HIGH PLAINS-OGALLALA AQUIFER STUDY

ROOSEVELT COUNTY, NEW MEXICO*

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PARTIAL TECHNICAL COMPLETION REPORT

Project Nos. WRRI 1423697 and 1345681

New Mexico Water Resources Research Institute
in cooperation with
Department of Agricultural Economics and
Agricultural Experiment Station, NMSU;

Department of Economics, UNM;

New Mexico State Engineer Office;

and

New Mexico Energy and Minerals Department

June 1982

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* The work upon which this publication is based was supported in part by funds provided by the Economic Development Administration, U.S. Department of Commerce, through the High Plains Associates and the New Mexico Water Resources Research Institute under Contract Number CO-A01-78-00-2550. Project Numbers: 1423697 and 1345681.

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ACKNOWLEDGEMENTS

This study was part of an interdisciplinary research project entitled, "Six-State High Plains Ogallala Aquifer Regional Resources Study," funded by the U.S. Department of Commerce through the High Plains Associates and New Mexico Water Resources Research Institute, New Mexico Interstate Stream Commission, and New Mexico Energy and Minerals Department.

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David P. Hale and Carl Slingerland of the New Mexico Interstate Stream Commission served as coordinators, under the direction of S. E. Reynolds, 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 formulation of the analysis. They included representatives from the High Plains Associates: Camp, Dresser, and McKee (Harvey O. Banks, Jean Williams, and Joe D. Harris); Arthur D. Little, Inc. (Richard Feeley, David Land, Russell Fries, and Rufus Perkins); and Black and Veatch (Charles L. Banning and Carl A. Vansant).

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Special thanks are also due to Kristi Spence, Luz Cadena, and Becky May for efficiently and expertly typing the many manuscripts and to Linda Harris for her able assistance in editing the manuscripts. Needless to say, errors remaining, either in logic or numerical content of this analysis, are attributable to the authors.

ABSTRACT

New Mexico participated with five High Plains states and the High Plains Associates in the Six-State High Plains-Ogallala Aquifer Area Study. The purpose of the study was to estimate the economic impacts over a 40-year planning horizon resulting from rapidly rising energy costs and the declining Ogallala aquifer water tables in Roosevelt County.

Four management strategies including a baseline, voluntary water conservation, mandatory irrigation water supply reduction, and interstate importation were evaluated.

For the baseline, the total gross output of all goods and services for Roosevelt County was about $119 million in 1977. It is projected to be $154 million in 1985, $192 million in 1990, $235 million in 2000, and $251 million in 2020. The differences in gross output among the management strategies are due to changes in the agricultural sectors.

The most important sector is agriculture which contributed about 63 percent of the total output in 1977. Even though the other sectors are projected to expand, agriculture is projected to contribute about 47 percent of the total in 2020.

The mining sectors are projected to have a small economic impact, increasing from about $4 million in 1977 to about $18 million in 2020. The trade sector is expected to expand faster than any of the other sectors, increasing from $9 million in 1977 to almost $25 million in 2020. The manufacturing sectors are projected to also increase from $9 million in 1977 to about $24 million in 2020.

The total employment in Roosevelt County in 1977 was 1,967 and is expected to increase to 3,151 by 1990 then decrease to 2,491 by 2020. Trade was the largest employer in 1977 throughout the period accounting for about 28 percent of the total in 1977, 31 percent in 1990, and 22 percent in 2020.

The alternative management strategies basically had very little impact on the economy of Roosevelt County. The voluntary strategy results in total output in 2020 of $12,000 more than the baseline. Under the mandatory strategy, output is $1.226 million more than under the baseline, and under the importation strategy output is $2.232 million more than the baseline. The impact on employment of the alternative management strategies in Roosevelt County is also minor. The voluntary strategy results in 41 more jobs than the baseline in 2020. The mandatory strategy is projected to have 37 more jobs than under the baseline and the importation strategy to have 117 more than under the baseline. Population in the county is projected to be affected in a similar manner as employment under the alternative strategies. Voluntary is projected to result in 142 more people than under the baseline in 2020, mandatory 120 more people than under the baseline, and under importation 363 more people than under the baseline in 2020.

KEYWORDS: *High Plains, *Ogallala Aquifer, *Roosevelt County, *New Mexico, *management strategies, energy, water resources, on-farm impacts, regional impacts, gross output, employment, population, economic projections, resources, interdisciplinary.

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INTRODUCTION

A large part of eastern New Mexico is situated in the High Plains, a somewhat homogenous region extending over large areas of Colorado, Kansas, Nebraska, New Mexico, Oklahoma and Texas (Figure 1). Discovery and subsequent exploitation of extensive ground water resources in the region, primarily from the Ogallala Formation, have generated dramatic economic growth. This growth has exerted greater and greater demand on ground water supplies. Water levels have declined and some irrigated areas have gone out of production. As a result, the area's economic activities that depend on irrigated agriculture are threatened due to the rapidly rising energy costs and the declining water tables. If significant areas were to be forced out of irrigated production in the New Mexico High Plains, the economy of the entire state could be adversely affected. In response to these concerns, New Mexico, five other High Plains states, and the High Plains Associates (general contractor) participated in the Six-State High Plains-Ogallala Aquifer Area Study.

The general purpose of this study was to estimate the economic impacts over a 40-year planning horizon on regional income and employment, population, irrigated and dryland cropping patterns, agricultural output, and farm income. The impacts were measured under alternative sets of assumptions regarding public policy, water and energy costs and availability, and irrigation management practices.

The ground water irrigated acreage of the High Plains region represents about 35 percent of the irrigated acreage in New Mexico (Lansford, et al., November 1981) and accounts for about one-third of the cash receipts from crop sales in the state.

Irrigation has been a fairly recent development in Roosevelt County. For example, in Roosevelt County irrigated cropland increased from 10,870 to 138,240 acres from 1940 to 1980 (Lansford, et al., September 1982). However, parts of Roosevelt County already have felt the effects of a declining water supply and rising energy costs. As a result, some irrigated cropland has been abandoned.

This report presents an in-depth look at the water, energy, and related resources in Roosevelt County, New Mexico, which is a part of the High Plains-Ogallala Aquifer Study region in New Mexico. Other re-

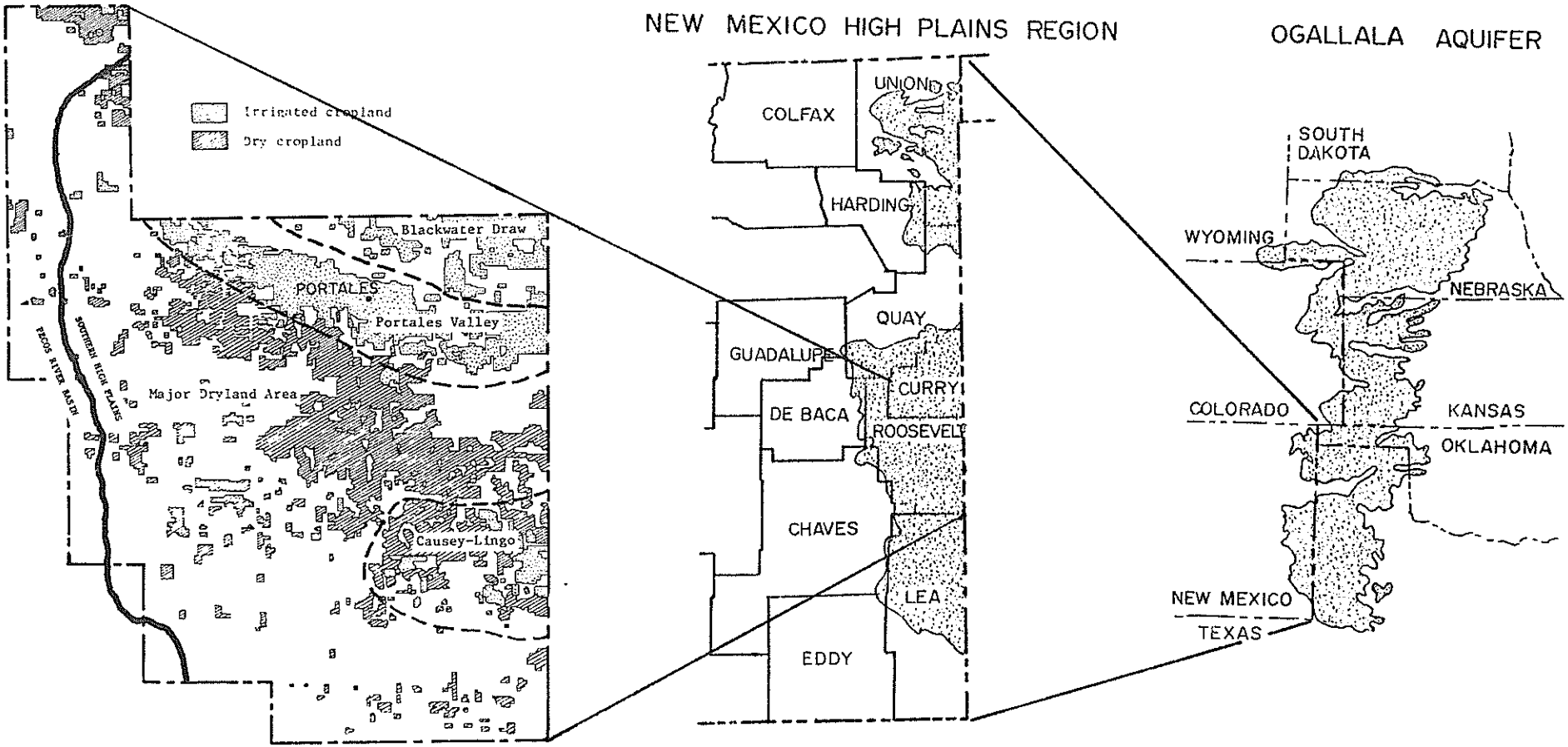

Figure 1. Ogallala Aquifer Region and New Mexico.

ports have been prepared for Lea County, Curry County, Quay County, Union and Harding counties, and for the New Mexico region (WRRI Reports 147 through 151).

MANAGEMENT STRATEGIES

Four management strategies, including a baseline, were evaluated: voluntary water conservation (Alternative Management Strategy 1); mandatory irrigation water supply reduction (Alternative Management Strategy 2); and importation, supply augmentation for those areas that physically exhaust their water supply under Alternative Strategy 1 (Alternative Management Strategy 5A). Management Strategy 3, local supply augmentation, and Management Strategy 4, intrastate transfers, were not evaluated for New Mexico.

Baseline

The baseline is defined as "no new public action or deliberate change--continuation of current trends in water and agricultural management in both public and private sectors." It was consistently assumed that under the baseline neither states nor the federal government would initiate new policies or programs to reduce demands on the Ogallala aquifer or other resources. Neither would they augment the water supply during the study period. It was further assumed that current trends in public and private sector resource demand and supply management would continue throughout the study period. Only those changes in resource management already underway and anticipated to continue as rational economic behavior would be considered to influence long-term baseline projections. Under the baseline, the continuation of present trends in water conservation is expected to result in water savings of about 10 percent on sprinkler-irrigated lands over the study period. It was assumed that there would be no reductions in water applications for furrow irrigated cropland.

Voluntary Irrigation Water Conservation

This alternative adds to the baseline by assuming incentives will be provided for technological change and improved water and agricultural management practices at the farm level. This alternative assumes an accelerated adoption rate of new and promising technologies. The changes in irrigation water and farm management practices are expected to occur through research and development, extension and education, and finally adoption of improved technology, improved farming practices, and improved plant varieties. The area of improved technology probably would include improved water conveyance and application systems. Improved farming practices would include techniques such as irrigation scheduling and evaporation reduction farming methods. Plant varieties might be adapted, through genetic research, to produce the same amount, only requiring less water. Operationally, this strategy is defined for two major irrigation systems: sprinkler and furrow.

Sprinkler water applications would be decreased by an additional 1.2 percent in 1985. There would be a 3 percent reduction in water applications in 1990, an additional 4 percent reduction in 2000, and an additional 5 percent reduction in 2020 for a total reduction of 12 percent from 1990 through 2020.

There would be a 4 percent reduction in water applications for furrow irrigation in 1985, an additional 5 percent reduction in 1990, an additional 6 percent reduction in 2000, and an additional 6 percent reduction in 2020 due to incentive programs and expanded research.

Mandatory Irrigation Water Supply Reduction

The mandatory strategy builds upon the voluntary strategy by adding mandatory water supply management. This strategy encompasses institutional/regulatory changes requiring water conservation, improved water and agricultural management practices at the farm level, and/or restrictions on new irrigated agricultural developments.

This strategy requires the supply of irrigation water to be reduced below what would be available under the voluntary strategy. Water supplies would be required to be reduced by 10 percent below the irriga-

tion water applications in the voluntary strategy by 1985, by 20 percent by 1990, and by 30 percent by 2000.

Importation (Supply Augmentation)

Irrigation water would be imported to fully supply those lands that physically exhaust their natural water supply. The irrigation water would be available in the year 2000 and be applied in a manner consistent with the voluntary strategy technology.

GENERAL DESCRIPTION

Roosevelt County, New Mexico, lies in eastern New Mexico (Figure 1). It is located on the Southern High Plains of the Llano Estacado. The only streamflows are those that flow following thunderstorms. The area slopes gently to the east and southeast, and with few exceptions is remarkably smooth.

Roosevelt County (Figure 1) lies partly in two major river basins: Pecos River, 334 square miles; and Texas Gulf Basin, 2,123 square miles.

The Texas Gulf Basin is also known as the "Llano Estacado" or Southern High Plains. The western edge of the Southern High Plains extends from north to south throughout the county and is located near the western border. The average elevation along the western edge is about 4,600 feet (MSL) and the plains slope to about 4,100 feet to the east along the New Mexico-Texas state line. The remaining area in the county drains towards the Pecos River and is part of the Pecos River Basin in the state (see Figure 1).

The landscape of Roosevelt County consists of rolling plains, sand hills, and scattered playa lakes. The caprock which defines much of the western edge of the Southern High Plains is poorly exposed and surface drainage is indefinite throughout the county. Extensive sandhills and dunes are located along Blackwater Draw in the northern part. The highest elevation is about 4,700 feet in the southwest corner near Elida and the lowest elevation is approximately 3,850 feet in the vicinity of the salt lakes near Arch. Surface water supplies are confined to a few water table ponds and intermittent storage after rainstorms in the playa

lakes. Water in the larger playas (Salt Lake, Little Salt Lake, and Lewiston Lake) has a high content of saline materials.

All of the county is in the Upper Sonoran Life Zone. Some oak shinnery is found in the southern part; otherwise, most of the vegetation consists of grasslands interspersed with irrigated lands in the vicinity of Portales.

Climate

Roosevelt County experiences a semiarid climate characterized by clear and sunny days, large diurnal temperature ranges, low humidity, and moderately low rainfall. The mean annual precipitation averages about 16 inches. The hot summer months are normally the wettest. Occasionally, thunderstorms are accompanied by hail which may damage crops and property. The average snowfall is light and the snows usually melt within a few days after occurrence. Moderate winds prevail most of the year and strong winds are common from January to May.

Temperatures in the area average about 58 degrees Fahrenheit. Winters are usually mild and dry, and temperatures above 100 degrees Fahrenheit are not uncommon in the summer months. The growing season usually begins in early April and lasts 182 to 190 days, ending in late October.

Land

Roosevelt County consists of approximately 1.6 million acres of land. About 3 percent of the land is under federal ownership, 13 percent under state ownership, and 84 percent is privately owned. Approximately 66 percent of the land in Roosevelt County is rangeland used for grazing and 30 percent is cropland (7 percent is irrigated and 23 percent dryland). Urban and urban fringe areas, roads, defense, parks, and fish and wildlife refuges comprise about 1 percent each of the county land. The remainder of the land includes 3,243 acres of inland water (NMISC, 1975).

Hydrology

The Ogallala Formation overlies much of the area in Roosevelt County (see Figure 1); however, water used for irrigation in the Portales Valley is obtained from the Quaternary Valley fill deposited by an ancient river that was beheaded by the Pecos River. Apparently, this was a major stream having the present course of the plains to the present course of the Double Mountain Fork of the Brazos River in Texas. Elsewhere, water of relatively poor quality has been obtained locally, in small quantities, from some sand in the Triassic red beds, and in some localities a portion of the water may be derived from sand and gravel in the Ogallala and Cretaceous formations.

Causey-Lingo Area, Roosevelt County

The principle water-bearing formation in the Causey-Lingo area is encountered below the base of the Ogallala Formation and is composed of unconsolidated sand and gravel of Cretaceous age which occurs in erosion channels cut into underlying red beds of Triassic age. The aquifer of the Cretaceous rocks is continuous with the lower part of the Ogallala Formation, which generally has only a few feet of saturation in the area and yields only small quantities of water to wells. Irrigation development by ground water began in this area about 1946 with major development of irrigated farms in 1954.

As of January 1975, the depth-to-water in this area ranged from 60 to over 175 feet, with an average of 70 feet from the land surface. The saturated thickness of the water-bearing aquifer ranged from 20 to 100 feet, with an average of approximately 50 feet. Irrigation wells yield up to 500 gallons per minute. Wells of 1,000 gallons per minute are not uncommon and 1,300 gallons per minute is the approximate upper limit. The specific well yield is approximately 15 gallons per minute per foot of drawdown. The pumping lift is approximately 140 feet.

Water level measurements have been maintained in this area by the U.S. Geological Survey since 1956 and reported by the State Engineer in the report series, "Water Levels in New Mexico." Irrigation well 6S 36E 9.143 was selected as being representative of the ground water response

in this general area. In 1956, the depth-to-water in this well was reported as 86.95 feet, and in 1975 the depth-to-water was 108.38 feet.

The water level fluctuates with some years indicating an increase in the water level. The general decline is 1.13 feet per year.

