SYNOPSIS OF THE OKLAHOMA COMPREHENSIVE WATER PLAN

OKLAHOMA WATER RESOURCES BOARD

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OKLAHOMA WATER RESOURCES BOARD

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CONTENTS

Preface 2

Introduction 3

Conservation 4

Statewide Appraisal 4

Regional Water Development Plans 8

Alternatives to Water Transfer 11

Statewide Water Conveyance System 11

Northern Water Conveyance System 16

Southern Water Conveyance System 17

Eastern Oklahoma Water Supply System 19

Considerations Related to Future Development 21

Conclusions 22

Recommendations 23

PREFACE

This report is a synopsis of the Oklahoma Comprehensive Water Plan prepared by the Oklahoma Water Resources Board, the state agency responsible for effective management and utilization of water in Oklahoma, and is submitted to provide the reader with an overview of Oklahoma's water resources and problems, as well as a proposed strategy for their management.

The Oklahoma Comprehensive Water Plan is a positive step toward the solution of the state's water problems. However, even as the planning process continues, water development projects necessary to offset Oklahoma's immediate needs must receive high priority from local, state and federal governments.

The projects proposed in the report are intended to serve only as a general guide in matching future water needs with supplies, and should not preclude the implementation of alternative projects consistent with the overall goals and objectives set forth in the Oklahoma Comprehensive Water Plan.

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INTRODUCTION

Dramatic increases in population, employment, income and standards of living amply demonstrate Oklahoma's vigorous growth — growth attributable to the state's vast oil and gas deposits, temperate climate, fertile land and abundant, high quality water. However, with this progress has come the unwelcome depletion and pollution of the state's most precious natural resource — water.

Concern for the state's dwindling supplies of water caused the Oklahoma Legislature in 1974 to assign the Oklahoma Water Resources Board the immense task of designing a statewide plan to meet the current and long-range water needs of the entire state. The Oklahoma Comprehensive Water Plan fulfills this mandate by providing for the orderly control, protection, conservation, development and utilization of Oklahoma's water resources.

Problems That Precipitated The Plan

Oklahoma has an abundance of water within its boundaries to meet all the state's future water requirements, but such water is unevenly distributed. Eastern Oklahoma boasts a wealth of stream and ground water resources and rainfall, while western areas often suffer severe and prolonged drought.

Western Oklahoma's giant Ogallala ground water basin (aquifer) which supports a vibrant agricultural economy is threatened with depletion and ultimate exhaustion as a result of overdrafting, and several other aquifers in the state face depletion and/or pollution problems.

Many Oklahoma communities lack reliable sources of good quality water due to natural or man-made pollution and inadequate or outdated treatment and distribution systems.

Central Oklahoma's potential for further economic growth is clouded by the prospect of future water shortages and poor quality water, thus discouraging new business and industry.

Without immediate attention, these problems pose a very real threat to Oklahoma's future growth and prosperity.

Evolution Of The Plan

In 1974, Senate Bill 510 authorized the development of the Oklahoma Comprehensive Water Plan and funded its initial phase. As Oklahoma's southern 33 counties exhibited the greater and more immediate water needs and because a wealth of information was available on the Red River basin, Phase I focused on the development of adequate water supplies to fulfill that area's needs through the year 2030.

As the Plan evolved, the Oklahoma Water Resources Board, along with several federal agencies whose participation was authorized and funded by Congress, became the principal participants in the Oklahoma Comprehensive Water Plan Planning Committee. The U.S. Army Corps of Engineers of the Department of Defense; the Bureau of Reclamation, U.S. Geological Survey and the U.S. Fish and Wildlife Service of the Department of the Interior; and the Soil Conservation Service of the U.S. Department of Agriculture, along with numerous state agencies and organizations, cooperated in the Plan's development.

The Phase I report published in 1975 proposed an interconnected conveyance system of canals, pipelines, conduits and pumping plants to transfer surplus water from southeastern Oklahoma to central areas, then southwestward. Subsequently, the Board received funding to prepare a similar plan for the northern 44 counties through the year 2040 and to update the plan for the southern 33 counties.

An Interim Report published in 1977 summarized the status of planning efforts and provided preliminary information on the northern 44 counties. During the next two years, the Board completed the hydrologic, economic, engineering and environmental studies used in the development of the statewide comprehensive water plan.

Goals And Objectives Of The Plan

The Oklahoma Comprehensive Water Plan is a flexible strategy for managing the state's water resources, and by its nature, must remain responsive to changes in supply and demand caused by residential, commercial, industrial and agricultural development. The plan was developed pursuant to relevant state and federal legislation, policy and guidelines, setting forth the following goals:

- to promote economic opportunity and development;
- to preserve and enhance the environment;
- to protect lives and property from floods;
- to expand agricultural production and agribusiness activity;
- to develop recreational potentials;
- to maintain and improve water quality;
- to encourage water conservation;
- to place excess and surplus water to beneficial use; and
- to encourage and provide for public participation in water resource planning.

