Electric Service Sector Multiplier - 1.82638.

d/ Table B-4, Other Services Sector Multiplier - 1.71560.

Table 10. Estimated Economic Impact on Regional Income in the Big Spring-Snyder Area if Weather Modification Increases Rainfall 10 Percent.

	Direct	Indirect	Total
Increase in Household Income to Farmers	$ 574,159	$114,321	$ 688,480
Less:			
Decreased Payments to Farm Labor	112,687	22,437	135,124 a/
Less Decreased Payments to Households Due to:			
Decrease in Fuel Purchases	98,882	44,062	142,944 b/
Decrease in Repair & Lubrication Purchases	30,106	9,708	39,814 c/
Subtotal Decrease in Income	241,675	76,207	317,882
Equals:			
Net Income Effect	332,484	38,114	370,598
Plus:			
Net Income Effect of Increased Dryland Crop and Livestock Production	1,605,250	319,630 d/	1,924,880
Equals:			
Estimated Net Income Effect of Weather Modification Activities	$1,937,734	$357,744	$2,295,478

a/ Table B-4, Column 33, Household Cell (1.19911), multiplied by direct decrease in payments to farm labor (Table 9).

b/ Table B-4, Column 20, Household Cell (0.39248), multiplied by direct decrease in fuel purchases (Table 9).

c/ Table B-4, Column 32, Household Cell (0.40934), multiplied by direct decrease in repair and lubrication purchases (Table 9).

d/ This figure is the sum of the indirect household income effect shown in Table 12.

the reduction in farm labor costs represents an equivalent to a decrease in income to farm labor, the $112,687 represents a negative direct income effect in the study area. However, the increased income to farmers would offset most of these negative effects, as explained below. Fuel savings from reduced irrigation pumping would increase the quantity of energy available to consumers and other energy users.

Interdependence coefficients from tables of direct and indirect requirements computed in developing the input-output model for the study area, were used to derive the indirect output and the household income effects (Appendix B). These tables describe the interrelationships existing among various sectors of the economy so that the total effects of a change in business activity of any sector can be quantified. For example, the direct effect of a decline in pump irrigation costs requires the processing sectors which supply these pump irrigation inputs to reduce their output, other things equal. Therefore, these sectors purchase less of the output of other sectors, and so on. This indirect contraction as a result of a reduced use of a given sector's output is termed the indirect effect. Contractions in output by processing sectors decrease income payments to local households, which in turn result in reduced incomes with which to purchase processed goods and services. The impact of this decline in local household consumption expenditures on sector output is included in the computations of economic effects upon the local area economy.

The indirect output effects related to the reduction in fuel costs when totaled, resulted in a negative effect of $300,974 (Table 9). The total income effect of this same reduction in fuel costs showed household income declining by $142,944. Along with the reduction in fuel costs, irrigation well repair and lubrication costs were estimated to decline by $97,268, resulting in a negative indirect output effect of $69,602 (Table 9) and a negative total income effect of $39,814 (Table 10).

The indirect output and indirect income effects associated with the $112,687 reduction in farm labor costs are estimated at $84,983 (Table 9) and $22,437 (Table 10) respectively. This decrease in farm labor inputs results in a decline in regional personal incomes of farm laborers. However, as was stated and explained above, the reduction in irrigation costs, other things equal, results in increased farm incomes estimated at $574,159 annually at 1977 prices.

The reduction in use of ground water irrigation inputs equivalent to 10 percent of the April-October rainfall would ultimately contract regional output by $1.0 million (Table 9) and regional income by $317,882 (Table 10). The decline in total regional output includes the negative direct output effect of $574,159, and the negative indirect output effect of $455,559. Approximately 76 percent, or $241,675, of the decline in total regional income results from decreased direct payments to households with an indirect (or "induced") reduction in payments to labor accounting for 24 percent, or $76,207.

Net Economic Effects on Irrigated Agriculture

As a result of the decline in irrigation input requirements and associated costs and the subsequent initial expansion in household income and expenditures by irrigation farmers, net output in the Big Spring-Snyder area would decline by $22,557 (Table 9) and net regional income would expand by $370,598 (Table 10). Although indirect output due to increased household spending by farmers would increase by $433,002, this is insufficient to overcome the decline in indirect output of $455,559 resulting from decreased spending to pump ground water for irrigation. The decline in payments to farm labor cancels some of the expansionary effect on regional output and income of the increased household income as it is spent by farm operators. Net direct income, then, increases by $332,484 which, when spent, would expand net indirect household income by $38,114 (Table 10). While the increase in household farm income stimulates an increase in total regional income of $688,480, the decline in ground water pump irrigation and associated costs generates an offsetting reduction in regional income of $317,882. Therefore, as Table 10 shows, net regional income would expand by $370,598.

Economic Effects on the Agricultural Sector

The two previous studies presented estimates of additional dryland crop and livestock production resulting from additional rainfall (Table 11).[22/] In order to gain a more complete picture of the economic effects of weather modification activities on the Big Spring-Snyder regional economy, the direct output and income effects of expanded dryland crop and livestock production were aggregated to conform with the data in this study. The figures in Table 11 were adjusted to 1977 prices, since the previous studies has used 1974 as the base year.

The increased dryland crop and livestock production would expand direct output and income by approximately $1.6 million (Table 12).

22/ Cited in footnotes 8 and 9.

Table 11. Estimated Direct Output and Income Effect of Expanded Dryland Crop and Livestock Production if Weather Modification Increases Rainfall 10 Percent.