Portales and Blackwater Draw Area, Roosevelt County

The Portales Valley is a broad and shallow impression ranging from 20 to 30 miles wide and extends about 50 miles long. A strip of sand dunes extends almost the entire length of the valley on its north side.

The Portales Valley has been eroded into and, in some places, through the Ogallala Formation. Material from the Ogallala Formation derived during the forming of the valley was reworked and redeposited in the valley. The reworked material is similar to the parent material. The main aquifer in this area is the sand and gravel strata in the redeposited valley (Berkstresser, 1956).

Large-scale irrigation development began in the Portales Valley in 1910. Irrigation increased again about 1925. Development of ground water for irrigation continued to expand and on May 1, 1950, the State Engineer declared the Portales Underground Water Basin. The area of the declared basin was extended on July 18, 1955, and redivided on November 3, 1955. It presently includes a total of 628 square miles.

As of January 1976, the depth-to-water in this area ranged from 30 to over 150 feet, with an average of 70 feet from the land surface. The saturated thickness of the Ogallala ranged from 50 to 150 feet, with an average of approximately 100 feet. Typical irrigation wells may have capacities of 350 gallons per minute up to 800 gallons per minute for newer sprinkler systems. Specific well yields of 40 gallons per minute per foot of drawdown would be typical. The pumping head is comprised of the depth-to-water from the land surface, plus the drawdown, plus any head that is to be delivered to the irrigation system, such as a sprinkler. Presently, the pumping head for a typical gravity flow system is approximately 80 to 90 feet in this area.

Water level measurements have been maintained by the U.S. Geological Survey since 1948 and reported by the State Engineer in the report series, "Water Levels in New Mexico." Irrigation well 1N 32E 34.333 was

selected as being representative of the ground water response in this general area. In 1948, the depth-to-water in this well was reported as 42.88 feet, and in 1976 the depth-to-water was 71.34 feet, with a general decline over the intervening years. The general rate of decline is approximately 1.67 feet per year.

The principle source of recharge to the Ogallala Formation is precipitation and infiltration into the aquifer. There is some discharge of ground water by natural means, such as through springs and seeps along the escarpments and evaporation and transpiration; however, these are probably quite small in relation to the amount of water removed from the aquifer by pumping.

The amount and rate of recharge from precipitation depend on the amount of moisture in the soil when rain or snowmelt begins and the temperature, vegetative cover, and permeability of the materials at the site of infiltration. Because of the wide variations in these factors and because of the lack of data, it is difficult to estimate the amount of recharge to the ground water reservoir. An unknown amount of water pumped from the Ogallala Formation for irrigation percolates back to the aquifer. This water does not constitute an addition to the water supply, but only a reduction in net discharge. The average annual recharge is estimated to be only a fraction of an inch.

Water Quality

The water is typically hard and has an objectionably high concentration of fluoride in many areas. The hardness, in addition to a high concentration of silica, makes it somewhat objectionable for domestic and many industrial uses. Except possibly in the vicinity of the playa lakes and in local areas where the ground water may have been contaminated by seepage from brine disposal pits (Ash, 1961, 1963, sheet 2), the water is satisfactory for irrigation. Only the excessive flouride content makes it objectionable for public supply.

Water Use

Ground water from the Ogallala and associated formations in Roosevelt County is used for irrigation, public supply, industrial supply, and domestic and stock purposes.

Water Rights Administration

Part of the northern portion of the county is within the Portales and Fort Sumner Underground Water Basin as declared by the State Engineer. Permits from the State Engineer are necessary prior to drilling wells within the boundaries of the declared basins. No permit is required to drill wells in the portion of the county outside the declared basins (see Figure 2).

Energy

All of the energy production in the High Plains of New Mexico is located in Lea and Roosevelt counties. Lea County accounts for about 90 to 95 percent of all energy produced in New Mexico's High Plains and Roosevelt County accounts for the remaining 5 percent.

Electricity

There is no electricity generation in Roosevelt County.

Oil Production

The Permian Basin of southeast New Mexico and west Texas has long been one of the major oil-producing provinces in the nation. There are four oil and gas producing counties (Chaves, Eddy, Lea, and Roosevelt) in southeastern New Mexico. Two of the four, Lea and Roosevelt counties, are in the High Plains study area. Since the Permian Basin has been producing oil and gas since the 1920s, the future discovery rate in both Lea and Roosevelt counties is expected to be more modest than in the past. However, the degree to which crude oil and casinghead gas

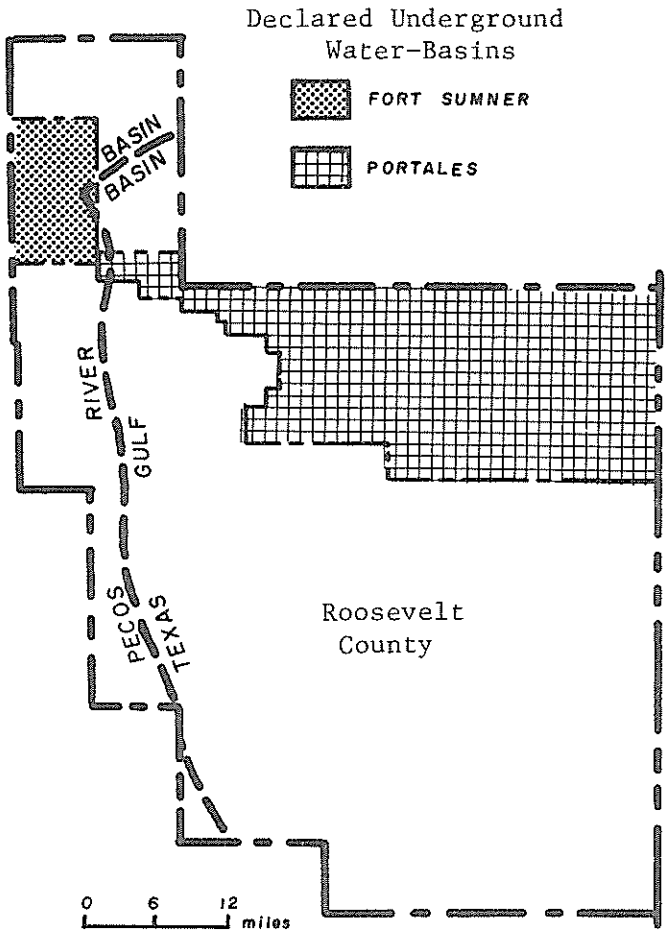

Figure 2. Declared Underground Water Basins in New Mexico.

production continues to decline also depends upon a number of exogenous factors ranging from technological to economic aspects of production. The uncertainty of such factors causes production projections beyond 10 years to be highly speculative.

In 1980, Roosevelt County produced only about 3 percent of the oil and condensate and 5 percent of the natural gas in the New Mexico High Plains study area. The historical crude oil production and casinghead gas is shown in Table 1. The general trend in crude oil and casinghead gas production has declined over the period from 1969 through 1980 with a slight increase in the early 1970s.

Dry Gas Production

Historically, Roosevelt County has been primarily an oil-producing province. Only recently has there been a major effort in dry gas exploration. The main area of exploration has been in southern Roosevelt County. The Atoka and Morrow formations are the main produc-

Table 1. Annual Historical Crude Oil, Casinghead Gas, and Dry Gas Production in Roosevelt County, New Mexico, 1969-1980.

Year	Crude Oil (millions of barrels)	Casinghead Gas (billions of cubic feet)	Dry Gas (billions of cubic feet)
1969	3.97	6.30	1.32
1970	5.84	9.58	1.47
1971	4.20	14.97	1.07
1972	2.28	9.83	1.28
1973	1.61	6.56	1.14
1974	1.36	4.94	0.90
1975	1.22	3.63	0.97
1976	1.33	4.15	1.54
1977	1.24	3.87	1.52
1978	1.29	2.33	1.57
1979	1.69	2.33	1.27
1980	1.50	2.25	1.77

ing horizons and as a general rule produce a rather high daily rate of gas. However, wells producing from these formations normally have relatively short production periods (seven-year average) compared to an average life of 35 years in northwest New Mexico's San Juan Basin.

During the last 12 years, more than 99 percent of the dry gas production from the High Plains study area has come from Lea County with less than 1 percent produced in Roosevelt County (Miller and Hill, 1979).

During the 1970s, dry gas production fluctuated yearly, making it difficult to detect any general trends (Table 1). For example, the production levels in 1971, 1974, and 1979 were lower than the previous year's production level. In all other years, production had shown an increase. The completion of several additional wells could have the effect of increasing total production 10 percent or more. Due to the characteristics of this type of gas production, projections are extremely difficult to make.

Agriculture

Roosevelt County is an important agricultural area in New Mexico. In 1977, it accounted for about 10 percent of the total irrigated acreage, about 27 percent of the total dryland crop acreage, and about 11 percent of the cash receipts from crop sales. The important irrigated crops in Roosevelt County were corn, grain sorghum, cotton, and wheat. According to 1977 published data, these four crops accounted for 80 percent of the irrigated acreage and 40 percent of the total cash receipts from crops in Roosevelt County (New Mexico Crop and Livestock Reporting Service, 1978). The important dryland crops in 1977 were grain sorghum, cotton, and wheat (Lansford, 1980). These three crops accounted for about 91 percent of the dry cropland acreage and 23 percent of the total cash receipts from crops in 1977.

OGALLALA HIGH PLAINS MODEL AND COMPONENTS

The purpose of this study was to estimate the economic impacts over a 40-year planning horizon on regional income, employment, population, irrigated and dryland cropping patterns, agricultural output, farm income, and energy production. The impacts were measured under alternative sets of assumptions regarding public policy, water and energy costs and availability, and irrigation management practices.

An interdisciplinary approach to the solution of the water resource problems of the High Plains region in New Mexico was made possible by integrating hydrology, geology, and engineering with economics. Research procedures developed to carry out this study were closely coordinated by the investigators to achieve the stated objectives. Inputs into the economic models were obtained from separate studies covering the hydrological, agricultural, and energy areas.

Assumptions concerning regional economic impacts, employment, population, crop yields, commodity prices, energy prices, input prices, and energy production were developed cooperatively among the six states and the general contractor. All states used basically the same assumptions for compatibility. A detailed description and discussion of the methodology for the separate area studies are presented in WRRI Report 151.

RESULTS

Results are presented for the Roosevelt County economic impacts and key resources by management strategy for selected years (1977, 1985, 1990, 2000, and 2020).

Because of the varying farm size, cropping patterns, and depths of pumping, the irrigated cropland in Roosevelt County was divided into four areas: Portales Valley East and West; Causey-Lingo; and Blackwater Draw area (Figure 1). The Portales Valley has about 80,000 acres of irrigated cropland, the Causey-Lingo area encompasses about 11,000 acres of irrigated cropland, and the Blackwater Draw and other scattered areas include the remaining 47,200 acres of irrigated cropland.

Water Resources

Projected withdrawals for irrigation, urban, rural, manufacturing, minerals, and livestock and recreational uses are presented in Table 2. Table 2 also shows projections for depth-to-water (ground surface to water table), and the remaining saturated thickness of the Ogallala Formation for the years 1977, 1985, 1990, 2000, and 2020 by subregion in Roosevelt County. The base year for all projections is 1977.

Other than areas of future agricultural and urban uses, there is little possibility of reducing water demand in Roosevelt County through voluntary or mandatory strategies. This does not mean conservation should be abandoned in all areas of water use. However, the use of water by irrigated agriculture (about 97 percent of the total ground water withdrawals) overshadows all other uses.

For these reasons, the only changes in the voluntary strategy projection and in the mandatory strategy projection (Table 2) from quantities shown in the baseline projection are for "irrigation" and "urban." Water requirements for other water-use categories are the same in all projections.

Other than irrigation and urban, the only significant increases in water demand are the amounts projected for "minerals." Most of this water is now used for secondary oil recovery and is expected to increase in the future. The projected amounts were reviewed and concurred with by personnel of the New Mexico Energy and Minerals Division.

Table 2. Estimated Withdrawals, Depth-to-Water, and Remaining Saturated Thickness of Ogallala Aquifer, Roosevelt County, New Mexico, 1977-2020.

Strategy and Category	Year 1977	1985	1990	2000	2020
Baseline					
Withdrawals (1,000 acre-ft.)					
Irrigation	(220.9)	(221.8)	(210.6)	(205.4)	(53.3)
Causey-Lingo	13.2	9.0	7.6	5.4	0.0
Portales-West	80.8	83.9	85.7	84.9	0.0
Portales-East	53.3	55.0	57.5	56.8	0.0
Blackwater-Draw	73.6	73.9	59.8	58.3	53.3
Urban	3.8	4.0	4.1	14.9	18.9
Rural	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Designated Areas*	0.1	0.1	0.1	0.1	0.1
Nondesignated Areas**	0.1	0.1	0.1	0.1	0.1
Manufacturing	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)
Designated Areas*	0.1	0.1	0.1	0.1	0.2
Nondesignated Areas**	0.1	0.1	0.1	0.1	0.1
Mining	(0.7)	(1.0)	(3.0)	(6.0)	(7.9)
Designated Areas*	0.1	0.1	0.4	0.7	1.0
Nondesignated Areas**	0.6	0.9	2.6	5.3	6.9
Livestock+	(1.2)	(1.2)	(1.2)	(1.2)	(1.3)
Designated Areas*	0.1	0.1	0.1	0.1	0.1
Nondesignated Areas**	1.1	1.1	1.1	1.1	1.2
Recreation, Fish & Wildlife+	0.1	0.2	0.2	35.8	35.8
Total Withdrawals	227.1	228.6	219.5	263.7	117.7
Depth-to-water (ft.)					
Causey-Lingo	70.0	77.1	80.3	88.1	>95.0
Portales-West	75.0	84.5	90.8	105.2	>125.0
Portales-East	50.0	71.0	85.0	113.0	>125.0
Blackwater-Draw	125.0	144.0	157.0	180.0	>224.0
Remaining saturated thickness (ft.)#					
Causey-Lingo	50.0	42.9	39.7	31.9	<25.0
Portales-West	75.0	65.5	59.2	44.8	<25.0
Portales-East	100.0	79.0	65.0	37.0	<25.0
Blackwater-Draw	125.0	106.0	93.0	70.0	<26.0
Voluntary Strategy					
Withdrawals (1,000 acre-ft.)					
Irrigation	(220.9)	(214.1)	(199.1)	(187.4)	(109.4)
Causey-Lingo	13.2	8.9	7.3	5.0	0.0
Portales-West	80.8	78.4	80.3	77.7	62.8
Portales-East	53.3	53.8	54.3	51.1	0.0
Blackwater-Draw	73.6	73.0	57.2	53.6	46.6
Urban	3.8	3.6	3.6	13.4	17.0
Rural	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Designated Areas*	0.1	0.1	0.1	0.1	0.1
Nondesignated Areas**	0.1	0.1	0.1	0.1	0.1
Manufacturing	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)
Designated Areas*	0.1	0.1	0.1	0.1	0.2
Nondesignated Areas**	0.1	0.1	0.1	0.1	0.1
Mining	(0.7)	(1.0)	(3.0)	(6.0)	(7.9)
Designated Areas*	0.1	0.1	0.4	0.7	1.0
Nondesignated Areas**	0.6	0.9	2.6	5.3	6.9
Livestock+	(1.2)	(1.2)	(1.2)	(1.2)	(1.3)
Designated Areas*	0.1	0.1	0.1	0.1	0.1
Nondesignated Areas**	1.1	1.1	1.1	1.1	1.2
Recreation, Fish & Wildlife+	0.1	0.2	0.2	35.8	35.8
Total Withdrawals	227.1	220.5	207.5	244.2	171.9
Depth-to-water (ft.)					
Causey-Lingo	70.0	97.1	100.3	106.3	>115.0
Portales-West	75.0	84.5	89.8	103.1	>125.0
Portales-East	50.0	71.0	84.0	110.0	>125.0
Blackwater-Draw	125.0	144.0	156.0	175.0	>210.0
Remaining saturated thickness (ft.)#					
Causey-Lingo	50.0	42.9	39.7	33.7	<25.0
Portales-West	75.0	65.5	60.2	46.9	<25.0
Portales-East	100.0	79.0	66.0	40.0	<25.0
Blackwater-Draw	125.0	106.0	94.0	75.0	40.0

Table 2 cont.

Strategy and Category	Year 1977	1985	1990	2000	2020
Mandatory Strategy					
Withdrawals (1,000 acre-ft.)					
Irrigation	(220.9)	(192.7)	(159.2)	(129.8)	(76.6)
Causey-Lingo	13.2	8.0	5.7	3.5	0.0
Portales-West	80.8	70.6	64.3	53.0	44.0
Portales-East	53.3	48.4	43.4	35.8	0.0
Blackwater-Draw	73.6	65.7	45.8	37.5	32.6
Urban	3.8	3.0	3.0	11.2	14.2
Rural	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Designated Areas*	0.1	0.1	0.1	0.1	0.1
Nondesignated Areas**	0.1	0.1	0.1	0.1	0.1
Manufacturing	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)
Designated Areas*	0.1	0.1	0.1	0.1	0.2
Nondesignated Areas**	0.1	0.1	0.1	0.1	0.1
Mining	(0.7)	(1.0)	(3.0)	(6.0)	(7.9)
Designated Areas*	0.1	0.1	0.4	0.7	1.0
Nondesignated Areas**	0.6	0.9	2.6	5.3	6.9
Livestock+	(1.2)	(1.2)	(1.2)	(1.2)	(1.3)
Designated Areas*	0.1	0.1	0.1	0.1	0.1
Nondesignated Areas**	1.1	1.1	1.1	1.1	1.2
Recreation, Fish & Wildlife+	0.1	0.2	0.2	35.8	35.8
Total Withdrawals	227.1	198.5	167.0	184.4	136.3
Depth-to-water (ft.)					
Causey-Lingo	70.0	77.1	80.3	85.6	>95.0
Portales-West	75.0	84.4	98.7	100.2	121.6
Portales-East	50.0	71.0	83.0	104.0	>125.0
Blackwater-Draw	125.0	144.0	155.0	170.0	195.0
Remaining saturated thickness (ft.)#					
Causey-Lingo	50.0	42.9	39.7	34.4	<25.0
Portales-West	75.0	65.6	60.3	49.8	28.4
Portales-East	100.0	79.0	67.0	46.0	<25.0
Blackwater-Draw	125.0	106.0	95.0	80.0	55.0

* Designated areas include Causey-Lingo, Portales-West, Portales-East, and Blackwater-Draw.