Considerations In Development Of The Plan

Major considerations in the development of the Oklahoma Comprehensive Water Plan were, among others, the policies of the state regarding areas of origin and utilization of surplus water. The Plan presupposes that no transfer of water from any area will be considered unless and until all the reasonably foreseeable future water needs of such areas are assured.

AREA OF ORIGIN PROTECTION AND EXCESS AND SURPLUS WATER

Area of origin protection is provided twice in the Oklahoma Statutes. Title 82, Section 105.12 assures users within a stream system all of the water required to supply their beneficial needs before any water can be transported for use outside the system, and requires the Oklahoma

Water Resources Board to review those needs every five years.

Title 82, Section 1086.1 affirms that only surplus and excess water shall be used outside an area of origin, and that residents within those areas have a prior right to the water for any beneficial use within the area of origin.

Thus, existing law specifically provides protection for all of the state, including those stream systems in eastern Oklahoma which are proposed as sources of export water.

Numerous definitions have been proposed by various persons and groups regarding "excess and surplus water" and "area of origin," long controversial issues in Oklahoma. The Oklahoma Water Resources Board believes the definition of "excess and surplus water" contained in the Board's "Rules, Regulations and Modes of Procedure" (1979) to be consistent with the intent of existing legislation. It states that, "'excess or surplus water' shall mean that amount of water which is greater than the present or reasonably foreseeable future water requirements needed to satisfy all beneficial uses within an area of origin."

The term "reasonably foreseeable" for the purposes of the Plan is considered to be 50 years, which is the planning horizon considered consistent with the present "state of the art" in population and water requirement forecasting, i.e., it marks the outer limits of reliable forecasting capabilities.

Under the authority of Title 82, Section 1085.3, the Oklahoma Water Resources Board, in 1963, divided the two major river basins, the Arkansas and Red, into 35 stream systems, which are the units used by the Board in managing and accounting for the state's stream water resources. For more efficient management these original 35 have recently been further subdivided into 49 stream systems. In view of the term "area of origin" being used interchangeably with "stream system" in certain statutes, it is clear that the designated stream systems are the "areas of origin" entitled to protection under existing law.

Additional assurance is provided through compensation to an area of origin in the form of payments to local governments in lieu of ad valorem taxes. Such protection is provided by 82 O.S. Section 1086.1 which states in part that: "In such cases where storage in the area of origin may be permitted, the purchasing entities shall pay to the county of origin, in lieu of ad valorem taxes and as part of the total cost of the purchase of water, an amount computed by averaging the tax on land similar to the land taken off the tax rolls as a result of the construction of such storage facilities within the county of origin."

OTHER PLANNING CONSIDERATIONS

Other considerations which influenced the design of the Plan are the policies and guidelines related to:

- development of reservoirs to maximum site potential;
- inclusion of as many beneficial purposes as feasible in each water development project;
- exemption of Grand River Dam Authority facilities from water transfer plans;
- conformance with Oklahoma laws;
- inclusion of authorized and existing federal projects;
- water conservation as a means of augmenting water supplies;
- limitations imposed by interstate stream compact agreements;
- attention to the goal of supplying all of the state's people with good quality water;
- restrictions regarding reservoir development on designated "scenic rivers";
- recognition of federal reserved and Indian water rights;
- exclusion of ground water as a source for interbasin transfer;
- preservation and enhancement of the environment; and
- conformance with pertinent federal legislation.

CONSERVATION

Concerns expressed by environmentalists, escalating costs of planning and constructing water development projects, depletion of some ground water aquifers, increasing water demands of a growing population, the shortage of suitable reservoir sites and increasingly stringent water quality criteria all combine to exert mounting pressures on existing water supplies.

Although insufficient in itself, water conservation offers a means of alleviating some of the state's water supply problems. The development of new water sources and the conservation of existing supplies must be considered jointly in any plan for supplying adequate water to all parts of the state. If any plan is to be successful, incentives for conservation must be provided and water conservation practiced regularly and consistently by all Oklahomans, in times of plenty as well as in times of drought.

Since uncertainty continues to surround energy supplies and their costs, and water-saving practices are proven means of conserving energy, conservation can also have a significant positive impact on future energy requirements.

Although water conservation must play an important role in meeting Oklahoma's future water supply needs, it cannot be considered a panacea. Water conservation and reuse do not increase the natural water supply of a basin, but simply permit increased beneficial use of existing supplies. However, it must be emphasized that conservation in both the public and private sectors is vital, if the life of existing water supplies are to be prolonged. Such "stretching" of available water can pay substantial dividends, if only to provide time for development of new water sources.