	Cotton	Grain Sorghum	Wheat	Crops Total	Livestock	Total
	(thousands of 1977 dollars)					
January	468.27	78.02	4.24	550.53	118.61	669.14
February	468.27	61.78	3.61	533.66	123.98	657.64
March	702.28	129.97	5.10	837.35	141.66	979.01
April	--	--	9.98	9.98	286.78	296.76
May	--	--	--	--	226.19	226.19
June	--	310.04	--	310.04	--	310.04
July	--	310.04	5.52	315.56	--	315.56
August	--	270.00	5.95	275.95	--	275.95
September	--	--	7.43	7.43	--	7.43
October	--	--	15.50	15.50	157.82	173.32
November	--	--	6.58	6.58	--	6.58
December	--	--	4.67	4.67	--	4.67
TOTAL	1,638.82	1,159.85	68.58	2,867.25	1,055.04	3,922.29
April-October						
TOTAL	--	890.08	44.38	934.46	670.79	1,605.25

SOURCE: Texas Water Development Board, The Economic Effects of Weather Modification Activities, Part I-Crop Production, November 1975, and Texas Water Development Board, The Economic Effects of Weather Modification Activities, Part II-Range Production and Interindustry Analysis, March, 1978.

Table 12. Estimated Impact on Regional Output and Income of Increased Dryland Crop and Livestock Production if Weather Modification Increases Rainfall 10 Percent.

Regional Output	Direct	Indirect	Stemming-From a/	Total
	(Thousands of 1977 Dollars)			
Increase in Production:				
From Grain Sorghum	$ 890.08	$ 671.26	$ 286.25	$1,847.59
From Wheat	44.38	33.48	14.25	92.11
From Livestock	670.79	505.88	767.73	1,944.40
TOTAL	$1,605.25	$1,210.62	$1,068.23	$3,884.10

Regional Income	Direct	Indirect	Total
	(Thousands of 1977 Dollars)		
Increase in Household Income:			
From Grain Sorghum	$ 890.08	$177.23	$1,067.31
From Wheat	44.38	8.84	53.22
From Livestock	670.79	133.56	804.35
TOTAL	$1,605.25	$319.63 b/	$1,924.88

a/ The "stemming-from" effect is the indirect and induced effect which occurs when the region's processing sectors purchase, transport, store, process, and market the regions increased crop and livestock production.

b/ This figure is derived from Table B-4, Column 33, Household Cell, (the multiplier, 1.19911-1.00000, times the direct increase in household income of $1,605,250).

SOURCE: Texas Water Development Board, The Economic Effects of Weather Modification Activities, Part I-Crop Production, November 1975, and Texas Water Development Board, The Economic Effects of Weather Modification Activities, Part II-Range Production and Interindustry Analysis, March, 1978.

Household expenditures of this income would raise indirect output by over $1.2 million, with indirect household income accounting for $319,630 of this total. An additional $1.07 million of output would occur due to the "stemming-from" effect of increased business to the local agribusinesses that would process the additional dryland crop and livestock production. The "stemming-from" effect is the indirect and induced effect which occurs when the region's processing sectors purchase, transport, store, process, and market the region's increased crop and livestock production. These multiplier effects in the study area would subsequently expand regional output by $3.9 million and regional income by approximately $1.9 million.

The concurrent decline in ground water pump irrigation requirements equivalent to a 10 percent increase in April-October rainfall, and the associated reduction in irrigation costs would reduce gross regional output by $1,029,718 and gross regional income by $317,882 in 1977 dollars. However, the expenditures by irrigation farmers of the $574,159 increase in irrigation farm income offsets other labor and irrigation input reductions through increased demand for regional output of $1,007,161 and regional income of $688,480 (Tables 9 and 10). The reduced expenditures for farm labor would tend to partially offset the additional irrigation farm income derived through reductions in irrigation costs, but this initial reduction in ground water irrigation requirements would ultimately reduce net regional output by $22,557 and expand regional income a net quantity of $370,598 (Tables 9 and 10). Thus, a 10 percent increase in April-October rainfall in the Big Spring-Snyder area would expand regional annual output in 1977 dollars by approximately $3.86 million and regional income by $2.30 million.

Summary

This phase of the study of the economic effects of weather modification activities in the Big Spring-Snyder area estimated the results of a decline in the need for ground water pump irrigation equivalent to 10 percent of April-October precipitation. As less irrigation is necessary, farming costs are lower and direct income to irrigation farmers increases. As might be expected, lower levels of irrigation require less inputs to the irrigation process, contracting the output and income of businesses and persons whose outputs of goods and services are used as inputs in irrigation.

The magnitude of these opposing events, an increase in household farming income and a decrease in the businesses that supply irrigation inputs were estimated using an input-output model of the Big Spring-Snyder area. Each of these effects were estimated. The estimates included direct output and income effects as well as the multiplier effects of indirect output.

The estimated net effects on regional output and income were combined with two previous studies on dryland crop and range production to evaluate the total net economic effects of weather modification activities in the regional economy. The additional rainfall could have the following net economic effects on the region:

1. A 22,800 acre-food reduction in ground water pump irrigation requirements in the study area would initially reduce irrigation costs by approximately $574,159 in 1977 dollars and would subsequently reduce regional output by $22,557, but would expand regional income of persons by $370,598;

2. The additional rainfall in the study area would expand dryland crop and livestock production, as well as farm income, by approximately $1.6 million, which would

eventually expand regional output by approximately $3.9 million and regional income by over $1.9 million; and,

3. The net effect of the additional rainfall in the dryland and irrigation crop sectors of the Big Spring-Snyder regional economy would be to create an overall expansion in regional output of approximately $3.86 million and a similar expansion of regional income of $2.30 million, or approximately one-half of one percent of total personal income in the Big Spring-Snyder area.

Preliminary analyses of data collected in the HIPLEX precipitation enhancement program show a potential 10 percent increase in annual growing season (April-October) precipitation in the Big Spring-Snyder, Texas area. The economic and employment effects of this program on agricultural production in the 14 county regional economy could be significant. Earlier studies have estimated that a 10 percent increase in precipitation could expand the dollar value of regional dryland and livestock output by $3.9 million and regional income by about $1.9 million. In this phase of the study, it has been estimated that a 10 percent increase in growing season precipitation could replace a total of 22,800 acre-feet of ground water that is now pumped annually from exhaustible ground water reserves and used for irrigation in the area. Such a savings in puming requirements not only saves water, but also reduces irrigation costs amounting to $574,200 annually. The estimated effects on regional income are $370,600 annually due to reduced expenses for pumping irrigation water, and would free $364,000 of irrigation pump energy for other uses. The net effect of the additional rainfall in the dryland, irrigation, and non-farm support sectors of the Big Spring-Snyder area regional economy would be to create an expansion of $3.9 million in output and $2.3 million in payroll or personal income.