** Nondesignated areas include the rest of the county.

\+ Includes surface water.

\# Saturated thickness is defined as the thickness of a lens of saturated porous material existing below the water table, capable of yielding significant quantities of ground water to wells. The remaining saturated thickness reflects the impact of all ground water withdrawals on the quantity of water stored in the porous medium and, thus, the thickness of the lens.

The voluntary projections for "urban" were estimated by reducing baseline projections by 10 percent. Mandatory projections were estimated by reducing voluntary projections by an additional 15 percent (a total of 25 percent with respect to the baseline quantities).

In the High Plains area of New Mexico, it was assumed that when the saturated thickness of the Ogallala aquifer in a given area becomes 25 feet or less, the water is no longer economically recoverable for irrigated agriculture and pumping for this purpose would cease. However, even though the water in the lower 25 feet of the aquifer is no longer economically extractable for irrigation use, many widely spaced wells producing small amounts of water could continue to produce sufficient supplies for urban and most other nonirrigation needs.

The estimated hydrologic conditions, well characteristics, irrigation system, and fuel source by subregion for the 1977 baseline conditions in Roosevelt County are presented in Appendix A.

The estimated remaining saturated thickness by subregion resulting from irrigation are presented in Table 3. Except for 1977 conditions, the estimated remaining saturated thickness shown in these tables does not reflect the impact of withdrawals for uses other than irrigation.

To estimate the total effect of all uses upon the saturated thickness, the values shown in Table 3 were modified and are presented in Table 2. A linear analysis was used to determine the necessary adjustments for uses other than irrigation in Roosevelt County. This was done on the basis of the 1975 Water-Use Inventory (Sorensen), and the location of uses as shown on Point Source Maps produced by the New Mexico Environmental Improvement Division (see selected references).

On-Farm Impacts

The on-farm impacts for Roosevelt County include a discussion by management strategy of the on-farm economic impacts (irrigated and total value of production as well as returns to land and management); land resource--including cropland and cropping patterns (irrigated, dry cropland, and rangeland); and the utilization of ground water for irrigation (see Appendix B for a summary of baseline). Supporting tables, describing the land, water, and economic impacts by the selected

Table 3. The Projected Effect of Irrigation on Remaining Saturated Thickness, Roosevelt County, New Mexico, 1977-2020.

Management Strategy	Year					
	1977	1985	1990	2000	2010	2020
	-----(feet of remaining saturated thickness)-----					
Baseline						
Causey-Lingo	50	43	40	34	25	<25
Portales-West	75	66	60	47	35	<25
Portales-East	100	79	66	38	<25	<24
Blackwater-Draw	125	106	93	74	54	36
Voluntary						
Causey-Lingo	50	43	40	35	31	<25
Portales-West	75	66	61	49	38	28
Portales-East	100	79	66	40	<25	<25
Blackwater-Draw	125	106	94	75	57	40
Mandatory						
Causey-Lingo	50	43	40	36	33	<25
Portales-West	75	66	61	52	44	37
Portales-East	100	79	67	46	29	<25
Blackwater-Draw	125	106	95	80	68	55

years, can be found in WRRI Report 151. A sensitivity analysis of the on-farm impacts to demonstrate the effect of both higher and lower crop prices, crop yield, and energy costs on the irrigated agricultural economy of New Mexico is also presented in WRRI Report 151.

For purposes of this section, only the total Roosevelt County on-farm impacts will be discussed. In Appendix C, tables are presented for Portales Valley East, Portales Valley West, Causey-Lingo, and Blackwater Draw showing acreage irrigated, total water withdrawals, value of production, and returns to land and management by period.

Value of Production

The 1977 total agricultural value of production (TVP) (irrigated crops, dryland crops, and rangeland) in Roosevelt County was about $54.4 million (Figure 3). Under all the management strategies, the total

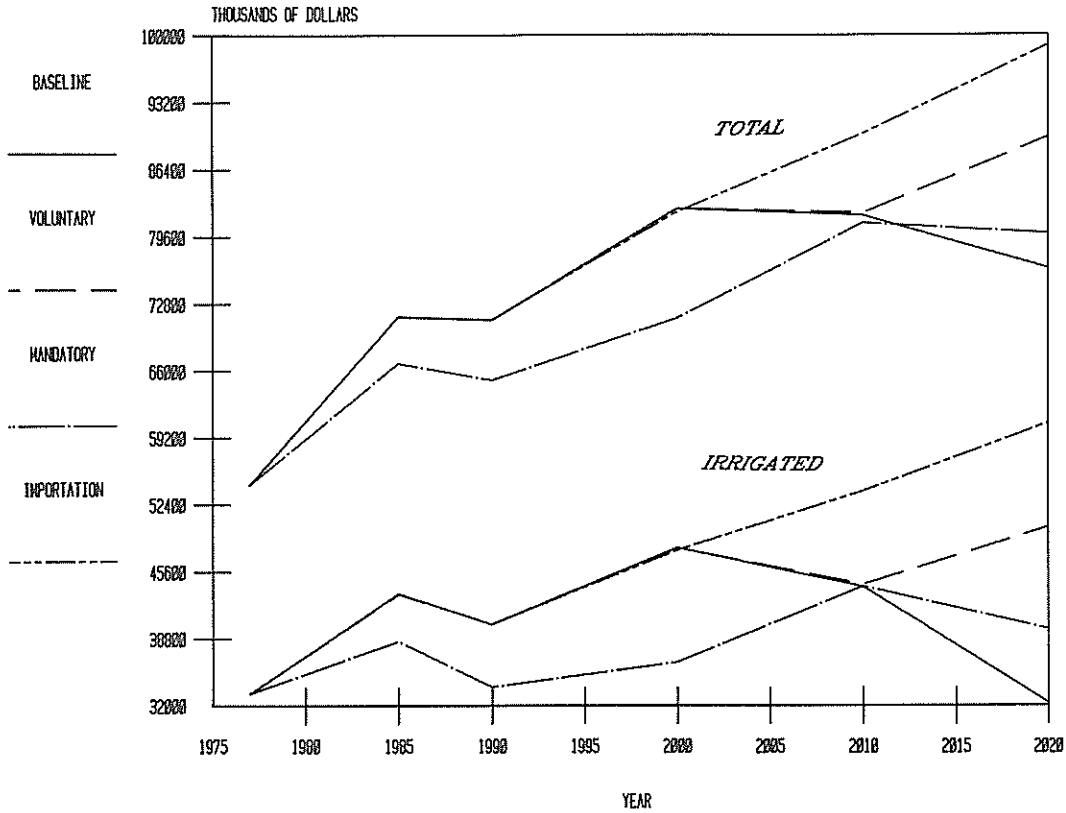

Figure 3. Total and Irrigated Value of Production for Roosevelt County, New Mexico, 1977-2020.

value of production is expected to increase significantly until 2000 due to increasing crop yields and prices. After 2000, decreases are expected under the baseline. A slight decline in 2010, with a significant increase in 2020, characterizes the voluntary strategy. Under the mandatory strategy, the peak occurs in 2010 with a slight decline in 2020. Under the importation strategy, TVP continues to increase throughout the study period. The net result in 2020 is an expected reduction of $13.4 million in value of production for the baseline strategy below that of the voluntary. TVP under baseline was $3.5 million below that of the mandatory strategy, and $22.6 million below the importation strategy (Table 4). The only areas left in irrigated agricultural production in 2020 under the baseline will be in the Causey-Lingo and Blackwater Draw areas. However, it must be noted that the change from a primarily irrigated agricultural economy to a dryland agricultural economy will induce increased variance in the county's agricultural TVP and income. Under the mandatory strategy, the TVP is

Table 4. Value of Production and Returns to Land and Management by Management Strategy for Selected Years, Roosevelt County, 1977-2020.

Strategy and Item	1977	1985	1990	2000	2010	2020
	(1,000 dollars)					
	Value of Production					
Baseline	54,416	71,509	71,101	82,441	81,735	76,339
Irrigated Cropland	33,234	43,393	40,242	48,016	44,040	32,278
Dry Cropland	8,519	12,793	15,156	18,217	21,487	27,853
Rangeland	12,663	15,322	15,702	16,208	16,208	16,208
Voluntary	54,416	71,431	71,151	82,441	81,985	89,697
Irrigated Cropland	33,234	43,315	40,293	48,016	44,290	50,118
Dry Cropland	8,519	12,793	15,156	18,217	21,487	23,371
Rangeland	12,663	15,322	15,702	16,208	16,208	16,208
Mandatory	54,416	66,764	65,033	71,328	80,975	79,873
Irrigated Cropland	33,234	38,562	33,900	36,419	44,101	39,765
Dry Cropland	8,519	12,880	15,370	18,590	20,546	23,718
Rangeland	12,663	15,322	15,763	16,319	16,328	16,390
Importation	54,416	71,431	71,151	82,080	89,985	98,945
Irrigated Cropland	33,234	43,315	40,293	47,773	53,743	60,666
Dry Cropland	8,519	12,793	15,156	18,098	20,034	22,070
Rangeland	12,663	15,322	15,702	16,208	16,208	16,208
	Returns to Land and Management*					
Baseline	13,992	24,380	28,259	37,044	40,501	41,921
Irrigated Cropland	9,301	16,020	17,722	23,591	24,616	21,635
Dry Cropland	1,978	4,684	6,691	9,446	11,919	16,372
Rangeland	2,713	3,676	3,846	4,007	3,966	3,913
Voluntary	13,992	24,485	28,466	37,511	40,859	48,068
Irrigated Cropland	9,301	16,126	17,929	24,057	24,975	30,418
Dry Cropland	1,978	4,684	6,691	9,446	11,919	13,736
Rangeland	2,713	3,676	3,846	4,007	3,966	3,913
Mandatory	13,992	23,738	25,117	30,268	39,972	41,706
Irrigated Cropland	9,301	15,353	14,452	16,531	24,544	23,757
Dry Cropland	1,978	4,709	6,804	9,703	11,433	13,992
Rangeland	2,713	3,676	3,861	4,035	3,996	3,957
Importation*	13,992	24,485	28,466	37,149	44,836	53,085
Irrigated Cropland	9,301	16,126	17,929	23,815	29,834	36,256
Dry Cropland	1,978	4,684	6,691	9,326	11,035	12,916
Rangeland	2,713	3,676	3,846	4,007	3,966	3,913

* A charge for irrigated water was not included in the importation strategy. Therefore, the returns are to land, management, and water for the years 2000, 2010, and 2020.

projected to increase $3.5 million (5 percent) in 2020, primarily due to the retention of additional irrigated acreage. The largest increase, 30 percent ($22.6 million), is expected to occur under the importation strategy. This increase is provided by the irrigated agriculture sector as imported water allows acreage to remain in production (Table 4).

The 1977 value of production for irrigated crops was about $33.2 million (61 percent of total agricultural value of production) in Roosevelt County (Figure 3). Under the baseline and mandatory strategies, the irrigated value of production is expected to follow the same general trend as TVP--initially increasing due to increasing crop yields and prices, then decline. Under the voluntary and importation strategies, TVP is expected to increase over the study period rising to $50.1 million under the voluntary strategy and to $60.7 million under the importation strategy. Under the mandatory strategy, irrigated value of production is expected to decline by 10 percent ($4.3 million) from 2010 to 2020 due to aquifer exhaustion in the Portales-East area. The mandatory water supply reduction strategy is expected to result in a $7.5 million increase in the irrigated value of production from the baseline in 2020 due to the retention of additional irrigated land. The value of production for the mandatory strategy is still $10.4 million below the voluntary water conservation strategy. This is due to changes in the cropping pattern and irrigation technologies assumed necessary to meet the mandatory strategy conditions while retaining no additional land in irrigation.

Returns to Land and Management

The total 1977 returns to land and management (irrigated crops, dryland crops, and rangeland) in Roosevelt County were about $14 million (Figure 4). There are projected to be significant increases in the county's returns to land and management under all strategies in all time periods. This is due to the increased value of production caused by greater crop yields and higher crop prices. Under all the strategies except importation, the increasing returns from the dry cropland sector contribute a great percentage of the increase in total returns to land and management. The dry cropland sector exhibits increased returns from

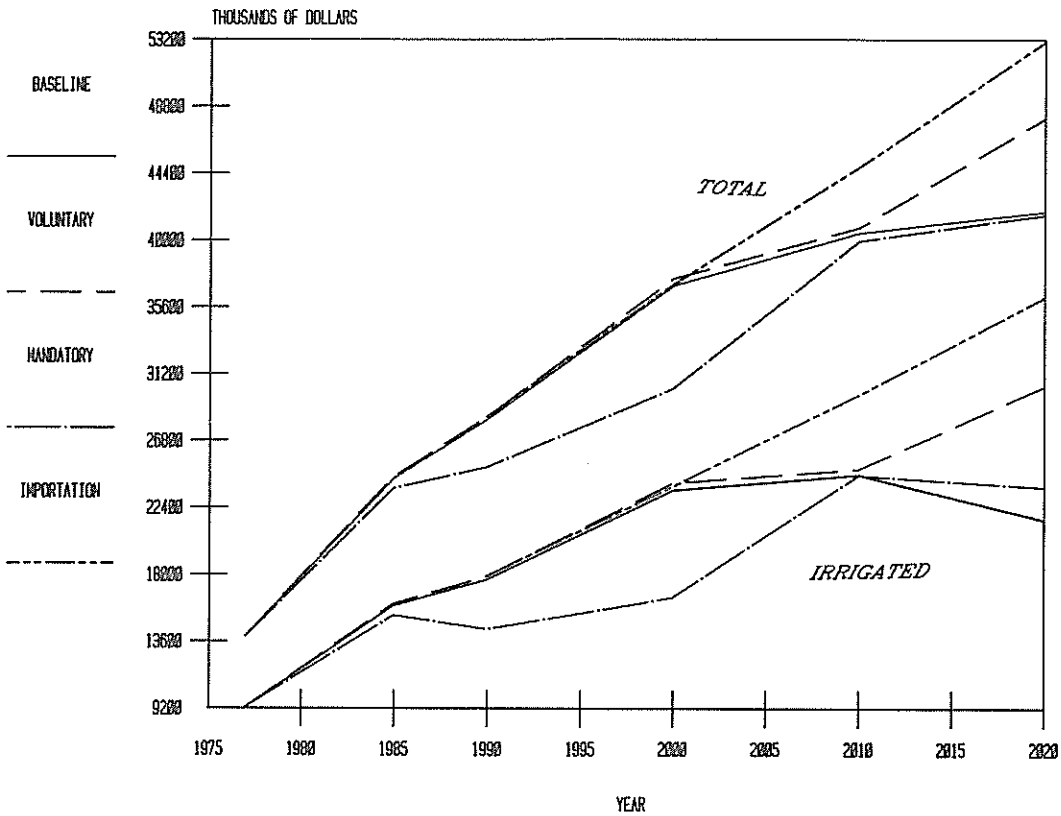

Figure 4. Total and Irrigated Returns to Land, Management, and Risk for Roosevelt County, New Mexico, 1977-2020.

both increased crop yields and higher crop prices as well as increased acreage as previously irrigated lands are converted to dryland.

The greatest expected increase of $39 million (279 percent) is expected to occur under the importation strategy (Table 4). This significant increase in 2020 is due to the full restoration of irrigated lands in Roosevelt County at higher crop yields and prices and no charge being made for the imported water. In 2020, under the voluntary strategy, the returns are expected to be $48 million, for an increase in returns of 244 percent. Under the mandatory strategy, the returns to land and management are projected to increase to $27.7 million (198 percent). Under the baseline, the returns are expected to increase to $41.9 million in 2020.

The 1977 returns to land and management for irrigated crops in Roosevelt County were about $9.3 million (Figure 4). Significant increases in returns are expected for all strategies through 2010. After 2010, irrigated returns are expected to decline under the baseline

due to aquifer exhaustion and under mandatory due to cropping pattern changes. Under the voluntary strategy, a $5.4 million increase in returns to irrigated land is expected between 2010 and 2020 due primarily to retaining irrigated land in production while growing the most profitable cropping pattern. Irrigated returns under the importation strategy are expected to increase almost four-fold from 1977 to 2020. This is due primarily to maintaining fully irrigated lands with no-cost water at higher 2020 crop yields and prices.

The baseline and voluntary strategies are projected to retain a higher percentage of returns to land and management in relation to the total value of production. This implies that returns to land and management capture a greater portion of the value of production in the future. However, under these strategies, there will be increased variability in income from the greater reliance on dryland farming. The greatest increase in both irrigated value of production and returns to land and management occurs under the importation strategy due to the full restoration of irrigated lands at projected higher crop yields and prices while no cost is included for the imported water.

The adoption of the voluntary strategy in Roosevelt County results in the greatest total and irrigated value of production and returns to land and management from the natural water supply in 2020. When compared to the mandatory strategy, the sum over the 43 years examined in the study indicates that the total irrigated value of production is greater for both the baseline and voluntary strategies by $44.5 and $62.3 million, respectively. The sum of the irrigated returns to land and management under the baseline and voluntary strategies when compared to mandatory water reductions indicates that returns under the voluntary strategy are $36.6 million more over the study period and that returns under baseline are $25.5 million more than under the mandatory strategy.

Any future increase in land value above the inflation rate will result in a reduction in the returns to land and management.