STATEWIDE APPRAISAL

Oklahoma is generally divided into two climatic regions, the humid east and semiarid west. The geographic distribution of rainfall decreases sharply from east to west, ranging from an annual 56 inches in the southeastern corner to 15 inches in the western Panhandle. Mean annua temperature varies from 56°F alon the southern border to 60°F in th

northeast, decreasing westward to 57°F in the Panhandle. Annual lake evaporation averages 48 inches in the extreme east and 65 inches in the southwestern corner. Evapotranspiration (loss of water into the air) and percolation (seepage of water into the ground) consume approximately 80 percent of Oklahoma's annual rainfall, leaving 20% available for use.

Estimates of these climatic variables are of great importance in accurately assessing Oklahoma's present water supplies and planning the development of future supplies.

Stream Water

Oklahoma boasts an abundance of stream water contributed by two mighty river systems, an impressive system of man-made lakes and generous rainfall, particularly in the eastern part of the state. Although Oklahoma possesses adequate water to fulfill all of the state's projected requirements, it suffers problems of inequitable distribution and natural and man-made pollution.

Runoff is a measure used to identify the amount of water from any form of precipitation that flows over the surface. Runoff levels in the state, ranging from 0.2 inches in the Panhandle to 20 inches in the southeast corner, reflect the dramatic contrast in precipitation amounts. In the northwest region, runoff amounts to approximately 820,000 acre-feet of water per year, compared to an estimated six million acre-feet per year in the southeast region. Average annual runoff originating within the entire state amounts to approximately 22 million acre-feet.

MAJOR RIVER BASINS

Oklahoma is drained by two major interstate rivers; the Arkansas in the north, and the Red River in the south, with a combined average inflow to the state of 12 million acre-feet each year. The average amount of water leaving the state is an estimated 34 million acre-feet, with the Arkansas carrying 22 million acre-feet; the Little River, three million; and the Red River, nine million.

The Arkansas and its tributaries drain 44,491 square miles, or about two-thirds of Oklahoma. Major tributaries are the Canadian, Illinois, Verdigris, Grand (Neosho), Poteau, Cimarron and Salt Fork Rivers.

The Red River and its tributaries drain 24,978 square miles, or about one-third of Oklahoma. Major tributaries of the Red River in Oklahoma are the Elm Fork, Salt Fork, North Fork, Washita, Blue, Kiamichi and Little Rivers and Boggy Creek.