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APPENDIX A

SECTOR DESCRIPTIONS WITH CORRELATIVE LISTING OF SIC CODES

Regional Model Sector Number	Sector	SIC
1	Irrigated Crops	0112, 0113, 0313, 0122, 0123, 0119
2	Dryland Crops	0212, 0213, 0413, 0219, 0141
3	Livestock	0235, 0135, 0136
4	All Other Agriculture	nec,* all 01, 07, 08, 09
5	Crude Petroleum and Natural Gas	1311
6	Natural Gas Liquids, Oil & Gas Field Services	1321, 1381, 1382, 1389
7	Construction	15, 16, 17
8	Meats & Dairies	201, 202
9	Milling & Feeds	204
10	Foods & Beverages	203, 205, 206, 207, 208, 209
11	Textile Products	22, 23
12	Wood Products, Printing & Publishing	24, 25, 26, 27
13	Chemicals, Petroleum Products, Plastic, Leather, Glass Products	28, 29, 30, 31, 322, 323
14	Clay, Stone, Cement Products	32, exc. 322 & 323
15	Other Manufacturing	19, 33, 34, 35, 36 37, 38, 29
16	Local & Long Distance Trucking, Storage, and Arrangement	42

* Not Elsewhere Classified

(continued)

SECTOR DESCRIPTIONS WITH CORRELATIVE LISTING OF SIC CODES
(continued)

Regional Model Sector Number	Sector	SIC
17	Other Transportation	40, 41, 44, 45, 46, 47
18	Communications	48
19	Gas Services	492, 4933, 914, 924, 934
20	Electrical Services	491, 4931, 915, 925, 035
21	Water & Sanitary Services	494, 495, 496, 910, 920, 930
22	Wholesale Farm Products	505, 4731
23	Wholesale Petroleum Products	5092
24	Other Wholesale	501, 504, 508, 502, 503, 506, 507, 509, nec*
25	Lumber Yards, Hardware, etc.	52, 5962, 5969
26	Auto Dealers, Repair, & Service Stations	551, 553, 554, 753, 7542
27	Other Retail	53, 56, 54, 559, 57, 58, 59 exc. 5962 & 5969, 7733
28	Finance, Insurance, Real Estate	60, 61, 62, 63, 64, 65, 66, 67
29	Amusement & Recreation	7816, 7817, 7818, 783, 79
30	Medical Services	80
31	Educational Services	821, 822
32	All Other Services	70, 72, 73, 8921, 7813, 7814, 7815, 782, 739, 751, 752, 76, 81, 82, 86, 84, 8811, 89

* Not Elsewhere Classified

APPENDIX B

INTERDEPENDENCE COEFFICIENTS BIG SPRING-SNYDER AREA
OPEN MODEL

	1	2	3	4	5	6	7	8
1 IRRIGATED CROPS	1.01991	.01056	.05748	.01887	.00002	.00002	.00012	.02753
2 DRYLAND CROPS	.00398	1.01811	.07808	.05335	.00003	.00002	.00028	.04324
3 LIVESTOCK	.00032	.00029	1.12847	.00301	.00020	.00010	.00005	.45067
4 OTHER AGRICUL.	.08491	.07495	.04309	1.16014	.00014	.00009	.00576	.27003
5 CRUDE PETROLEUM	.04015	.03887	.01327	.02040	1.01098	.09857	.00932	.01145
6 OTHER MINING	.00900	.01020	.00328	.00517	.09069	1.06000	.02336	.00200
7 CONSTRUCTION	.00351	.00357	.00299	.00640	.00041	.00160	1.00151	.00247
8 MEATS + DAIRIES	.00025	.00024	.00025	.00043	.00044	.00022	.00008	1.00104
9 MILLING + FEEDS	.00241	.00212	.01038	.03286	.00001	.00001	.00016	.01260
10 FOOD + BEVERAGES	.00028	.00025	.00825	.00232	.00021	.00013	.00006	.00574
11 TEXTILES	.00016	.00015	.00043	.00112	.00005	.00027	.00108	.00059
12 WOOD PRODUCTS	.00086	.00092	.00284	.00274	.00030	.00056	.00326	.00487
13 CHEMICALS	.14543	.17139	.05404	.08087	.00723	.03836	.02920	.04414
14 CEMENT PRODUCTS	.00045	.00382	.00060	.00084	.00053	.00143	.07650	.00053
15 OTHER MANUFACTUR	.00321	.00412	.00273	.00376	.00079	.00531	.01494	.00245
16 LOCAL + LD TRUCK	.00516	.00485	.01137	.01351	.00100	.00378	.01007	.02229
17 OTHER TRANSPORT	.00899	.00960	.00709	.00958	.00321	.00496	.00724	.00532
18 COMMUNICATIONS	.00379	.00397	.00387	.00593	.00137	.00239	.00372	.00554
19 GAS SERVICE	.01493	.00340	.00274	.00500	.00100	.00250	.00203	.00324
20 ELECTRIC SERVICE	.01314	.00695	.00602	.01464	.00386	.00728	.00332	.00844
21 WATER SERVICE	.00040	.00043	.00034	.00075	.00018	.00067	.00059	.00112
22 WHSALE FARM PROD	.00770	.00867	.06230	.05186	.00002	.00001	.00026	.04277
23 WHSALE PETROLEUM	.01078	.01440	.00469	.01037	.00043	.00122	.00157	.00467
24 OTHER WHOLESALE	.00612	.00709	.00426	.00436	.00081	.00445	.00120	.00351
25 LUMBER + HARDWAR	.05087	.05961	.04856	.05634	.00008	.00037	.01203	.03175
26 AUTO + SVC STATN	.02884	.03597	.01683	.02022	.00159	.00641	.00462	.01264
27 OTHER RETAIL	.00048	.00050	.00044	.00206	.00028	.00134	.00160	.00088
28 F.I.R.E.	.01313	.01124	.01718	.01294	.00259	.00501	.01243	.01123
29 AMUSE + RECREATE	.00002	.00002	.00002	.00003	.00016	.00013	.00004	.00002
30 MEDICAL SERVICE	.00002	.00002	.00003	.00002	.00005	.00029	.00003	.00019
31 EDUC SERVICES	.01472	.01426	.01228	.01728	.02815	.01181	.00412	.00986
32 OTHER SERVICES	.00443	.00287	.00274	.00844	.00245	.00597	.00747	.00521
TOTAL DIR/IND REQ	1.49834	1.52340	1.60693	1.62557	1.15926	1.26531	1.23803	2.05005