Irrigation Water

The quantity of irrigation water diverted is expected to decline from 221,000 acre-feet in 1977 to 64,611 acre-feet in 2020 under the

baseline with most of the decrease occurring after 2000 (Table 5). Aquifer exhaustion is expected in the Portales Valley East and West after 2000. Under the voluntary strategy, the quantity of irrigation water diverted is expected to be only slightly less (3 percent in 1985, 5 percent in 1990, and 9 percent in 2000) than under the baseline. However, under the voluntary strategy in Roosevelt County, enough water is conserved to support irrigation in all areas but Portales-East. Under the mandatory strategy, the water used for irrigation is a fixed percentage of that used under the voluntary and, as a result, the lowest water diversions are expected. Under the mandatory strategy, aquifer exhaustion is expected to occur before 2020 in only the Portales-East area, the same situation as voluntary (Figure 5).

Under the importation strategy, water was imported to fully irrigate those lands that exhaust their natural water supply under the voluntary strategy. In Roosevelt County, it was estimated that 46,428 acre-feet would be imported in 2010 and 40,061 acre-feet in 2020. Costs of this water delivered to the farms in Roosevelt County ranged from $600 to $800 per acre-foot. It was estimated that farmers could afford to pay $150 and $165 per acre-foot in 2020 and have the same profit levels as dryland producers.

Cropland and Cropping Pattern

The irrigated cropland in Roosevelt County is expected to decrease from 109,250 acres in 1977 to 78,160 acres by 2010 for both the baseline and voluntary strategies (Table 6). Under the baseline, irrigated cropland is expected to continue to decline to 41,400 acres in 2020, while under the voluntary strategy, irrigated cropland is expected to remain constant at 78,600 acres, due to the retention of land in irrigation through voluntary conservation. Under the mandatory strategy, the irrigated acreage is expected to decline to about 89,500 acres in 2010. In 2010, the mandatory strategy had 11,350 more irrigated acres than either baseline or voluntary. By 2020 under voluntary, more acreage is irrigated than under mandatory as it is projected to drop to 63,760 acres. Under importation, the irrigated acreage is expected to decline by about 7,000 acres through 2020 (Table 6).

Table 5. Quantity of Irrigation Water Diverted by Management Strategy for Selected Years, Roosevelt County, New Mexico, 1977-2020.

	1977	1985	1990	2000	2010	2020
	(acre-feet)					
Baseline	221,013	222,232	212,196	207,288	139,466	64,611
Voluntary	221,013	214,612	200,744	187,170	136,940	120,093
Mandatory	221,013	193,138	160,633	131,146	130,970	84,043
Importation	221,013	214,612	200,744	187,170	183,368	160,154

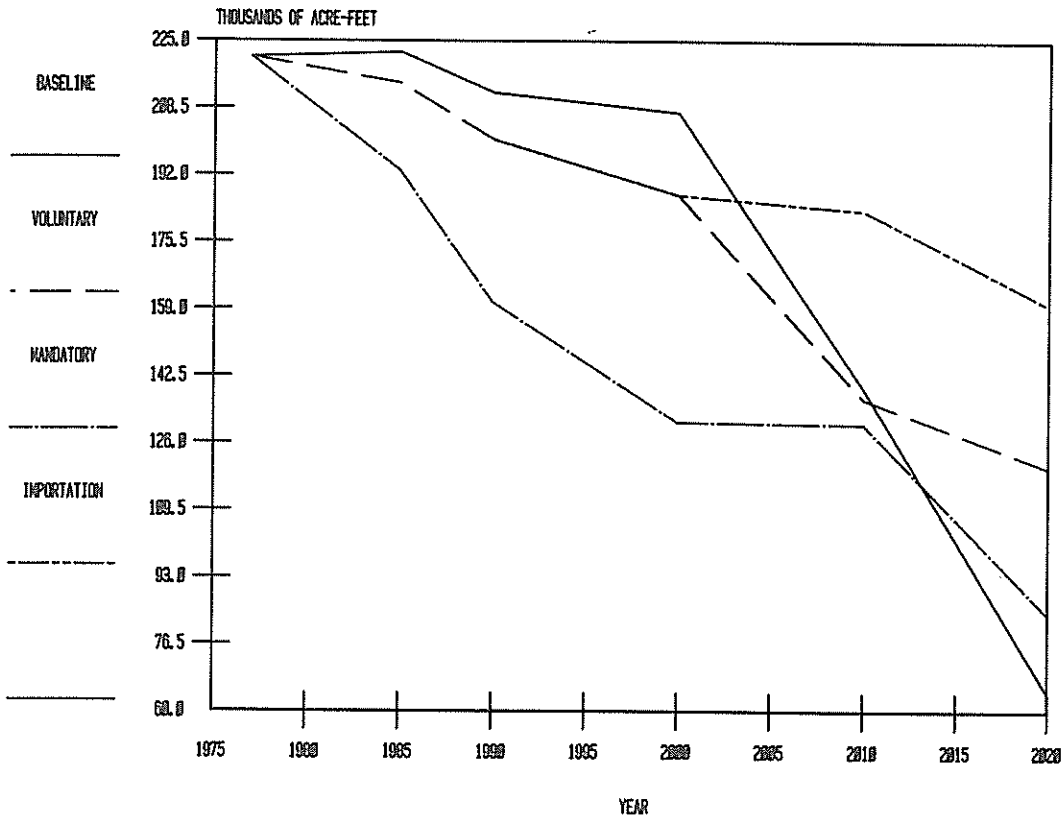

Figure 5. Quantity of Irrigation Applied, Roosevelt County, 1977-2020.

Table 6. Irrigated Cropland Acreages by Crop by Management Strategy for Selected Years, Roosevelt County, New Mexico, 1977-2020.

Strategy and Crop	1977	1985	1990	2000	2010	2020
	(irrigated acres)					
Baseline	109,250	106,739	105,758	104,215	78,158	41,386
Alfalfa	8,778	12,540	15,675	15,675	9,300	0
Corn (grain)	21,000	21,750	22,500	22,500	13,908	7,093
Grain Sorghum	23,402	29,577	33,800	32,988	18,600	0
Wheat	21,498	19,097	22,826	20,741	22,517	18,750
Peanuts	9,200	10,337	10,957	12,311	13,833	15,543
Other Crops*	25,373	13,438	0	0	0	0
Voluntary	109,250	106,739	105,758	104,215	78,158	78,586
Alfalfa	8,778	12,540	15,675	15,675	9,300	9,300
Corn (grain)	21,000	21,750	22,500	22,500	22,500	13,310
Grain Sorghum	23,402	29,577	33,800	32,988	18,600	18,600
Wheat	21,498	19,097	22,454	20,741	13,925	21,833
Peanuts	9,200	10,337	10,957	12,311	13,833	15,543
Other Crops*	25,373	13,438	372	0	0	0
Mandatory	109,250	106,085	99,996	94,202	89,509	63,764
Alfalfa	8,778	5,955	3,344	0	0	0
Corn (grain)	21,000	21,750	14,881	14,512	9,694	6,226
Grain Sorghum	23,402	29,314	33,376	32,378	29,285	17,691
Wheat	21,498	24,965	35,600	27,902	34,871	12,832
Peanuts	9,200	10,337	4,596	197	13,833	15,543
Other Crops*	25,373	13,763	8,200	19,213	1,826	11,473
Importation	109,250	106,739	105,758	104,215	103,101	102,296
Alfalfa	8,778	12,540	15,675	15,675	15,675	15,675
Corn (grain)	21,000	21,750	22,500	22,500	22,500	13,621
Grain Sorghum	23,402	29,577	33,800	32,988	32,385	31,932
Wheat	21,498	19,097	22,454	20,741	18,709	25,526
Peanuts	9,200	10,337	10,957	12,311	13,832	15,542
Other Crops*	25,373	13,438	372	0	0	0

* Includes cotton and planted pasture.

The dry cropland acreage in 1977 was about 170,700 acres. As irrigation water stocks become depleted, acreage will revert to dryland, thus the dryland acreage in each period becomes the base acreage plus the change in irrigated acreage. As a result, dryland acreage varies greatly across management strategies and time periods but generally is projected to increase over time. The rangeland acreage in Roosevelt

County is expected to remain fairly constant over time for all the management strategies at about 1.2 million acres.

Under the baseline, a significant decrease in the acreage of the less profitable crops of alfalfa, cotton, grain sorghum, and pasture is expected over time. Corn, peanuts, and wheat are projected to become the dominant crops (Table 6). Under the voluntary strategy, the same results as the baseline are expected except that alfalfa and grain sorghum acreage remain significant. The acreage changes under voluntary are not expected to be as great as under the baseline.

Under the mandatory strategy, shifts expected include alfalfa acreage declining to zero by 2000 and part of the corn acreage shifting to cotton. Under the importation strategy, there were increases in alfalfa, peanuts, grain sorghum, and wheat acreages (Table 6).

Sensitivity Analysis

Sensitivity analyses were performed on three key on-farm variables. Analyses were performed on the variables of crop prices, crop yields, and energy prices to determine the effects of increases or decreases in these variables upon irrigated acreage, irrigation water usage, value of production, and returns to land and management compared to baseline.

Crop prices, crop yields, and energy prices were increased and decreased over the length of the study period for a total of six alternatives. The results of this analysis indicate that the land use, irrigation water used, value of production, and returns are very sensitive to changes in crop prices, increased crop yields, or increased energy costs (Table 7). When crop yields and energy costs were decreased, there were no changes in resource use but there were changes in the economic variables.

When crop prices were increased or decreased or crop yields increased, a more profitable and more water conserving cropping pattern emerged. This new cropping pattern resulted in enough water conservation to continue irrigation in the Portales Valley West subregion through 2020. Thus, under these three alternatives, 37,200 more acres were irrigated applying over 70,000 acre-feet more water than under the

Table 7. Effect of Sensitivity Analysis on Irrigated Value of Production and Returns to Land and Management, Roosevelt County, New Mexico.

	Changes from Baseline Irrigated Value of Production		Changes from Baseline Irrigated Returns to Land and Management		Irrigated Cropland		Water	
	($million)	(%)	($million)	(%)	(acres)	(%)	(acre-ft.)	(%)
Crop Prices								
Increased	+20.4	+63.3	+10.8	+49.9	+37,200	+89.9	+72,875	+112.8
Decreased	+15.3	+47.3	- 5.7	-26.2	+37,200	+89.9	+72,875	+112.8
Crop Yields								
Increased	+29.0	+89.8	+ 5.9	+27.1	+37,200	+89.9	+78,398	+121.3
Decreased	- 6.3	-19.5	- 6.3	-29.1	0.0	0.0	0.0	0.0
Energy Costs								
Increased	+ 1.5	+ 4.5	- 1.0	- 4.8	+5164.0	+12.5	+5,656	+ 8.8
Decreased	0.0	0.0	+ .63	+ 2.9	0.0	0.0	0.0	0.0

baseline. Decreased crop yields resulted in no change in resource use. The value of production and returns to land and management were increased/decreased as crop prices or yields increased/decreased (Table 7).

A very similar situation resulted when energy costs were increased. A change in the cropping pattern emerged that allowed additional land to be irrigated in 2020. There were 5,200 more irrigated acres in 2020 than under the baseline, applying 5,700 more acre-feet of water. There were also minor (less than 5 percent) increases in the value of production and returns. With decreased energy prices, there was no change in resource use or in the value of production and a small (less than 1 percent) increase in returns.

The sensitivity analysis indicates in Roosevelt County that resource use is sensitive to crop prices and increased crop yields and energy prices. The economic variables indicate that the value of production and returns are much more sensitive to changes in crop prices and yields than to changes in energy prices.

Regional Impacts

Baseline

The baseline assumes the continuation of current trends and no new public agricultural policies or programs. Under the baseline, the continuation of present trends in water conservation is expected to result in water savings of about 10 percent on sprinkler-irrigated lands over the study period. The on-farm impact results and the energy impact results were incorporated into the county impacts analysis.

Gross Output

The total gross output of all goods and services projected for the Roosevelt County economy is reported in Table 8. It was about $119 million in 1977. It is projected to be $154 million in 1985, $192 million in 1990, $235 million in 2000, and $251 million in 2020. The economy of Roosevelt County is estimated to be predominantly agricultural throughout the period (Figure 6).

Table 8. Gross Output by Major Sector for Each of the Alternative Management Strategies, Roosevelt County, New Mexico, 1977-2020.

Sector	Gross Output ($1977)				
	1977	1985	1990	2000	2020
	(millions of dollars)				
Baseline					
Agriculture	74.590	96.558	100.573	117.651	118.999
Mining	3.926	6.877	9.828	15.712	18.169
Manufacturing	8.523	10.668	17.074	21.325	23.864
TCU*	7.352	9.202	14.728	18.395	20.586
Construction	3.298	4.128	6.607	8.252	9.234
FIRE**	7.536	9.432	15.097	18.855	21.101
Trade	8.914	11.157	17.857	22.303	24.959
Services	4.916	6.153	9.848	12.300	13.765
Total	119.055	154.175	191.612	234.793	250.677
Voluntary					
Agriculture	74.590	96.557	100.750	117.504	119.016
Mining	3.926	6.877	9.828	15.712	18.169
Manufacturing	8.523	10.668	17.074	21.325	23.864
TCU*	7.352	9.202	14.728	18.395	20.586
Construction	3.298	4.128	6.607	8.252	9.229
FIRE**	7.536	9.432	15.097	18.855	21.101
Trade	8.914	11.157	17.857	22.303	24.959
Services	4.916	6.153	9.848	12.300	13.765
Total	119.055	154.174	191.789	234.646	250.689
Mandatory					
Agriculture	74.590	96.578	100.785	117.848	119.258
Mining	3.926	6.877	9.828	15.712	18.171
Manufacturing	8.523	10.668	17.076	21.331	23.881
TCU*	7.352	9.213	14.759	18.556	20.970
Construction	3.298	4.128	6.609	8.260	9.276
FIRE**	7.536	9.435	15.109	18.917	21.320
Trade	8.914	11.159	17.867	22.346	25.135
Services	4.916	6.155	9.853	12.328	13.892
Total	119.055	154.213	191.886	235.298	251.903
Importation					
Agriculture	74.590	96.557	100.750	117.709	119.125
Mining	3.926	6.877	9.828	15.713	18.175
Manufacturing	8.523	10.668	17.074	21.336	23.899
TCU*	7.352	9.202	14.728	18.567	21.099
Construction	3.298	4.128	6.607	8.305	9.396
FIRE**	7.536	9.432	15.097	18.978	21.670
Trade	8.914	11.157	17.857	22.428	25.472
Services	4.916	6.153	9.848	12.365	14.073
Total	119.055	154.174	191.789	235.401	252.909

* Transportation, Communication, and Utilities.
** Finance, Insurance, and Real Estate.

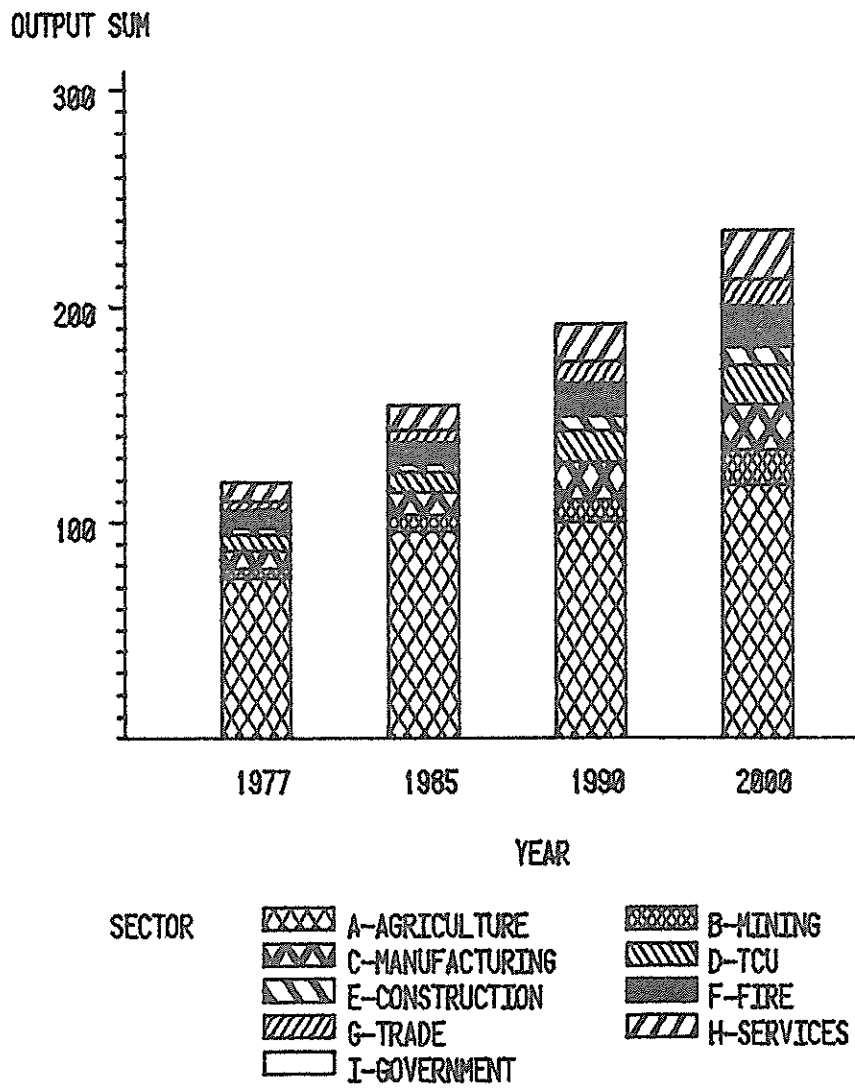

Figure 6. Projected Gross Output for Roosevelt County, Baseline Conditions, 1977-2020.