INTERDEPENDENCE COEFFICIENTS BIG SPRING-SNYDER AREA
OPEN MODEL

	9	10	11	12	13	14	15	16
1 IRRIGATED CROPS	.30969	.04735	.02050	.00050	.00002	.00002	.00002	.00002
2 DRYLAND CROPS	.17791	.02888	.00577	.00129	.00002	.00002	.00001	.00002
3 LIVESTOCK	.00118	.00145	.00220	.00011	.00011	.00007	.00003	.00012
4 OTHER AGRICUL.	.03938	.03420	.00225	.02772	.00019	.00015	.00007	.00012
5 CRUDE PETROLEUM	.02155	.01092	.00272	.00746	.26331	.02176	.00572	.02045
6 OTHER MINING	.00509	.00290	.00057	.00207	.06672	.11830	.00323	.00447
7 CONSTRUCTION	.00207	.00100	.00027	.00230	.00569	.00153	.00090	.00161
8 MEATS + DAIRIES	.00239	.00305	.00007	.00009	.00023	.00016	.00006	.00026
9 MILLING + FEEDS	1.00556	.00594	.00008	.00079	.00001	.00001	.00000	.00001
10 FOOD + BEVERAGES	.00311	1.00624	.00005	.00010	.00012	.00012	.00006	.00013
11 TEXTILES	.00367	.00020	1.02554	.00235	.00019	.00009	.00045	.00020
12 WOOD PRODUCTS	.00208	.00654	.00163	1.02758	.00191	.00358	.00166	.00124
13 CHEMICALS	.07902	.04265	.00762	.02758	1.18237	.01394	.01798	.06954
14 CEMENT PRODUCTS	.00137	.00045	.00010	.00110	.00123	1.06955	.00186	.00020
15 OTHER MANUFACTUR	.00196	.00362	.00209	.00242	.00302	.00158	1.01353	.00563
16 LOCAL + LD TRUCK	.01092	.00889	.00523	.01110	.00442	.01494	.00463	1.01896
17 OTHER TRANSPORT	.01380	.00478	.00148	.00871	.03302	.01120	.00611	.00668
18 COMMUNICATIONS	.00397	.00511	.00247	.00539	.00282	.00450	.00332	.03763
19 GAS SERVICE	.00757	.00288	.00180	.00246	.01596	.01495	.00275	.01005
20 ELECTRIC SERVICE	.01119	.00785	.00590	.00950	.01678	.01415	.00659	.01700
21 WATER SERVICE	.00070	.00093	.00042	.00233	.00122	.00076	.00035	.00089
22 WHSALE FARM PROD	.00712	.00291	.00050	.00134	.00002	.00001	.00001	.00001
23 WHSALE PETROLEUM	.00639	.00158	.00046	.00082	.00090	.00127	.00051	.00607
24 OTHER WHOLESALE	.00414	.00232	.00161	.00327	.00423	.00553	.00657	.00536
25 LUMBER + HARDWAR	.02583	.00545	.00147	.00173	.00016	.00011	.00029	.00039
26 AUTO + SVC STATN	.01564	.00468	.00161	.00224	.00177	.00312	.00147	.01509
27 OTHER RETAIL	.00055	.00078	.00069	.00092	.00061	.00089	.00105	.00033
28 F.I.R.E.	.00724	.00305	.00474	.00454	.00480	.01006	.00261	.03125
29 AMUSE + RECREATE	.00002	.00005	.00004	.00004	.00008	.00008	.00002	.00020
30 MEDICAL SERVICE	.00001	.00015	.00001	.00002	.00004	.00006	.00003	.00004
31 EDUC SERVICES	.00890	.00633	.00371	.00462	.01201	.00915	.00297	.01622
32 OTHER SERVICES	.00626	.00437	.00387	.00772	.00604	.00655	.00342	.01210
TOTAL DIR/IND REQ	1.78627	1.25753	1.10749	1.17021	1.63700	1.32820	1.08829	1.28386

Table B-3 (con't)

INTERDEPENDENCE COEFFICIENTS BIG SPRING-SNYDER AREA
OPEN MODEL

	17	18	19	20	21	22	23	24
1 IRRIGATED CROPS	.00002	.00002	.00004	.00003	.00002	.00025	.00002	.00003
2 DRYLAND CROPS	.00002	.00002	.00004	.00003	.00001	.00058	.00001	.00001
3 LIVESTOCK	.00005	.00013	.00029	.00017	.00003	.00008	.00007	.00006
4 OTHER AGRICUL.	.00010	.00019	.00020	.00018	.00015	.00623	.00012	.00010
5 CRUDE PETROLEUM	.01649	.00261	.60310	.06363	.01910	.00720	.00613	.00469
6 OTHER MINING	.00447	.00054	.05427	.00625	.00844	.00143	.00163	.00121
7 CONSTRUCTION	.00430	.00023	.00072	.00080	.01636	.00620	.00040	.00072
8 MEATS + DAIRIES	.00011	.00029	.00065	.00038	.00005	.00012	.00015	.00013
9 MILLING + FEEDS	.00000	.00001	.00001	.00001	.00000	.00022	.00000	.00000
10 FOOD + BEVERAGES	.00022	.00014	.00031	.00018	.00004	.00007	.00008	.00006
11 TEXTILES	.00025	.00009	.00012	.00026	.00072	.00545	.00014	.00022
12 WOOD PRODUCTS	.00138	.00369	.00042	.00233	.00142	.00153	.00274	.00217
13 CHEMICALS	.04577	.00739	.00842	.01289	.03361	.01731	.02076	.01469
14 CEMENT PRODUCTS	.00585	.00031	.00038	.00071	.04803	.00063	.00019	.00019
15 OTHER MANUFACTUR	.00472	.00059	.00188	.00072	.00179	.00121	.00062	.00079
16 LOCAL + LD TRUCK	.00156	.00095	.00136	.00143	.00176	.01007	.00083	.00290
17 OTHER TRANSPORT	1.01714	.00166	.00281	.00279	.00225	.00487	.01775	.00254
18 COMMUNICATIONS	.00517	1.00270	.00271	.00392	.00292	.01081	.01105	.01161
19 GAS SERVICE	.00381	.00169	1.00753	.10195	.01913	.00578	.00264	.00253
20 ELECTRIC SERVICE	.00811	.00884	.00357	1.00122	.04787	.01312	.00525	.01057
21 WATER SERVICE	.00104	.00085	.00032	.00214	1.06355	.00130	.00047	.00176
22 WHSALE FARM PROD	.00001	.00002	.00003	.00002	.00001	1.01245	.00001	.00004
23 WHSALE PETROLEUM	.00685	.00007	.00047	.00065	.00124	.00094	1.00099	.00119
24 OTHER WHOLESALE	.00349	.00046	.00139	.00182	.00630	.00237	.00037	1.00107
25 LUMBER + HARDWAR	.00045	.00003	.00008	.00028	.00022	.00043	.00003	.00011
26 AUTO + SVC STATN	.00087	.00028	.00321	.01290	.00312	.00416	.00547	.00572
27 OTHER RETAIL	.00110	.00045	.00022	.00010	.00028	.00164	.00198	.00492
28 F.I.R.E.	.01368	.00430	.00469	.00466	.00543	.02457	.00715	.01183
29 AMUSE + RECREATE	.00002	.00019	.00026	.00004	.00002	.00005	.00003	.00005
30 MEDICAL SERVICE	.00002	.00002	.00003	.00001	.00001	.00003	.00001	.00005
31 EDUC SERVICES	.00625	.01850	.04128	.02417	.00271	.00631	.00809	.00527
32 OTHER SERVICES	.00862	.00897	.00454	.00430	.02030	.01141	.01579	.00760
TOTAL DIR/IND REQ	1.16194	1.06628	1.74536	1.25105	1.30690	1.15882	1.11096	1.09483

Table B-3 (con't)

INTERDEPENDENCE COEFFICIENTS BIG SPRING-SNYDER AREA
OPEN MODEL

	25	26	27	28	29	30	31	32
1 IRRIGATED CROPS	.00002	.00001	.00360	.00003	.00005	.00017	.00077	.00019
2 DRYLAND CROPS	.00001	.00001	.00059	.00002	.00003	.00014	.00088	.00008
3 LIVESTOCK	.00006	.00003	.00462	.00012	.00008	.00043	.00700	.00022
4 OTHER AGRICUL.	.00012	.00010	.00346	.00017	.00020	.00105	.00452	.00030
5 CRUDE PETROLEUM	.00616	.00247	.00283	.00260	.00417	.00571	.00411	.00483
6 OTHER MINING	.00124	.00050	.00062	.00064	.00081	.00126	.00069	.00111
7 CONSTRUCTION	.00086	.00053	.00048	.00405	.00288	.00055	.00166	.00202
8 MEATS + DAIRIES	.00013	.00006	.00948	.00026	.00017	.00094	.01556	.00046
9 MILLING + FEEDS	.00000	.00000	.00022	.00001	.00003	.00008	.00025	.00003
10 FOOD + BEVERAGES	.00009	.00005	.00333	.00016	.00015	.00177	.00727	.00067
11 TEXTILES	.00008	.00010	.00280	.00016	.00092	.00135	.00024	.00574
12 WOOD PRODUCTS	.00277	.00289	.00599	.00231	.00455	.00123	.00293	.00484
13 CHEMICALS	.01781	.00576	.00483	.00273	.00795	.01824	.00641	.01520
14 CEMENT PRODUCTS	.00018	.00014	.00015	.00100	.00089	.00061	.00052	.00058
15 OTHER MANUFACTUR	.00068	.00277	.00081	.00027	.00264	.00203	.00176	.00254
16 LOCAL + LD TRUCK	.00370	.00101	.00235	.00042	.00081	.00175	.00369	.00209
17 OTHER TRANSPORT	.00293	.00120	.00142	.00104	.00444	.00209	.00150	.00504
18 COMMUNICATIONS	.01265	.01253	.00899	.00960	.00895	.00645	.00467	.01137
19 GAS SERVICE	.00390	.00204	.00296	.00332	.00408	.00298	.00455	.00258
20 ELECTRIC SERVICE	.01110	.01012	.01297	.01314	.01712	.01008	.01496	.00919
21 WATER SERVICE	.00162	.00136	.00147	.00123	.00267	.00208	.00232	.00176
22 WHSALE FARM PROD	.00001	.00001	.00048	.00002	.00002	.00008	.00069	.00003
23 WHSALE PETROLEUM	.00623	.00038	.00039	.00017	.00052	.00016	.00018	.00109
24 OTHER WHOLESALE	.00379	.00184	.00319	.00142	.00525	.00817	.00238	.00325
25 LUMBER + HARDWAR	1.00136	.00006	.00054	.00007	.00011	.00010	.00056	.00008
26 AUTO + SVC STATN	.00791	1.05590	.00215	.00129	.00512	.00069	.00065	.00351
27 OTHER RETAIL	.00239	.00101	1.00217	.00441	.00424	.00312	.00031	.00709
28 F.I.R.E.	.01285	.01180	.01395	1.02347	.01073	.00886	.00221	.00879
29 AMUSE + RECREATE	.00005	.00002	.00091	.00012	1.00204	.00002	.00006	.00013
30 MEDICAL SERVICE	.00002	.00002	.00027	.00130	.00061	1.00740	.00001	.00002
31 EDUC SERVICES	.00683	.00338	.00662	.01389	.00804	.00371	1.00093	.00564
32 OTHER SERVICES	.00543	.00792	.01153	.01538	.01054	.00982	.00364	1.01661
TOTAL DIR/IND REQ	1.11299	1.12602	1.11618	1.10482	1.11080	1.10310	1.09786	1.11708