Agricultural. The agricultural sectors are expected to increase between 1977 and 2020 with about $76 million in 1977 and $119 million in 2020. This growth is projected to be relatively stable over the period (Figure 6). The agricultural sectors accounted for about 63 percent of the total output in 1977 and are projected to account for about 47 percent in 2020.

Mining. The mining sectors (primarily oil and gas extraction) are projected to have a major impact on the local economy (Figure 6). In 1977, the mining sectors accounted for about $4 million, or about 3 percent of the total, and by 1985 they are projected to account for $7

million, or about 4 percent of the total. The mining activity is expected to increase to about $10 million in 1990, $16 million in 2000, and $18 million in 2020.

The amount of oil and gas production in Roosevelt County is small when compared to the total for the High Plains. Lea County accounts for about 95 percent of the production in the area. Roosevelt County's production trends are expected to be similar to those in Lea County with oil and gas production declining and other mining activities increasing over the period. The annual rate of decline, under the most likely projection, differs slightly for crude oil and casinghead gas. Crude oil production is estimated to decline 7 percent annually through 2020 (Figure 7), while casinghead gas production is estimated to decline 8 percent from 1980 through 1984, 9 percent from 1985 through 1989, and 10 percent from 1990 through 2020 (Figure 8). Dry gas production in Roosevelt County is expected to go from 1.46 billion cubic feet in 1980, to 1.1 billion cubic feet in 1985, and .10 billion cubic feet in 2020 (Figure 9).

Additional details on energy impacts are presented in Appendix C. Appendix C also contains a sensitivity analysis on three levels of production--high, expected, and low.

Electrical Production. There is no electricity production in Roosevelt County.

Manufacturing. The manufacturing sectors are projected to increase from $9 million in 1977 to about $24 million in 2020. The contribution of the manufacturing sectors to the total is expected to be about 7 percent in 1977 and 1985, about 9 percent in 1990, and about 10 percent in 2000 (Table 8).

Transportation, Communication, and Utilities (TCU). The TCU sectors, taken together, generally show an increase over the period. These sectors are projected to increase from $7 million in 1977 to $21 million in 2020 (Table 8). The contribution of these sectors to the total was about 6 percent in 1977 and is expected to reach 8 percent in 2020.

Construction. The construction sectors are projected to increase gradually over the period (Figure 6). These sectors accounted for about $3 million in 1977. They are projected to reach $9 million in 2020.

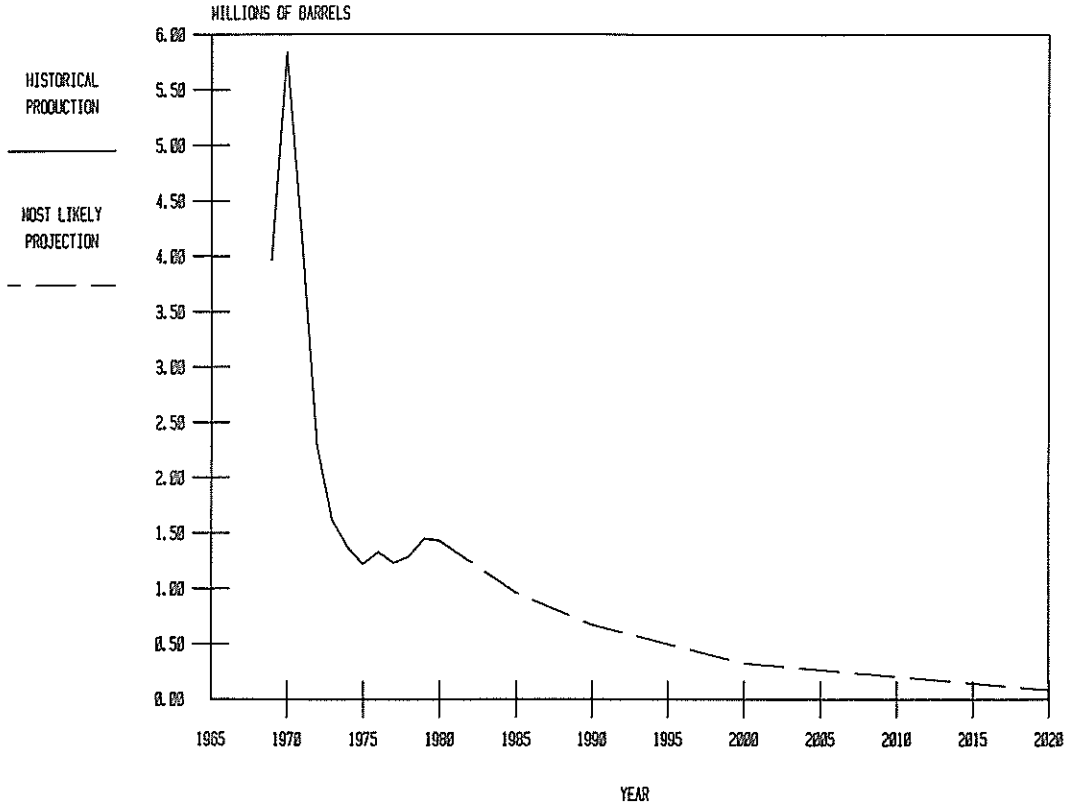

Figure 7. Crude Oil Production for Roosevelt County, Historical and Most Likely Projection, 1967-2020.

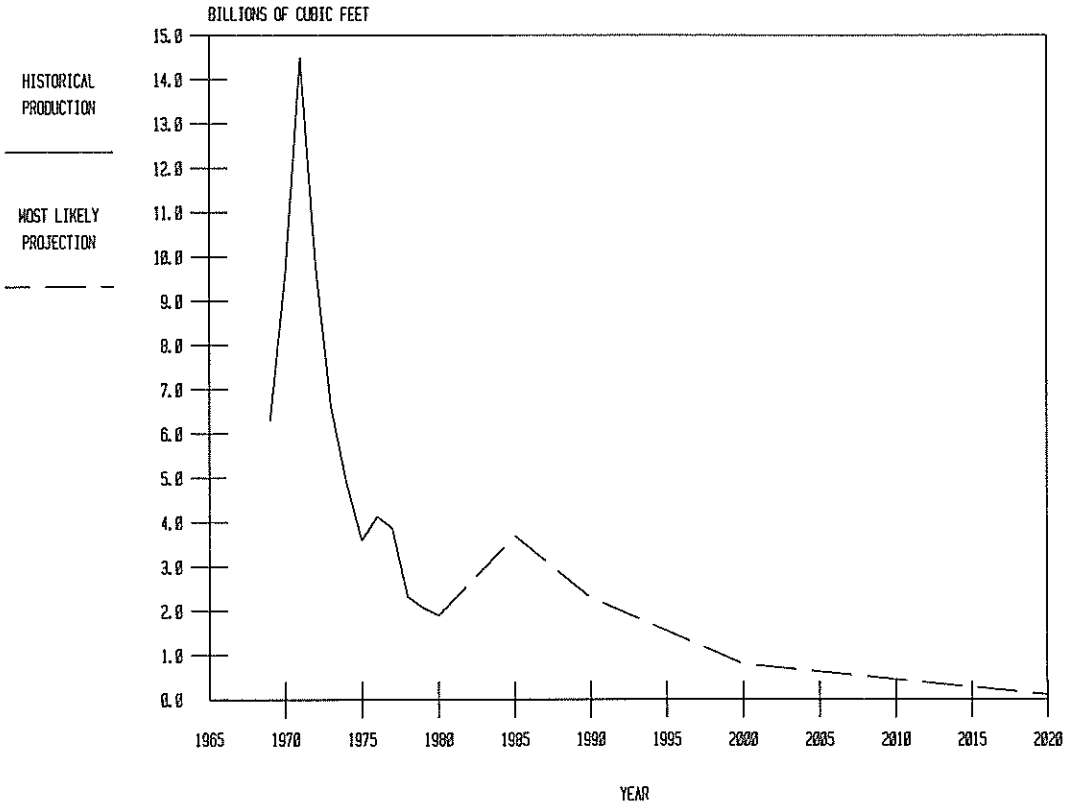

Figure 8. Casinghead Production for Roosevelt County, Historical and Most Likely Projection, 1967-2020.

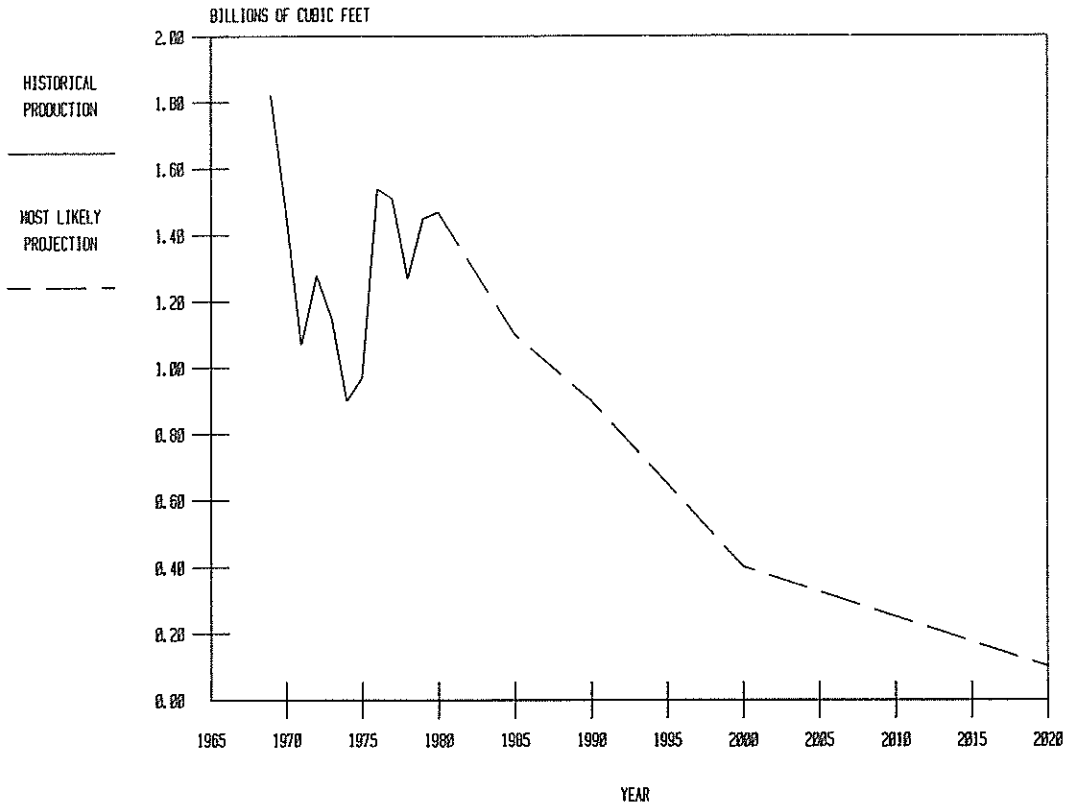

Figure 9. Dry Gas Production for Roosevelt County, Historical and Most Likely Projection, 1967-2020.

Finance, Insurance, and Real Estate (FIRE). The FIRE sectors are projected to increase from about $8 million in 1977 to about $21 million in 2020 (Table 8).

Trade. The trade sector is expected to increase slowly over the period from about $9 million in 1977 to about $25 million in 2020 (Table 8). In 1977, it accounted for about 7 percent of the total and by 2020 it is projected to be about 10 percent.

Service. The service sectors are projected to expand slowly between 1977 and 2020 with about $5 million in 1977 and $14 million in 2020 (Table 8). They accounted for about 4 percent of the total in 1977 and about 5 percent in 2020.

Employment

Total employment in the form of jobs for the baseline and each alternative by major sector is reported in Table 9. Employment projected for the baseline is summarized by major sector in Figure 10. The total jobs were 1,967 in 1977 and are expected to increase to 2,498 in 1985; 3,159 in 1990; decrease to 3,114 in 2000; and 2,491 by 2020. Trade was the largest employer in 1977 accounting for about 22 percent. The percentage is expected to be about 24 percent in 1985, then decline to about 19 percent in 1990, 15 percent in 2000, and 22 percent in 2020. Mining employed about 1 percent in 1977, and is expected to employ 2 percent by 2020. Trade sectors employed 28 percent in 1977 and are expected to employ 27 percent in 1985. They are expected to employ 31 percent in 1990, 29 percent in 2000, and 22 percent in 2020. The agricultural sector accounted for about 20 percent of the jobs in 1977, 16 percent in 1985, 12 percent in 1990, and 13 percent in 2000 and 2020. Construction provided about 5 percent of the jobs in 1977 and 1985, 7 percent in 1990, 8 percent in 2000, and then increased to 11 percent in 2020 (Table 9).

Population

The total population projected for Roosevelt County for the baseline and alternative management strategies is presented in Table 10. The region is estimated to have about 7,197 people in 1977; 7,241 in 1985; 9,613 in 1990; 10,572 in 2000; and 8,388 in 2020. Between 1985 and 1990, the population is projected to increase by 2,372, or about 6.5 percent annually. Between 2000 and 2020, the population is projected to decrease to 8,388. This is still about 17 percent above the 1977 level.

Alternative Management Strategies

Gross Output

The gross output by major sector for each of the alternative management strategies is also summarized in Table 8. For 1977, all of

Table 9. Employment by Major Sector for Each of the Alternative Management Strategies, Roosevelt County, New Mexico, 1977-2020.

Sector	Jobs 1977	1985	1990	2000	2020
	(number of jobs)				
Baseline					
Agriculture	392	404	372	407	337
Mining	15	34	48	66	44
Manufacturing	92	127	157	128	82
TCU*	114	159	232	214	129
Construction	93	131	208	254	276
FIRE**	125	158	246	290	291
Trade	555	680	966	890	546
Services	155	203	321	387	402
Government	426	602	609	478	384
Total	1,967	2,498	3,159	3,114	2,491
Voluntary					
Agriculture	392	422	391	416	368
Mining	15	34	48	66	44
Manufacturing	92	128	157	128	82
TCU*	114	160	233	217	130
Construction	93	132	209	256	277
FIRE**	125	159	247	292	293
Trade	555	682	975	898	549
Services	155	203	324	390	404
Government	426	605	612	481	385
Total	1,967	2,525	3,196	3,144	2,532
Mandatory					
Agriculture	392	407	377	395	348
Mining	15	34	48	66	44
Manufacturing	92	128	157	129	82
TCU*	114	161	233	219	132
Construction	93	132	209	257	279
FIRE**	125	159	248	293	296
Trade	555	682	975	900	553
Services	155	204	324	391	407
Government	426	605	612	481	387
Total	1,967	2,512	3,183	3,131	2,528
Importation					
Agriculture	392	422	391	446	401
Mining	15	34	48	66	44
Manufacturing	92	128	157	129	83
TCU*	114	160	233	219	133
Construction	93	132	209	258	283
FIRE**	125	159	247	294	301
Trade	555	682	975	903	561
Services	155	203	324	392	412
Government	426	605	612	483	390
Total	1,967	2,525	3,196	3,190	2,608

* Transportation, Communication, and Utilities.
** Finance, Insurance, and Real Estate.

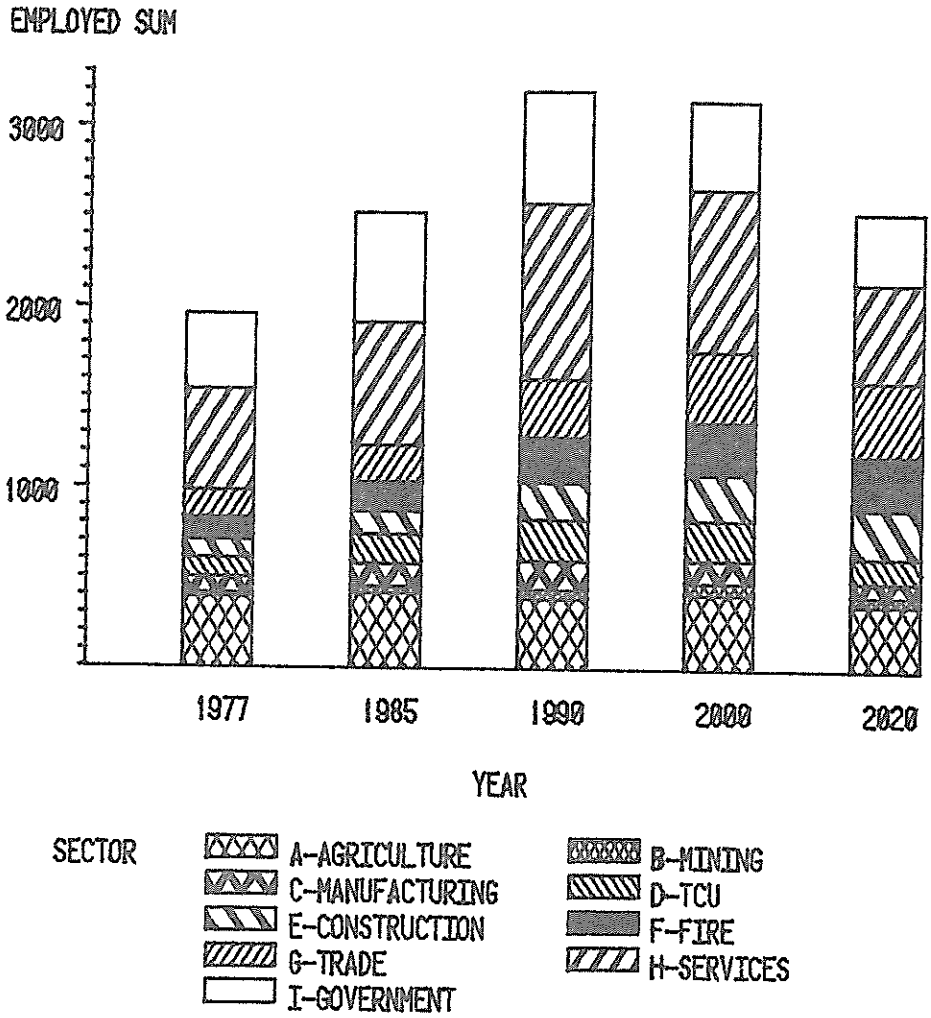

Figure 10. Projected Employment for Roosevelt County.

the output estimates for the management strategies were the same as the baseline.