Table B-4

INTERDEPENDENCE COEFFICIENTS BIG SPRING-SNYDER AREA
CLOSED MODEL

	1	2	3	4	5	6	7	8
1 IRRIGATED CROPS	1.02126	.01204	.05864	.02006	.00148	.00128	.00116	.02855
2 DRYLAND CROPS	.00483	1.01855	.07895	.05366	.00091	.00078	.00091	.04364
3 LIVESTOCK	.00335	.00330	1.13129	.00490	.00312	.00264	.00213	.45302
4 OTHER AGRICUL.	.08852	.07834	.04641	1.16185	.00338	.00290	.00823	.27225
5 CRUDE PETROLEUM	.04549	.04433	.01750	.02389	1.01568	.10316	.01295	.01553
6 OTHER MINING	.01063	.01185	.00456	.00610	.09197	1.06106	.02494	.00393
7 CONSTRUCTION	.00418	.00426	.00304	.00741	.00089	.00194	1.00191	.00313
8 MEATS + DAIRIES	.00587	.00581	.00469	.00427	.00583	.00490	.00392	1.00629
9 MILLING + FEEDS	.00254	.00225	.01045	.03273	.00014	.00012	.00026	.01234
10 FOOD + BEVERAGES	.00377	.00371	.01091	.00500	.00353	.00300	.00242	.00837
11 TEXTILES	.00227	.00223	.00208	.00308	.00203	.00179	.00252	.00210
12 WOOD PRODUCTS	.00188	.00191	.00381	.00381	.00124	.00115	.00432	.00582
13 CHEMICALS	.16099	.18736	.06685	.09206	.02225	.05177	.04013	.05575
14 CEMENT PRODUCTS	.00102	.00428	.00104	.00124	.00076	.00183	.07661	.00092
15 OTHER MANUFACTUR	.00415	.00524	.00419	.00406	.00175	.00660	.01546	.00300
16 LOCAL + LD TRUCK	.00918	.00920	.01461	.01647	.00547	.00711	.01246	.02495
17 OTHER TRANSPORT	.01323	.01398	.01077	.01234	.00742	.00806	.00968	.00831
18 COMMUNICATIONS	.00952	.00867	.00788	.00991	.00637	.00706	.00675	.00935
19 GAS SERVICE	.01806	.00656	.00510	.00671	.00377	.00511	.00402	.00582
20 ELECTRIC SERVICE	.02242	.01571	.01328	.02050	.01261	.01504	.00932	.01461
21 WATER SERVICE	.00205	.00206	.00163	.00154	.00170	.00153	.00135	.00255
22 WHSALE FARM PROD	.00833	.00892	.06232	.05249	.00037	.00032	.00052	.04349
23 WHSALE PETROLEUM	.01187	.01594	.00583	.01178	.00158	.00240	.00237	.00539
24 OTHER WHOLESALE	.01498	.01603	.01073	.01083	.00878	.01175	.00670	.01002
25 LUMBER + HARDWAR	.05325	.06211	.05023	.05773	.00211	.00185	.01381	.03319
26 AUTO + SVC STATN	.05091	.05711	.03347	.03563	.02225	.02394	.01968	.02803
27 OTHER RETAIL	.06195	.06137	.04903	.04427	.05902	.05253	.04321	.04509
28 F.I.R.E.	.02364	.02171	.02540	.02065	.01237	.01357	.01981	.01898
29 AMUSE + RECREATE	.00051	.00051	.00041	.00036	.00049	.00043	.00035	.00037
30 MEDICAL SERVICE	.01271	.01259	.01006	.00883	.01215	.01060	.00866	.00921
31 EDUC SERVICES	.02168	.02127	.01752	.02232	.03523	.01784	.00871	.01523
32 OTHER SERVICES	.01295	.01099	.00901	.01417	.01083	.01316	.01314	.01127
33 HOUSEHOLDS	.45005	.44573	.35581	.31242	.43053	.37545	.30653	.32577
TOTAL DIR/IND REQ	2.15806	2.17594	2.12752	2.08306	1.78803	1.81266	1.68495	2.52625

Table B-4 (con't)