Any differences in gross output between the management strategies came about because of changes in the agricultural and mining sectors. The voluntary and importation strategies both result in output levels slightly below baseline in 1985 and 1990. The mandatory strategy is projected to be slightly above the baseline. In 2020 under the voluntary strategy, output is estimated to be $12,000 more than the baseline. This difference is due to $17,000 more output in the agricultural sectors and $5,000 less output in the construction sectors.

Table 10. Summary of Population Projections for Roosevelt County for Each of the Management Strategies, 1977-2020.

Strategy	Population Projection				
	1977	1985	1990	2000	2020
Baseline	7,197	7,241	9,613	10,572	8,388
Voluntary	7,197	7,310	9,723	10,653	8,530
Mandatory	7,197	7,273	9,685	10,604	8,508
Importation	7,197	7,310	9,724	10,789	8,751

The mandatory strategy is projected to be about $1.226 million higher than the baseline. The importation strategy results in $2.232 million more than the baseline in 2020. The importation strategy results in a higher level of output in all of the sectors. This is due to the availability of imported water for agriculture which results in more output sufficient to stimulate the rest of the economy.

Employment

Employment in the form of jobs for each of the alternative management strategies is also summarized in Table 9 by major sector. The number of jobs was the same for all management strategies in 1977.

The voluntary strategy results in 27 more jobs than under baseline in 1985 and 37 more in 1990, but is projected to have 30 more in 2000 and 41 more in 2020. The number of jobs in all of the sectors is projected to be greater for the voluntary strategy than for baseline; however, the strategy is not projected to result in employment levels sufficient enough to overcome the general decline in employment in the economy after 1990 in baseline.

The mandatory strategy also results in higher levels of employment in all periods than baseline, but they were slightly less than the voluntary levels. The importation strategy results in the highest employment levels in 2000 and 2020 with 76 more jobs in 2000 and 117 more in 2020 than the baseline. All of the sectors respond with higher

levels of employment as a result of the stimulant that the imported water is projected to have on the agricultural economy. However, between 1985 and 1990, the total employment is expected to increase by about 1,192 jobs, then decline by 668 jobs. The imported water's stimulant to the agricultural sectors is not sufficient to overcome the general decline in employment levels after 1990.

Population

The total population for each of the management strategies is also summarized in Table 10. For 1977, all of the projections for the management strategies were the same. In 1985, the voluntary and importation strategies are projected to result in 69 more people than the baseline, and under mandatory 32 more than baseline. In 1990, the voluntary strategy is expected to result in 110 more people than the baseline, and mandatory is projected to result in 72 more people than under the baseline. Under the importation strategy, population is projected to increase by 111 more people than under baseline. In 2000, the voluntary strategy is expected to result in 81 more people than under baseline, mandatory to have 32 more than baseline, and importation to have 217 more than baseline. In 2020, voluntary is expected to have 142 more people than under baseline, mandatory to have 120 more, and importation to have 363 more than under baseline. The importation strategy is expected to result in the greatest population in Roosevelt County throughout the period.

SUMMARY

The general purpose of this report was to estimate the economic impacts over a 40-year planning horizon on regional income and employment, population, irrigated and dryland cropping patterns, agricultural output, and farm income resulting from rapidly rising energy costs and the declining water tables. If significant areas were to be forced out of irrigated production in the New Mexico High Plains, the economy of the entire state could be adversely affected. In response to these

concerns, New Mexico, five other High Plains states, and the High Plains Associates (general contractor) participated in the Six-State High Plains-Ogallala Aquifer Area Study. The impacts were measured under alternative sets of assumptions regarding public policy, water and energy costs and availability, and irrigation management practices.

Four management strategies including a baseline were evaluated: voluntary water conservation; mandatory irrigation water supply reduction; and importation, supply augmentation for those areas that physically exhaust their water supply.

The total gross output of all goods and services produced in Roosevelt County was about $119 million in 1977. It is projected to be $154 million in 1985, $192 million in 1990, $235 million in 2000, and $251 million in 2020 for the baseline.

The differences in gross output among the management strategies are due to changes in the agricultural and mining sectors. Changes such as the increased output in agriculture and mining resulted in higher levels of output in the rest of the economy.

In all strategies, the output levels were only slightly different from the baseline. By 2020, the voluntary strategy is only $12,000 greater than the baseline, mandatory is $1.226 million more than the baseline, and the importation strategy is $2.232 million more than the baseline. The agricultural sectors account for the majority of the output throughout the period. They generally increase throughout the period with about $75 million in 1977 and about $119 million in 2020. In 1977, the agricultural sectors accounted for about 63 percent of the total output, but by 2020 they are expected to decline to about 47 percent due to the expansion in the other sectors.

The employment levels projected for the baseline and each management strategy are also summarized by major sector in Table 9. These levels follow a similar pattern as the output with essentially minor differences between the strategies and baseline. The voluntary strategy was estimated to have 41 more jobs than baseline in 2020. The mandatory strategy was projected to have 37 more jobs than baseline, and the importation strategy was projected to have 117 more jobs than baseline. These levels are insignificant when compared to the change in employment

over the period. The employment was projected to increase from about 1,967 jobs in 1977 to a peak of 3,159 in 1990, then decline to 2,491 in 2020.

The population of Roosevelt County was projected to follow a similar pattern as output and employment, with about 7,197 in 1977, increasing to about 7,241 in 1985, 9,613 in 1990, 10,572 in 2000, and dropping to about 8,388 in 2020. The management strategies were projected to be slightly higher than the baseline throughout the period, but did not amount to enough to offset the general decline projected. The importation strategy resulted in the highest level with about 363 more than baseline in 2020.

In Roosevelt County, a continuation of a "business as usual" (baseline) policy is estimated to result in the lowest irrigated acreage, irrigation water diversions, value of production, and returns to land and management of any of the management strategies examined. If voluntary water demand reduction policies are implemented, an increase in irrigated acreage, water diversions, value of production, and returns is expected over the baseline by 2020.

The implementation of a mandatory water supply reduction policy in Roosevelt County is expected to result in an increase in the acreage irrigated. However, this would be accomplished with a much lower level of water diversions than voluntary. The irrigated value of production ($79.9 million) was slightly higher than baseline, but the returns to land and management ($41.7 million) were slightly less than baseline. This is due to changes in cropping patterns and levels of irrigation water applications which reduce crops.

If the natural water supply in the High Plains is augmented with imported water from adjacent areas during the last half of the study period, it is anticipated that this policy would result in significant impacts in Roosevelt County. In 2010, it was estimated that there would be about 24,943 more acres of irrigated cropland, and in 2020 that there would be about 60,910 more acres. The irrigation water diversions were also projected to increase substantially over the baseline in 2010 and 2020. The value of production was estimated to be about $22.6 million more than baseline in 2020 and the returns were expected to be about $11.2 million more.

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APPENDIX A

HYDROLOGIC AND IRRIGATION SYSTEMS ASSUMPTIONS

Table A-1. Hydrologic and Irrigation Systems Information, 1977 Estimate, Baseline Conditions, Roosevelt County, New Mexico.

Item	Unit of Measure	Causey-Lingo	Portales East	Portales West	Blackwater Draw
Hydrologic Information					
Saturated thickness	feet	50	100	75	125
Maximum irrigated acreage	acres	8,800	24,800	36,200	36,500
Depth-to-water	feet	70	50	75	125
Average water withdrawals (1977 base)	acre-feet	12,900	51,800	82,400	71,200
Average water decline	ft./yr.	1.0	2.4	1.2	2.4
Gallons per minute					
flood	gpm	--	700	500	--
sprinkler	gpm	400	760	400	850
Specific capacity	gpm/ft. drawdown	15	40	40	40
Irrigation Systems					
Type					
flood	percent	--	17	59	--
sprinkler	percent	100	83	41	100
Pumping plant fuels					
natural gas	percent	--	--	40	--
electricity	percent	100	84	60	93
diesel	percent	--	5	--	3
LPG	percent	--	11	--	4
Average Pumping Plant Efficiencies[1/]					
natural gas	percent	--	--	9.3	--
electricity	percent	50.4	44.4	44.5	46.1
diesel	percent	--	13.4	--	13.9
LPG	percent	--	12.5	--	13.0

[1/] Good efficiencies were considered to be 13.8 percent for natural gas, 66.1 percent for electricity, 19.9 percent for diesel, and 18.6 percent for LPG.

APPENDIX B
SUBAREA ANALYSIS

Value of Production

The 1977 total agricultural value of production (TVP)--irrigated crops, dryland crops, and rangeland--in the Causey-Lingo area of Roosevelt County was about $3.1 million (Table B-1). The total agricultural value of production is expected to triple by 2020. The 1977 value of production for irrigated crops was about $1.5 million (48 percent of the TVP). The TVP for irrigated crops is expected to nearly triple by 2020.

The 1977 TVP for dry cropland was about $1.6 million (52 percent of TVP). The TVP for dry cropland is expected to more than triple by 2020 (Table B-1).

Returns to Land and Management

The 1977 total returns to land and management (RLM)--irrigated crops, dryland crops, and rangeland--were about $567,400 (Table B-1). Under the baseline, the RLM is expected to increase by 10-fold by 2020.

The 1977 returns to land and management for irrigated crops were $210,900 (Table B-1). Significant increases are expected to occur under the baseline at slightly more than 12-fold due primarily to increased peanut acreages (Table B-1). The RLM for dry cropland is expected to increase from $356,500 in 1977 to $3.0 million in 2020.

Irrigation Water

The quantity of irrigation water diverted is expected to decrease from 13,200 acre-feet in 1977 to 5,400 acre-feet in 2000 then increase to 7,850 acre-feet in 2020 as the Ogallala aquifer is dewatered (Table B-1).

Cropland and Cropping Pattern

The irrigated cropland in the Causey-Lingo area of Roosevelt County is expected to decrease from 9,050 acres in 1977 to 3,460 acres by 2010, then increase to 3,890 by 2020 (Table B-1). The dry cropland acreage is expected to increase from 31,750 in 1977 to 42,100 acres by 2020.

Irrigated grain sorghum acreages are expected to decrease over time starting with 2,700 acres in 1977 and ending with 1,640 acres in 2000 (Table B-1). Irrigated wheat is expected to increase from 3,600 acres in 1977 to 2,000 acres in 2020. The peanuts acreage is expected to become the dominant and only crop by 2010. Dryland cotton acreage is expected to increase from 1,300 acres in 1977 to 3,370 acres by 2020. Dryland grain sorghum is expected to decrease from 14,900 acres in 1977 to 11,000 acres in 2020. Dryland wheat is expected to increase from 15,600 acres in 1977 to 27,800 acres in 2020.

Table B-1. Summary of On-Farm Impacts, Causey-Lingo, Roosevelt County, New Mexico, 1977-2020--Baseline.

Item	Unit	1977	1985	1990	2000	2010	2020
Value of Production	dollars	3,073,237	4,043,078	4,600,901	5,415,853	8,020,742	9,201,439
Irrigated Cropland	dollars	1,483,594	1,359,262	1,284,430	1,185,194	3,263,862	4,106,273
Dry Cropland	dollars	1,589,643	2,683,816	3,316,471	4,230,659	4,756,880	5,095,166
Returns to Land & Management	dollars	567,417	1,410,546	1,881,129	2,671,757	4,533,549	5,543,679
Irrigated Cropland	dollars	210,887	436,787	425,110	486,338	1,903,934	2,557,208
Dry Cropland	dollars	356,530	973,759	1,456,019	2,185,419	2,629,615	2,986,471
Irrigation Water							
Quantity	acre-ft	13,220	8,997	7,583	5,430	7,151	7,843
Cost	dollars	259,237	155,926	142,860	114,251	152,378	170,267
Land Use							
Irrigated Cropland	acres	9,051	6,540	5,558	4,015	3,458	3,886
Dry Cropland	acres	31,751	36,771	38,734	41,820	42,934	42,078
Irrigation Energy							
Electricity	1000 kwh	6,822	3,327	2,629	1,666	2,101	2,228
Irrigated Crops							
Cotton							
Acreage	acres	2,444	0	0	0	0	0
Production	cwt	8,552	0	0	0	0	0
Irrigation Water	acre-ft	4,081	0	0	0	0	0
Irrigation Water Cost	dollars	80,021	0	0	0	0	0
Value of Production	dollars	581,553	0	0	0	0	0
Returns to Land & Mgt.	dollars	56,717	0	0	0	0	0
Grain Sorghum							
Acreage	acres	2,711	2,616	2,450	1,638	0	0
Production	cwt	94,867	111,254	114,645	87,099	0	0
Irrigation Water	acre-ft	4,283	4,034	3,734	2,437	0	0
Irrigation Water Cost	dollars	83,982	69,910	70,344	51,268	0	0
Value of Production	dollars	342,201	494,724	516,061	417,817	0	0
Returns to Land & Mgt.	dollars	13,515	122,459	129,730	138,127	0	0
Peanuts							
Acreage	acres	276	458	329	369	3,458	3,886
Production	cwt	6,900	11,813	9,089	11,574	116,566	141,596
Irrigation Water	acre-ft	621	1,005	713	782	7,151	7,843
Irrigation Water Cost	dollars	12,178	17,422	13,438	16,460	152,378	170,267
Value of Production	dollars	172,500	307,141	236,323	312,502	3,263,862	4,106,273
Returns to Land & Mgt.	dollars	88,902	148,514	116,187	169,190	1,903,934	2,557,208
Wheat							
Acreage	acres	3,620	3,466	2,779	2,008	0	0
Production	bu	126,700	147,341	144,402	123,278	0	0
Irrigation Water	acre-ft	4,235	3,958	3,136	2,211	0	0
Irrigation Water Cost	dollars	83,056	68,594	59,078	46,523	0	0
Value of Production	dollars	387,340	557,397	532,046	454,875	0	0
Returns to Land & Mgt.	dollars	51,753	165,814	179,193	179,021	0	0
Dryland Crops							
Cotton							
Acreage	acres	1,270	2,206	3,099	3,346	3,435	3,366
Production	cwt	2,858	5,674	8,581	10,503	11,235	11,454
Value of Production	dollars	571,500	1,012,800	1,436,676	1,582,317	1,657,099	1,656,743
Returns to Land & Mgt.	dollars	0	0	0	0	0	0
Grain Sorghum							
Acreage	acres	14,923	12,502	10,071	10,873	11,163	10,940
Production	cwt	193,992	197,522	175,016	214,727	234,553	241,979
Value of Production	dollars	2,238	1,875	1,511	1,631	1,674	1,641
Returns to Land & Mgt.	dollars	0	0	0	0	0	0
Wheat							
Acreage	acres	15,558	22,063	25,564	27,601	28,336	27,772
Production	bu	202,247	348,401	493,397	629,555	696,037	730,904
Value of Production	dollars	7,779	11,032	12,782	13,801	14,168	13,886
Returns to Land & Mgt.	dollars	0	0	0	0	0	0

Portales Valley West

Value of Production

The 1977 total agricultural value of production (TVP), which is the same as the irrigated TVP in Portales Valley West of Roosevelt County, was about $9.1 million (Table B-2). The total and irrigated agricultural value of production is expected to double by 2010 and then drop to zero as the aquifer becomes dewatered.

Returns to Land and Management

The 1977 returns to land and management (RLM) were about $2.3 million (Table B-2). Under the baseline, the RLM is expected to almost triple by 2010 and then drop to zero by 2020 as the aquifer becomes dewatered.

Irrigation Water

The quantity of irrigation water diverted is expected to decrease from 80,800 acre-feet in 1977 to 76,200 acre-feet in 2010 and then drop to zero by 2020 (Table B-2).

Cropland and Cropping Pattern

The irrigated cropland is expected to remain constant at 37,200 acres from 1977 to 2010 and then drop to zero by 2020 (Table B-2).

Irrigated alfalfa, grain sorghum, and peanuts acreages are expected to increase over time (Table B-2). Irrigated cotton and wheat acreages are expected to decrease from 1977 to 2010.

Table B-2. Summary of On-Farm Impacts, Portales Valley West, Roosevelt County, New Mexico, 1977-2020--Baseline.

Item	Unit	1977	1985	1990	2000	2010	2020
Value of Production	$1,000	9,138	11,851	12,954	15,704	18,415	0
Irrigated Cropland	$1,000	9,138	11,851	12,954	15,704	18,415	0
Returns to Land & Management	dollars	2,349,784	3,884,603	4,885,661	6,905,360	8,864,962	0
Irrigated Cropland	dollars	2,349,784	3,884,603	4,885,661	6,905,360	8,864,962	0
Irrigation Water							
Quantity	acre-ft	80,841	83,881	84,665	83,787	76,227	0
Cost	dollars	841,694	1,086,586	1,287,357	1,549,977	1,696,799	0
Land Use							
Irrigated Cropland	acres	37,200	37,200	37,200	37,200	37,200	0
Irrigation Energy							
Natural Gas	mcf	233,465	0	0	0	0	0
Electricity	1000 kwh	14,042	23,226	23,711	22,592	23,364	0
Irrigated Crops							
Alfalfa							
Acreage	acres	5,208	7,440	9,300	9,300	9,300	0
Production	ton	24,998	42,139	54,429	59,696	72,279	0
Irrigation Water	acre-ft	20,667	29,524	36,905	36,905	30,183	0
Irrigation Water Cost	dollars	216,976	281,663	416,294	561,702	671,872	0
Value of Production	dollars	1,549,901	2,677,076	3,532,446	4,090,393	5,230,815	0
Returns to Land & Mgt.	dollars	429,979	854,784	1,094,257	1,440,686	2,100,195	0
Cotton							
Acreage	acres	10,044	6,696	0	0	0	0
Production	cwt	42,687	32,530	0	0	0	0
Irrigation Water	acre-ft	21,795	14,530	0	0	0	0
Irrigation Water Cost	dollars	228,823	138,619	0	0	0	0
Value of Production	dollars	2,902,716	2,209,547	0	0	0	0
Returns to Land & Mgt.	dollars	400,333	305,968	0	0	0	0
Grain Sorghum							
Acreage	acres	12,276	15,996	18,600	18,600	18,600	0
Production	cwt	552,420	874,780	1,118,905	1,271,484	1,352,862	0
Irrigation Water	acre-ft	20,501	26,076	29,957	29,242	28,545	0
Irrigation Water Cost	dollars	209,929	436,252	549,114	616,431	635,409	0
Value of Production	dollars	1,961,091	3,847,836	4,986,560	6,046,518	6,567,447	0
Returns to Land & Mgt.	dollars	446,591	1,297,127	1,712,404	2,529,187	2,966,218	0
Peanuts							
Acreage	acres	2,976	3,436	4,383	4,924	5,533	0
Production	cwt	77,376	92,217	126,039	160,495	193,967	0
Irrigation Water	acre-ft	6,696	7,546	9,511	10,431	11,441	0
Irrigation Water Cost	dollars	68,567	126,246	174,328	219,883	254,673	0
Value of Production	dollars	1,934,400	2,397,652	3,277,008	4,333,358	5,431,066	0
Returns to Land & Mgt.	dollars	1,064,128	1,208,097	1,682,865	2,439,753	3,266,011	0
Wheat							
Acreage	acres	6,696	3,632	4,917	4,376	3,767	0
Production	bu	267,840	198,542	325,747	345,472	320,283	0
Irrigation Water	acre-ft	11,182	6,205	8,292	7,209	6,058	0
Irrigation Water Cost	dollars	117,399	103,806	147,621	151,961	134,845	0
Value of Production	dollars	790,128	719,194	1,157,751	1,233,287	1,185,682	0
Returns to Land & Mgt.	dollars	8,753	218,627	396,135	495,734	532,538	0

Portales Valley East

Value of Production

The 1977 irrigated agricultural value of production in Portales Valley East of Roosevelt County was about $6.5 million (Table B-3). The total and irrigated agricultural value of production is expected to increase 62 percent by 2020 and decrease to zero after 2000 as the aquifer is dewatered.

Returns to Land and Management

The 1977 irrigated returns to land and management (RLM) were about $1.6 million (Table B-3). Under the baseline, the RLM is expected to increase 175 percent by 2000 and drop to zero thereafter.

Irrigation Water

The quantity of irrigation water diverted is expected to increase from 53,300 acre-feet in 1977 to 55,900 acre-feet in 2010 and then decrease to zero after 2000 as the aquifer is dewatered (Table B-3).

Cropland and Cropping Pattern

The irrigated cropland is expected to remain constant at 25,500 acres from 1977 to 2000 and decrease to zero by 2020 (Table B-3).

Irrigated pasture, alfalfa, and peanuts acreages are expected to increase over time to 2000. Irrigated wheat and cotton acreages are expected to decrease from 1977 to 2000 (Table B-3).

Table B-3. Summary of On-Farm Impacts, Portales Valley East, Roosevelt County, New Mexico, 1977-2020--Baseline.

Item	Unit	1977	1985	1990	2000	2010	2020
Value of Production	$1,000	6,537	7,001	8,759	10,588	0	0
Irrigated Cropland	$1,000	6,537	7,001	8,759	10,588	0	0
Returns to Land & Management	dollars	1,599,104	2,404,935	3,176,229	4,440,909	0	0
Irrigated Cropland	dollars	1,599,104	2,404,935	3,176,229	4,440,909	0	0
Irrigation Water							
Quantity	acre-ft	53,326	54,454	56,713	55,925	0	0
Cost	dollars	824,455	787,418	953,241	1,187,960	0	0
Land Use							
Irrigated Cropland	acres	25,500	25,500	25,500	25,500	0	0
Irrigation Energy							
Electricity	1000 kwh	19,027	14,418	14,946	14,793	0	0
Diesel	gallons	102,076	0	45,671	53,781	0	0
LP Gas	gallons	180,031	213,318	166,032	195,624	0	0
Irrigated Crops							
Alfalfa							
Acreage	acres	3,570	5,100	6,375	6,375	0	0
Production	ton	17,136	29,247	38,305	42,012	0	0
Irrigation Water	acre-ft	14,167	19,840	24,151	23,986	0	0
Irrigation Water Cost	dollars	130,915	229,780	358,322	463,269	0	0
Value of Production	dollars	1,062,432	1,858,031	2,486,007	2,878,669	0	0
Returns to Land & Mgt.	dollars	312,562	554,838	682,939	907,251	0	0
Cotton							
Acreage	acres	6,885	0	0	0	0	0
Production	cwt	30,791	0	0	0	0	0
Irrigation Water	acre-ft	12,370	0	0	0	0	0
Irrigation Water Cost	dollars	209,036	0	0	0	0	0
Value of Production	dollars	2,093,805	0	0	0	0	0
Returns to Land & Mgt.	dollars	254,737	0	0	0	0	0
Grain Sorghum							
Acreage	acres	8,415	10,965	12,750	12,750	0	0
Production	cwt	378,675	599,648	766,991	871,582	0	0
Irrigation Water	acre-ft	14,053	17,875	20,535	20,045	0	0
Irrigation Water Cost	dollars	254,157	287,962	375,177	454,827	0	0
Value of Production	dollars	1,344,296	2,637,630	3,418,206	4,144,790	0	0
Returns to Land & Mgt.	dollars	195,877	900,242	1,175,057	1,701,444	0	0
Peanuts							
Acreage	acres	2,268	1,275	2,630	2,955	0	0
Production	cwt	58,968	34,221	75,623	96,297	0	0
Irrigation Water	acre-ft	5,103	2,800	5,706	6,259	0	0
Irrigation Water Cost	dollars	92,291	45,113	104,254	142,006	0	0
Value of Production	dollars	1,474,200	889,759	1,966,205	2,600,015	0	0
Returns to Land & Mgt.	dollars	770,933	450,056	1,010,061	1,453,776	0	0
Wheat							
Acreage	acres	4,362	8,160	3,745	3,420	0	0
Production	bu	196,290	446,036	250,218	270,051	0	0
Irrigation Water	acre-ft	7,633	13,939	6,321	5,635	0	0
Irrigation Water Cost	dollars	138,056	224,563	115,488	127,858	0	0
Value of Production	dollars	562,698	1,615,708	888,311	964,047	0	0
Returns to Land & Mgt.	dollars	64,995	499,799	308,172	378,438	0	0

Blackwater Draw

Value of Production

The 1977 irrigated agricultural value of production in the Blackwater Draw area of Roosevelt County was about $16.1 million (Table B-4). The total and irrigated agricultural value of production is expected to increase 75 percent by 2020. The irrigated value of production in Blackwater Draw represented 48 percent of the total irrigated value of production in 1977, 42 percent in 2000, and 87 percent in 2020.

Returns to Land and Management

The 1977 returns to land and management (RLM) were $5.1 million (Table B-4). Under the baseline, the RLM is expected to increase almost 300 percent. The irrigated returns to land and management in the Blackwater Draw area represented 55 percent of the irrigated RLM in 1977, 50 percent in 2000, and 88 percent in 2020.

Irrigation Water

The quantity of irrigation water diverted is expected to decrease from 73,625 acre-feet in 1977 to 56,768 acre-feet in 2020 (Table B-4).

Cropland and Cropping Pattern

The irrigated cropland is expected to remain constant at 37,500 acres from 1977 to 2020 (Table B-4).

Irrigated peanuts and wheat acreages are expected to increase over time while corn and pasture acreages are expected to decrease over time (Table B-4).

Table B-4. Summary of On-Farm Impacts, Blackwater Draw, Roosevelt County, New Mexico, 1977-2020--Baseline.

Item	Unit	1977	1985	1990	2000	2010	2020
Value of Production	$1,000	16,075	23,182	17,245	20,539	22,361	28,171
Irrigated Cropland	$1,000	16,075	23,182	17,245	20,539	22,361	28,171
Returns to Land & Management	$1,000	5,142	9,294	9,235	11,758	13,847	19,078
Irrigated Cropland	$1,000	5,142	9,294	9,235	11,758	13,847	19,078
Irrigation Water							
Quantity	acre-ft	73,625	74,899	63,233	62,145	56,089	56,768
Cost	dollars	1,866,291	1,699,149	1,612,211	1,888,661	1,850,034	2,012,769
Land Use							
Irrigated Cropland	acres	37,500	37,501	37,500	37,500	37,500	37,500
Irrigation Energy							
Electricity	1000 kwh	45,605	32,595	26,853	25,374	23,484	24,297
Diesel	gallons	117,577	0	69,116	65,417	60,548	62,656
LP Gas	gallons	258,516	323,330	152,289	144,129	133,414	138,057
Irrigated Crops							
Corn for Grain							
Acreage	acres	21,000	21,750	22,500	22,500	13,908	7,093
Production	bu	2,520,000	3,222,156	3,571,360	3,928,469	2,575,560	1,388,473
Irrigation Water	acre-ft	40,320	40,764	41,663	40,669	24,540	12,216
Irrigation Water Cost	dollars	1,022,056	924,767	1,062,254	1,235,978	809,430	433,125
Value of Production	$1,000	5,481	9,029	10,176	11,931	8,027	4,411
Returns to Land & Mgt.	$1,000	1,863	4,569	4,986	6,274	4,410	2,507
Peanuts							
Acreage	acres	3,680	5,169	3,616	4,063	4,842	11,657
Production	cwt	99,360	144,060	107,981	137,501	176,249	458,770
Irrigation Water	acre-ft	8,280	11,352	7,846	8,605	10,011	23,528
Irrigation Water Cost	dollars	209,886	257,525	200,047	261,527	330,192	834,211
Value of Production	$1,000	2,484	3,746	2,808	3,713	4,935	13,304
Returns to Land & Mgt.	$1,000	1,644	2,449	1,827	2,510	3,461	9,659
Pasture							
Acreage	acres	6,000	6,742	0	0	0	0
Production	1977 $	6,780,000	7,618,460	0	0	0	0
Irrigation Water	acre-ft	16,500	18,098	0	0	0	0
Irrigation Water Cost	dollars	418,252	410,576	0	0	0	0
Value of Production	dollars	6,780,000	9,218,337	0	0	0	0
Returns to Land & Mgt.	dollars	1,100,408	1,634,380	0	0	0	0
Wheat							
Acreage	acres	6,820	3,840	11,384	10,937	18,750	18,750
Production	bu	511,500	349,787	1,267,593	1,439,250	2,657,121	2,846,921
Irrigation Water	acre-ft	8,525	4,685	13,724	12,871	21,538	21,024
Irrigation Water Cost	dollars	216,097	106,281	349,910	391,156	710,412	745,433
Value of Production	$1,000	1,330	1,188	4,262	4,896	9,399	10,457
Returns to Land & Mgt.	$1,000	535	642	2,423	2,974	5,976	6,912

Dry Cropland and Rangeland

Value of Production

The 1977 dry cropland agricultural value of production in Roosevelt County was about $6.9 million (Table B-5). The dryland agricultural value of production is expected to more than triple by 2020 due primarily to increased acreage, prices, and yields.

The 1977 TVP for rangeland was about $12.7 million (23 percent of TVP). The TVP for rangeland is expected to increase by 28 percent by 2020 (Table B-5).

Returns to Land and Management

The 1977 dry cropland returns to land and management (RLM) in Roosevelt County were about $1.6 million (Table B-5). Under the baseline, the RLM is expected to increase 725 percent. Rangeland is expected to increase from $2.7 million in 1977 to $4.0 million in 2000 and then decline to $3.9 million in 2020.

Cropland and Cropping Pattern

The dry cropland is expected to increase from 138,950 acres in 1977 to 188,900 acres by 2020 (Table B-5).

The cotton acreage is expected to increase over time starting with 5,600 acres in 1977 and ending with 15,100 acres in 2020 (Table B-5). Grain sorghum is expected to decrease from 65,300 acres in 1977 to 49,100 acres in 2020. Irrigated wheat is expected to increase from 68,100 acres in 1977 to 124,700 acres in 2020.

Table B-5. Summary of On-Farm Impacts, Dry Cropland and Rangeland, Roosevelt County, New Mexico, 1977-2020--Baseline.

Item	Unit	1977	1985	1990	2000	2010	2020
Returns to Land & Management	$1,000	1,621	3,710	5,235	7,260	9,289	13,385
Dry Cropland	$1,000	1,621	3,710	5,235	7,260	9,289	13,385
Land Use							
Dry Cropland	acres	138,951	138,951	138,950	138,950	151,700	188,900
Irrigation Water							
Value of Production	$1,000	6,929	10,110	11,840	13,987	16,730	22,758
Dry Cropland	$1,000	6,929	10,110	11,840	13,987	16,730	22,758
Dryland Crops							
Cotton							
Acreage	acres	5,558	8,337	11,116	11,116	12,136	15,112
Production	cwt	12,506	21,442	30,784	34,896	39,696	51,420
Value of Production	dollars	822,584	1,413,912	2,078,263	2,408,922	2,774,112	3,695,824
Returns to Land & Mgt.	dollars	237,493	424,648	730,360	1,018,068	1,245,283	1,781,221
Grain Sorghum							
Acreage	acres	65,307	48,633	36,127	36,127	39,442	49,114
Production	cwt	848,984	768,325	627,831	713,445	828,763	1,086,299
Value of Production	dollars	3,137,977	3,474,260	2,869,888	3,468,624	4,110,721	5,507,736
Returns to Land & Mgt.	dollars	544,003	1,135,645	1,058,254	1,622,064	2,055,719	2,904,109
Wheat							
Acreage	acres	68,086	81,981	91,707	91,707	100,122	124,674
Production	bu	885,111	1,294,557	1,769,955	2,091,742	2,459,358	3,281,195
Value of Production	dollars	2,968,528	5,221,383	6,891,721	8,109,030	9,844,924	13,554,112
Returns to Land & Mgt.	dollars	839,494	2,149,492	3,446,564	4,620,266	5,987,974	8,700,117

APPENDIX C
ENERGY IMPACTS

This section contains a summary of the electrical energy impacts and the oil and casinghead gas energy impacts on the High Plains region of New Mexico (extracted from Miller and Hill, 1981). All of the energy production in the High Plains is located in Lea and Roosevelt counties. Lea County accounts for about 90 to 95 percent of all energy produced on the High Plains.

Electrical Energy Impacts

Electric Generating Capacity

Generation capacity projections were made on a region-wide basis and gave considerable weight to assessments made by the utilities and cooperatives serving the High Plains region. It could reasonably be argued, however, that additional capacity will most likely continue to be concentrated in the Southern High Plains region, given the more diverse structure of the local economy and its proximity to fuel sources.

Electric Energy Production

The projected unit performance for 1980 and 1990 is summarized in Table C-1. New combustion turbine capacity would be for peakload generation with an annual output of 1,500 full load hours; new combined cycle capacity would be for intermediate operation with an annual output of 3,500 full load hours.

The low, expected, and high band projections of electric energy production by power plants in the New Mexico High Plains are presented in Table C-2 and generating capacity in Table C-3 (Figure C-1). In these projections, the 1985 values are linear interpolations between the 1980 and 1990 values.

Under all scenarios, production within the study region is projected to diminish as existing units are retired or put on standby. The cost and availability of water and fuel (i.e., coal) were considered in the analysis.

Table C-1. Projected Performance in 1980 and 1990 for Power Plants in the New Mexico High Plains.

Station (Units)	Capacity	1980 Performance	1990 Performance
North Lovington Diesel (Lea County)	19	Average of 1977 and 1978 capacity factors	Retired
North Lovington S-1 & 2 (Lea County)	49	Average of 1977 and 1978 capacity factors	Peakload: 1,500 full-load hours
Maddox 1 (Lea County)	118	Average of 1977 and 1978 capacity factors	Intermediate: 3,500 full-load hours
Maddox 2 (Lea County)	66	Average of 1977 and 1978 capacity factors	Peakload: 1,500 full-load hours
Cunningham 1 (Lea County)	75	Average of 1977 and 1978 capacity factors	Retired
Cunningham 2 (Lea County)	190.4	Average of 1977 and 1978 capacity factors	Peakload: 1,500 full-load hours

Table C-2. Projected Annual Electric Energy Production for the High Plains, New Mexico, 1985-2020.

Year	Electricity Production		
	Low Band	Expected Band	High Band
	(gigawatt-hours)		
1985	1,886	1,886	2,074
1990	887	887	1,262
2000	0	375	1,250
2020	0	375	1,250

Table C-3. Projected Annual Electric Energy Generating Capacity for the High Plains Region, New Mexico, 1985-2020.