INTERDEPENDENCE COEFFICIENTS BIG SPRING-SNYDER AREA
CLOSED MODEL

	9	10	11	12	13	14	15	16
1 IRRIGATED CROPS	.31044	.04837	.02097	.00153	.00125	.00118	.00088	.00132
2 DRYLAND CROPS	.17885	.02958	.00602	.00189	.00076	.00072	.00054	.00081
3 LIVESTOCK	.00347	.00322	.00421	.00217	.00257	.00241	.00178	.00273
4 OTHER AGRICUL.	.04204	.03570	.00424	.02975	.00288	.00275	.00201	.00303
5 CRUDE PETROLEUM	.02584	.01416	.00593	.01116	.26832	.02584	.00891	.02560
6 OTHER MINING	.00622	.00354	.00148	.00299	.06849	.11935	.00449	.00591
7 CONSTRUCTION	.00234	.00107	.00059	.00296	.00680	.00198	.00158	.00224
8 MEATS + DAIRIES	.00660	.00635	.00350	.00390	.00477	.00448	.00330	.00509
9 MILLING + FEEDS	1.00526	.00610	.00017	.00087	.00012	.00011	.00008	.00013
10 FOOD + BEVERAGES	.00593	1.00817	.00217	.00245	.00292	.00274	.00203	.00311
11 TEXTILES	.00486	.00130	1.02695	.00362	.00175	.00166	.00123	.00187
12 WOOD PRODUCTS	.00240	.00713	.00185	1.02877	.00235	.00438	.00182	.00251
13 CHEMICALS	.09097	.05195	.01640	.03837	1.19503	.02596	.02672	.08355
14 CEMENT PRODUCTS	.00132	.00061	.00045	.00189	.00133	1.07038	.00267	.00083
15 OTHER MANUFACTUR	.00269	.00426	.00298	.00322	.00406	.00287	1.01403	.00656
16 LOCAL + LD TRUCK	.01405	.01162	.00799	.01385	.00773	.01798	.00673	1.02243
17 OTHER TRANSPORT	.01710	.00730	.00387	.01111	.03684	.01387	.00805	.00991
18 COMMUNICATIONS	.00851	.00798	.00563	.00846	.00756	.00841	.00641	.04222
19 GAS SERVICE	.01034	.00492	.00395	.00473	.01890	.01737	.00487	.01280
20 ELECTRIC SERVICE	.01774	.01313	.01112	.01550	.02450	.02138	.01176	.02520
21 WATER SERVICE	.00157	.00217	.00108	.00345	.00276	.00257	.00105	.00281
22 WHSALE FARM PROD	.00732	.00319	.00055	.00149	.00031	.00029	.00022	.00033
23 WHSALE PETROLEUM	.00696	.00208	.00125	.00142	.00159	.00254	.00096	.00750
24 OTHER WHOLESALE	.01117	.00679	.00656	.00932	.01112	.01168	.01123	.01301
25 LUMBER + HARDWAR	.02760	.00661	.00274	.00284	.00186	.00171	.00128	.00191
26 AUTO + SVC STATN	.03229	.01643	.01514	.01653	.01977	.01995	.01372	.03405
27 OTHER RETAIL	.04868	.03608	.03848	.04279	.05017	.04850	.03651	.05307
28 F.I.R.E.	.01570	.00868	.01101	.01111	.01362	.01802	.00840	.03996
29 AMUSE + RECREATE	.00040	.00029	.00031	.00035	.00042	.00039	.00030	.00044
30 MEDICAL SERVICE	.01000	.00721	.00772	.00859	.01032	.00974	.00731	.01092
31 EDUC SERVICES	.01410	.01044	.00830	.00935	.01831	.01479	.00692	.02221
32 OTHER SERVICES	.01288	.00886	.00860	.01379	.01323	.01330	.00833	.01922
33 HOUSEHOLDS	.35401	.25554	.27331	.30421	.36532	.34486	.25889	.38589
TOTAL DIR/IND REQ	2.29965	1.63083	1.50552	1.61441	2.16774	1.83419	1.46503	1.84926

Table B-4 (con't)

INTERDEPENDENCE COEFFICIENTS BIG SPRING-SNYDER AREA
CLOSED MODEL

	17	18	19	20	21	22	23	24
1 IRRIGATED CROPS	.00139	.00123	.00138	.00135	.00150	.00160	.00154	.00159
2 DRYLAND CROPS	.00085	.00076	.00085	.00083	.00091	.00115	.00094	.00096
3 LIVESTOCK	.00283	.00257	.00299	.00283	.00299	.00288	.00312	.00319
4 OTHER AGRICUL.	.00318	.00288	.00319	.00313	.00344	.00910	.00350	.00359
5 CRUDE PETROLEUM	.02103	.00716	.60824	.06851	.02415	.01222	.01149	.01018
6 OTHER MINING	.00634	.00184	.05558	.00763	.00990	.00294	.00294	.00267
7 CONSTRUCTION	.00507	.00071	.00085	.00182	.01702	.00705	.00096	.00194
8 MEATS + DAIRIES	.00524	.00479	.00563	.00530	.00552	.00529	.00579	.00592
9 MILLING + FEEDS	.00013	.00012	.00014	.00013	.00014	.00030	.00015	.00015
10 FOOD + BEVERAGES	.00322	.00292	.00338	.00321	.00342	.00327	.00356	.00363
11 TEXTILES	.00197	.00174	.00189	.00186	.00326	.00720	.00220	.00222
12 WOOD PRODUCTS	.00232	.00415	.00123	.00325	.00269	.00238	.00343	.00345
13 CHEMICALS	.05962	.02020	.02217	.02692	.04896	.03202	.03594	.03117
14 CEMENT PRODUCTS	.00645	.00060	.00068	.00079	.04856	.00119	.00078	.00089
15 OTHER MANUFACTUR	.00549	.00109	.00254	.00139	.00278	.00245	.00145	.00242
16 LOCAL + LD TRUCK	.00525	.00454	.00574	.00508	.00625	.01347	.00544	.00755
17 OTHER TRANSPORT	1.02048	.00453	.00688	.00630	.00566	.00855	.02197	.00670
18 COMMUNICATIONS	.00934	1.00642	.00769	.00823	.00805	.01581	.01569	.01682
19 GAS SERVICE	.00654	.00463	1.01061	.10494	.02195	.00880	.00607	.00570
20 ELECTRIC SERVICE	.01641	.01565	.01185	1.00894	.05695	.02146	.01374	.01992
21 WATER SERVICE	.00275	.00251	.00163	.00371	1.06573	.00277	.00182	.00397
22 WHSALE FARM PROD	.00034	.00031	.00035	.00034	.00036	1.01276	.00038	.00039
23 WHSALE PETROLEUM	.00854	.00124	.00144	.00236	.00270	.00258	1.00267	.00261
24 OTHER WHOLESALE	.01124	.00707	.00908	.00986	.01429	.01027	.00892	1.01010
25 LUMBER + HARDWAR	.00205	.00177	.00197	.00194	.00233	.00239	.00220	.00227
26 AUTO + SVC STATN	.01996	.01740	.02226	.03187	.02420	.02355	.02703	.02769
27 OTHER RETAIL	.05718	.04928	.05465	.05377	.05996	.05770	.06378	.06835
28 F.I.R.E.	.02333	.01245	.01386	.01382	.01558	.03400	.01695	.02219
29 AMUSE + RECREATE	.00047	.00041	.00045	.00045	.00050	.00047	.00052	.00053
30 MEDICAL SERVICE	.01157	.01015	.01125	.01108	.01232	.01167	.01272	.01305
31 EDUC SERVICES	.01304	.02433	.04769	.03089	.00981	.01330	.01521	.01246
32 OTHER SERVICES	.01674	.01617	.01241	.01134	.02867	.01899	.02429	.01642
33 HOUSEHOLDS	.40932	.35961	.39863	.39248	.43629	.41280	.45041	.46212
TOTAL DIR/IND REQ	1.75969	1.59123	2.32919	1.82638	1.94684	1.76238	1.76758	1.77284

INTERDEPENDENCE COEFFICIENTS BIG SPRING-SNYDER AREA
CLOSED MODEL

	25	26	27	28	29	30	31	32
1 IRRIGATED CROPS	.00149	.00159	.00480	.00158	.00144	.00171	.00235	.00157
2 DRYLAND CROPS	.00090	.00097	.00129	.00096	.00087	.00110	.00183	.00091
3 LIVESTOCK	.00301	.00320	.00669	.00324	.00288	.00357	.01000	.00286
4 OTHER AGRICUL.	.00339	.00363	.00585	.00363	.00330	.00498	.00797	.00331
5 CRUDE PETROLEUM	.01103	.00811	.00693	.00827	.00907	.01115	.00983	.00955
6 OTHER MINING	.00277	.00213	.00174	.00223	.00225	.00280	.00238	.00252
7 CONSTRUCTION	.00190	.00087	.00079	.00493	.00386	.00093	.00290	.00288
8 MEATS + DAIRIES	.00559	.00592	.01390	.00602	.00533	.00678	.02102	.00530
9 MILLING + FEEDS	.00014	.00015	.00026	.00015	.00014	.00020	.00038	.00014
10 FOOD + BEVERAGES	.00343	.00365	.00606	.00368	.00327	.00558	.01081	.00425
11 TEXTILES	.00208	.00224	.00493	.00225	.00304	.00321	.00226	.00716
12 WOOD PRODUCTS	.00339	.00460	.00739	.00350	.00541	.00238	.00451	.00543
13 CHEMICALS	.03273	.02194	.01742	.01924	.02263	.03332	.02299	.02968
14 CEMENT PRODUCTS	.00081	.00077	.00065	.00214	.00098	.00079	.00097	.00091
15 OTHER MANUFACTUR	.00237	.00456	.00220	.00142	.00334	.00341	.00348	.00335
16 LOCAL + LD TRUCK	.00733	.00558	.00600	.00451	.00511	.00549	.00801	.00615
17 OTHER TRANSPORT	.00663	.00550	.00473	.00537	.00815	.00566	.00561	.00834
18 COMMUNICATIONS	.01762	.01836	.01293	.01482	.01329	.01167	.00981	.01632
19 GAS SERVICE	.00657	.00556	.00523	.00678	.00690	.00656	.00806	.00517
20 ELECTRIC SERVICE	.01947	.01923	.02026	.02188	.02497	.01874	.02385	.01704
21 WATER SERVICE	.00282	.00296	.00262	.00293	.00382	.00395	.00400	.00380
22 WHSALE FARM PROD	.00036	.00039	.00074	.00039	.00035	.00048	.00106	.00035
23 WHSALE PETROLEUM	.00754	.00161	.00139	.00159	.00146	.00158	.00172	.00246
24 OTHER WHOLESALE	.01259	.01125	.01052	.01004	.01318	.01696	.01134	.01113
25 LUMBER + HARDWAR	1.00314	.00228	.00231	.00230	.00206	.00231	.00285	.00205
26 AUTO + SVC STATN	.02856	1.07855	.02072	.02334	.02433	.02195	.02323	.02308
27 OTHER RETAIL	.06169	.06510	1.05390	.06708	.06058	.06501	.06500	.06320
28 F.I.R.E.	.02267	.02270	.02240	1.03329	.02012	.01889	.01325	.01808
29 AMUSE + RECREATE	.00050	.00053	.00143	.00053	1.00248	.00052	.00054	.00047
30 MEDICAL SERVICE	.01230	.01320	.01068	.01400	.01265	1.01981	.01340	.01156
31 EDUC SERVICES	.01416	.01051	.01316	.02149	.01475	.01124	1.00861	.01263
32 OTHER SERVICES	.01400	.01675	.01888	.02353	.01856	.01821	.01236	1.02461
33 HOUSEHOLDS	.43526	.46725	.37804	.45949	.41227	.45198	.47468	.40934
TOTAL DIR/IND REQ	1.74824	1.81164	1.66688	1.77660	1.71282	1.76292	1.79105	1.71560

Table B-4 (con't)

INTERDEPENDENCE COEFFICIENTS BIG SPRING-SNYDER AREA
CLOSED MODEL

	33
1 IRRIGATED CROPS	.00405
2 DRYLAND CROPS	.00246
3 LIVESTOCK	.00815
4 OTHER AGRICUL.	.00905
5 CRUDE PETROLEUM	.01417
6 OTHER MINING	.00428
7 CONSTRUCTION	.00187
8 MEATS + DAIRIES	.01505
9 MILLING + FEEDS	.00038
10 FOOD + BEVERAGES	.00927
11 TEXTILES	.00560
12 WOOD PRODUCTS	.00306
13 CHEMICALS	.04159
14 CEMENT PRODUCTS	.00173
15 OTHER MANUFACTUR	.00330
16 LOCAL + LD TRUCK	.01120
17 OTHER TRANSPORT	.01057
18 COMMUNICATIONS	.01358
19 GAS SERVICE	.00847
20 ELECTRIC SERVICE	.02338
21 WATER SERVICE	.00448
22 WHSALE FARM PROD	.00098
23 WHSALE PETROLEUM	.00402
24 OTHER WHOLESALE	.02310
25 LUMBER + HARDWAR	.00584
26 AUTO + SVC STATN	.05737
27 OTHER RETAIL	.15402
28 F.I.R.E.	.02696
29 AMUSE + RECREATE	.00137
30 MEDICAL SERVICE	.03384
31 EDUC SERVICES	.01941
32 OTHER SERVICES	.02246
33 HOUSEHOLDS	1.19911
TOTAL DIR/IND REQ	1.75415