Year	Electric Energy Production		
	Low	Most Likely	High
	(gigawatt-hours)		
1985	522	522	522
1990	447	447	697
2000	0	250	500
2020	0	250	500

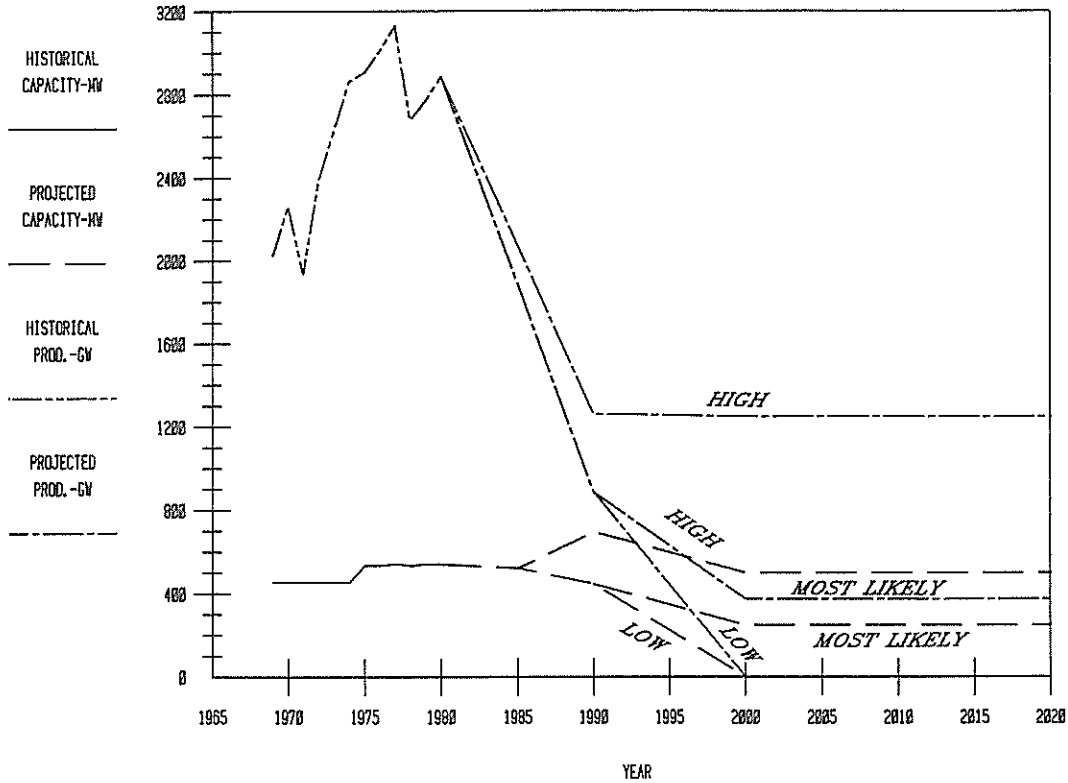

Figure C-1. Electricity Generation and Production, Historical and Most Likely Projected Levels, High Plains.

Electricity Sales

Historical and projected electricity sales for the High Plains region are presented in Table C-4 and Figure C-2. Electricity sales for 1969-78, on a county-level basis, are included in Appendix B of the final New Mexico energy report by Miller and Hill.

Under the low projections, electricity sales in the study area are projected to increase from 1,768.87 million kWh in 1980 to 5,053.97 million kWh in 2020, an overall increase of 186 percent. The underlying assumption of this scenario is that regional electricity sales will continue to increase, but at a decreasing rate. For example, electricity sales increased 59 percent from 1969 through 1978, while sales are projected to increase only 57 percent for the 1980-1990 time frame. Higher electricity price is the primary factor expected to reduce the

Table C-4. Projected Annual Electricity Energy Sales for the High Plains Region, New Mexico, 1985-2020.

Year	Electricity Sales	
	Low	Most Likely
	----------(million kilowatt hours)---------	
1985	2,277.82	2,820.93
1990	2,781.77	3,324.89
2000	3,745.66	4,288.78
2020	5,053.97	5,597.09

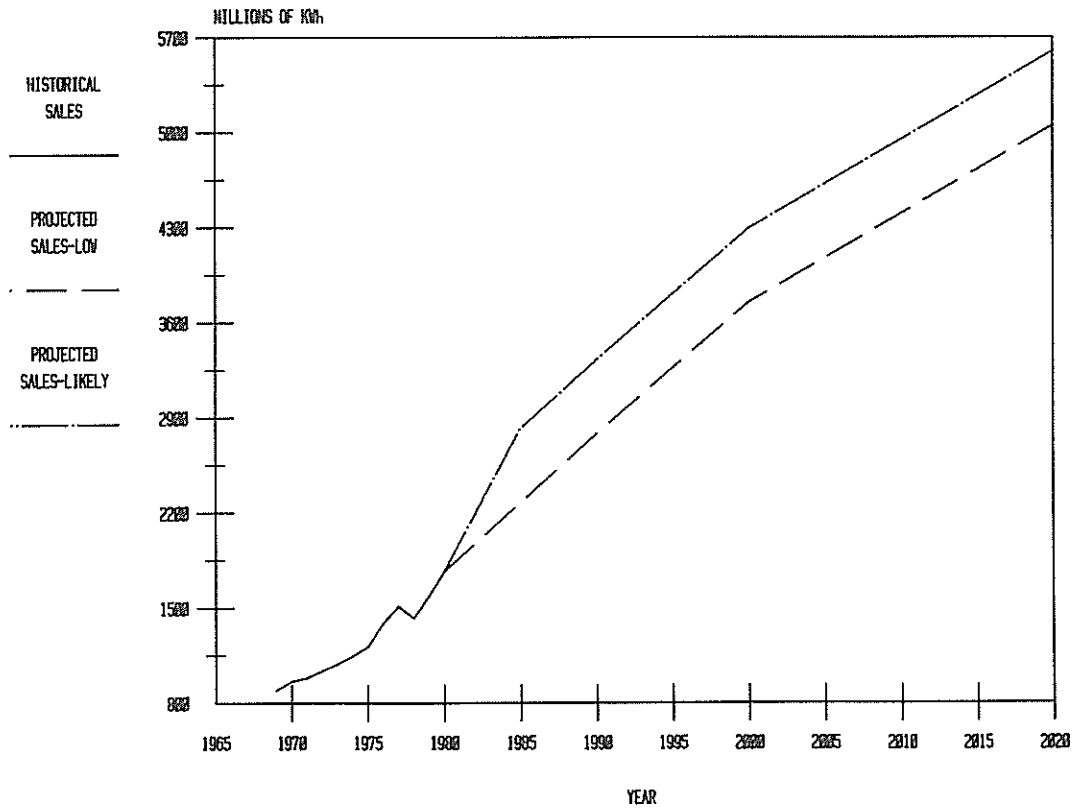

Figure C-2. Historical and Projected Electric Sales for High Plains, New Mexico, 1969-2020.

growth rate. Population, conservation, and previous patterns were also considered to be contributing factors by Southwestern Public Service Company.

The most likely projection shows electricity sales increasing substantially by 1985. During the 1980-85 time frame, sales are expected to increase 59 percent under this scenario compared to a 29 percent increase under the low projection. Carbon dioxide development in the Bravo Dome area (Union, Harding, and Quay counties) accounts for this larger increase. By the year 2020, electricity sales are projected to reach 5,597.09 million kWh, which is about 10 percent greater than the sales level under the low scenario. The overall impact of these projections is increased electricity sales at a decreasing rate. This corresponds with most other electricity demand projections which were reviewed in the course of the study.

Oil and Casinghead Gas Impacts

Roosevelt County Crude Oil and Casinghead Gas Production

A 5 percent annual decline through 2020 in the production of both crude oil and casinghead gas is expected under the high projection assumption (Figure C-3). Annual crude oil production in 1985 is estimated to be 1.12 million barrels and is expected to decline to 0.19 million barrels in 2020, or a decrease of 83 percent from the 1985 level of production (Table C-5 and Figure C-3). Casinghead gas production also is expected to drop off 83 percent during this time frame, from 4.6 billion cubic feet in 1985 to 0.8 billion cubic feet in 2020 under the high projection (Figure C-4). Under the low projection, both crude oil and casinghead gas production are expected to decline 97.5 percent by 2020 from the 1985 production levels (i.e., 0.02 million barrels of oil and .1 billion cubic feet of casinghead gas) (Table C-5).

The most likely projections of crude oil production are expected to drop off to 0.08 million barrels in 2020, which is a 92 percent reduction from the 1985 production level of 0.96 million barrels. Casinghead gas production is estimated to be 3.7 billion cubic feet in 1985 and is expected to decrease 97 percent by 2020 to 0.1 billion cubic feet (Figure C-4).

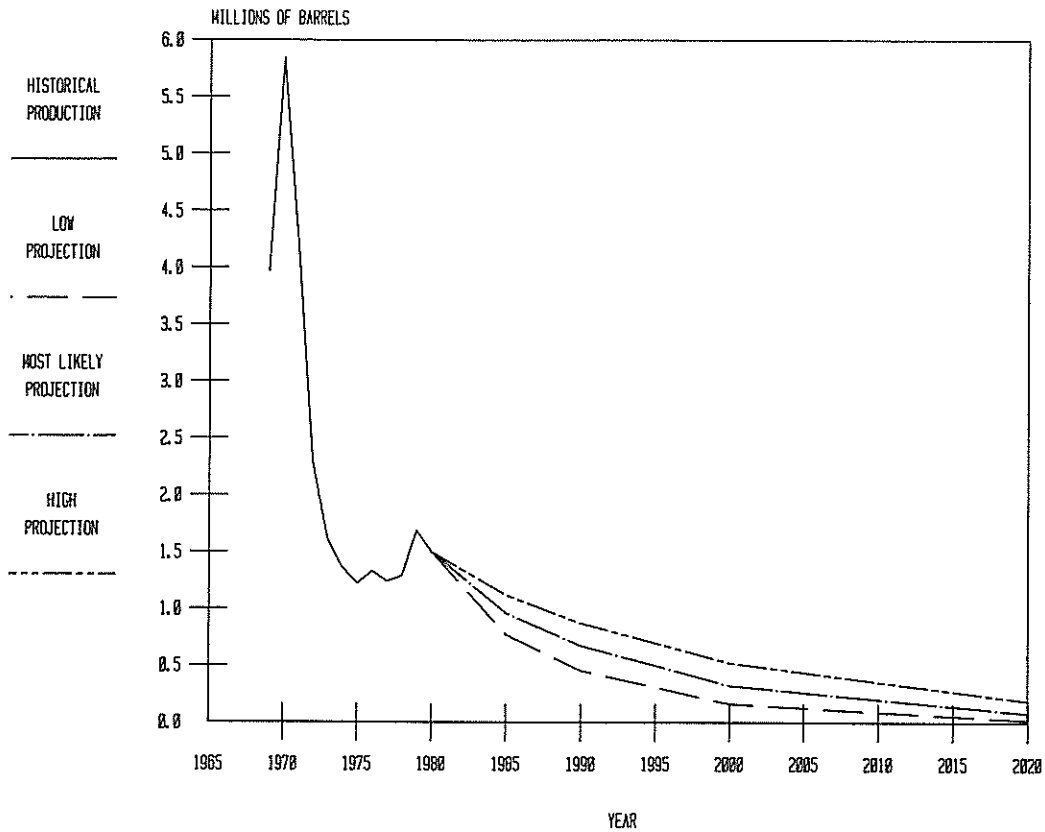

Figure C-3. Crude Oil Production for Roosevelt County, Historical and Projected Amounts, 1965-2020.

Table C-5. Projected Annual Oil Production and Casinghead Gas for Roosevelt County, 1985-2020.

Year	Oil Production			Casinghead Gas Production		
	Low	Most Likely	High	Low	Most Likely	High
	----(millions of barrels)----			---(billions of cubic feet)--		
1985	.77	.96	1.12	3.1	3.7	4.6
1990	.45	.67	.87	1.9	2.3	3.6
2000	.16	.32	.52	.6	.8	2.1
2020	.02	.08	.19	.1	.1	.8

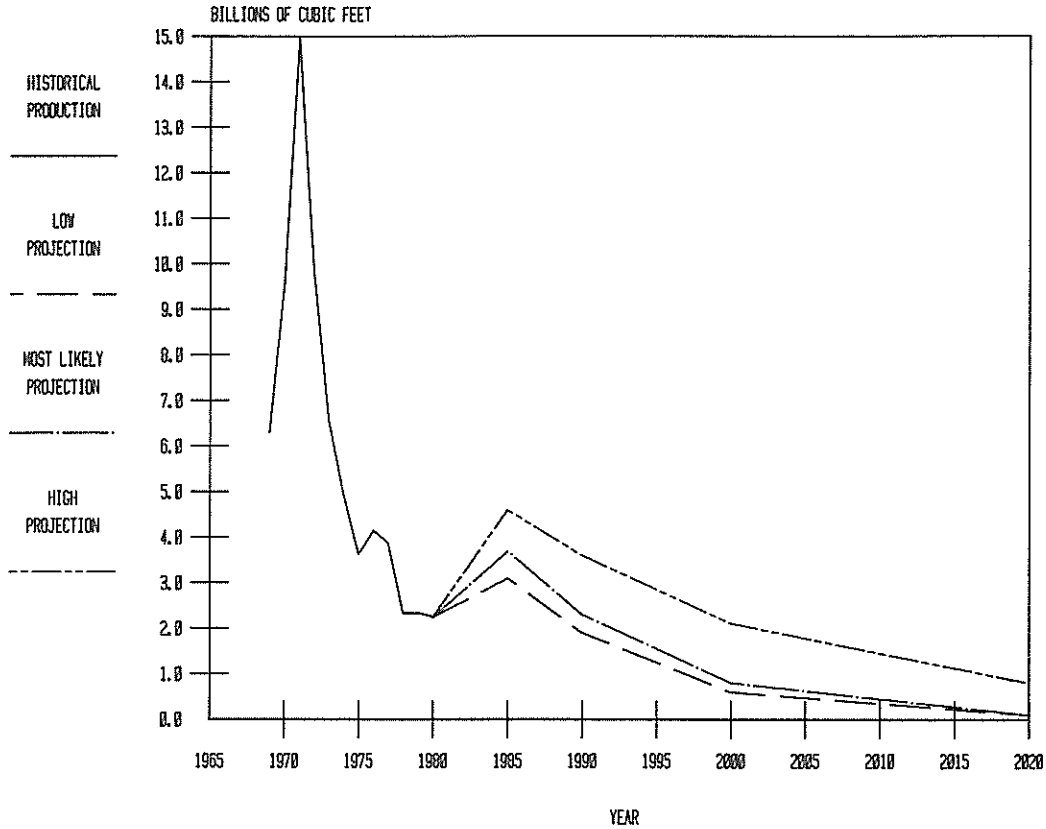

Figure C-4. Casinghead Gas Production for Roosevelt County, Historical and Projected Amounts, 1965-2020.

Dry Gas Production

The Roosevelt County dry gas production projection under the high projection production levels of dry gas in Roosevelt County by 2020 is estimated to amount to 0.10 billion cubic feet, or a 93 percent reduction from the 1985 level of 1.2 billion cubic feet (Table C-6).

The annual rate of decline under the low projection scenario indicates the level of production in Roosevelt County in 2020 to drop to zero (Figure C-5).

Under the most likely projection, dry gas production in Roosevelt County in 1985 is estimated to be 1.1 billion cubic feet. By the year 2020, production in Roosevelt County is projected to have dropped to 0.10 billion cubic feet.

Table C-6. Projected Dry Gas Production for Roosevelt County, 1985-2020.

Year	Dry Gas Production		
	Low	Most Likely	High
	(billions of cubic feet)		
1985	1.00	1.10	1.20
1990	.70	.90	1.00
2000	.30	.40	.50
2020	0.00	.10	.10

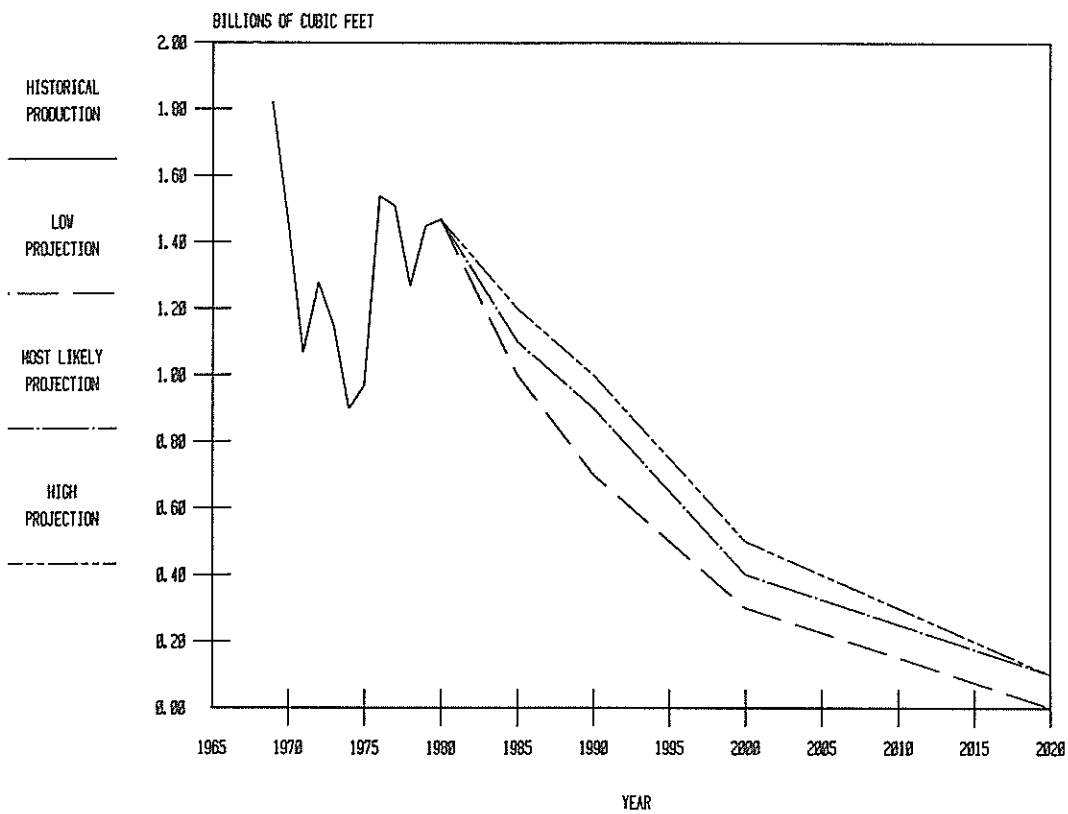

Figure C-5. Dry Gas Production for Roosevelt County, Historical and Projected Amounts, 1965-2020.