In the western part of the state,

FIGURE I—WATER RESOURCES DEVELOPMENT PROJECTS

DEVELOPED

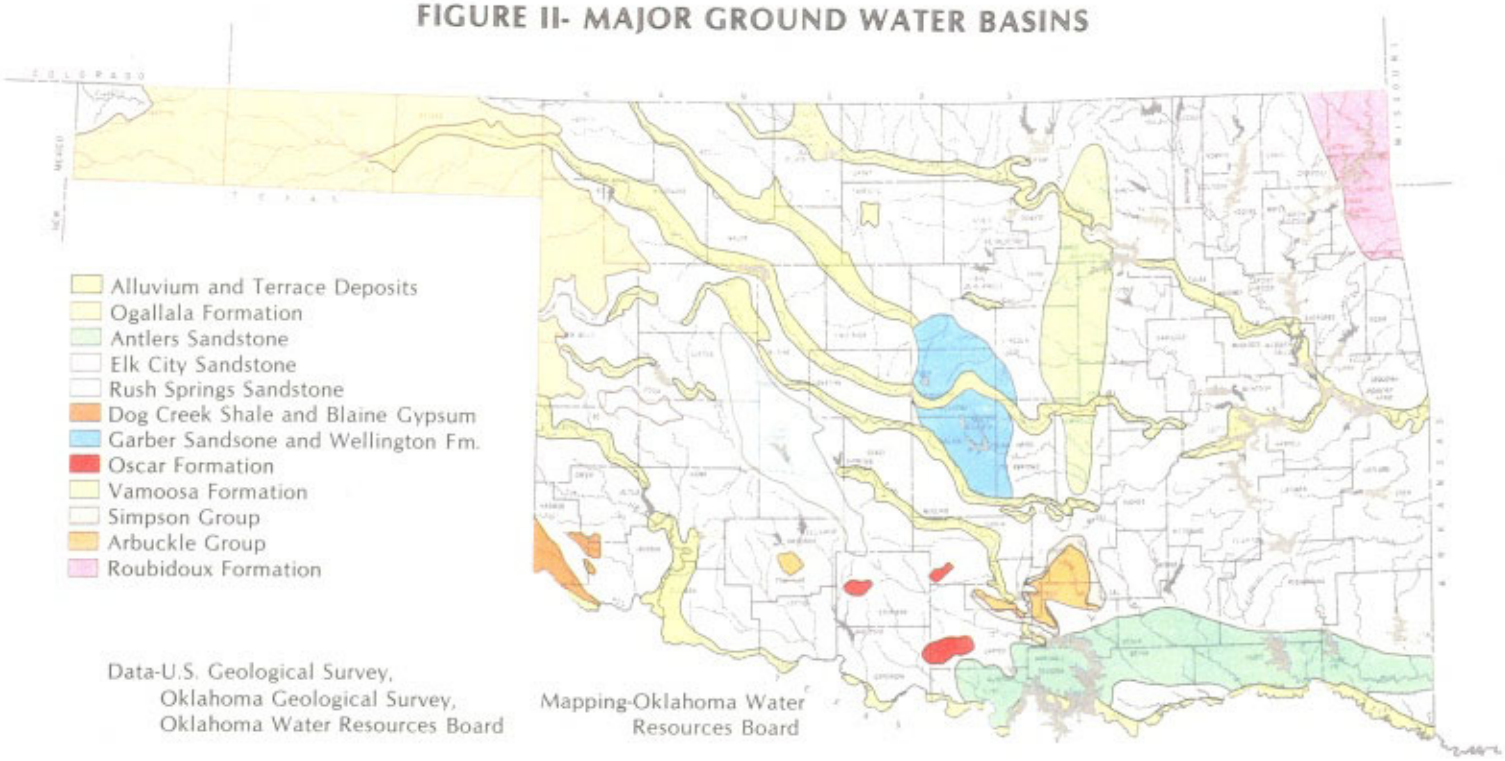
NAME OF SOURCE	STREAM	PURPOSE*	FLOOD CONTROL STORAGE (AF)	WATER SUPPLY STORAGE (AF)	WATER SUPPLY YIELD (AF/YR)	CONSTRUCTION AGENCY☐	DATE OF COMPLETION	
Altus Lake	North Fork of Red River	WS, FC, R, I	19,600	146,000	18,600	BR	Dec	1948
Arbuckle Lake	Rock Creek	WS, FC, R, FW	36,400	62,600	22,700	BR	Jan	1967
Arcadia Lake+	Deep Fork	WS, FC, R	70,700	27,300	12,100	COE	Oct	1984
Atoka Lake	North Boggy Creek	WS, R	0	123,500	65,000	City of Okla. City		1964
Birch Lake	Birch Creek	WS, FC, WQ, R, FW	39,000	15,200	6,700	COE	Mar	1977
Broken Bow Lake	Mountain Fork River	WS, FC, P, R, FW, WQ	450,000	152,500	196,000	COE	Apr	1970
Candy Lake+	Candy Creek	WS, FC, R, FW	31,260	43,100	8,620	COE	Jul	1982
Canton Lake	North Canadian River	WS, FC, I	267,800	107,000[2]	13,440	COE	Jul	1948
Lake Carl Blackwell	Stillwater Creek	WS, R	0	55,000	7,000	U.S. Dept. of Agric.		1948
Clayton Lake+	Jack Fork Creek	WS, FC, R, FW	128,200	297,200	156,800	COE	Oct	1981
Copan Lake+	Little Caney River	WS, FC, WQ, R, FW	184,300	33,600	21,300	COE	Oct	1981
Draper Lake	East Elm Creek	WS, R	0	100,000	88,000[1]	City of Okla. City		1962
Lake Ellsworth	East Cache Creek	WS, R	0	68,700	9,500	City of Lawton		1962
Eucha Lake	Spavinaw Creek	WS, R	0	79,600	84,000[2]	City of Tulsa		1952
Eufaula Lake	Canadian River	WS, FC, N, P	1,470,000	56,000	56,000	COE	Feb	1964
Fort Cobb Lake	Cobb Creek	WS, FC, R, I	63,330	78,350	13,300	BR	Nov	1959
Fort Gibson Lake	Grand (Neosho) River	FC, P	919,200	0	0	COE	Sept	1953
Fort Supply Lake	Wolf Creek	WS, FC, R	86,800	400	220	COE	May	1942
Foss Lake	Washita River	WS, FC, R, I	180,400	203,700	18,000	BR	Feb	1961
Grand Lake O'the Cherokees	Grand (Neosho) River	FC, P	525,000	0	0	GRDA		1940
Great Salt Plains Lake	Salt Fork of Arkansas River	FC, R	240,000	0	0	COE	May	1941
Lake Hefner	Bluff Creek	WS, R	0	75,000	17,000	City of Okla. City		1943
Heyburn Lake	Polecat Creek	WS, FC, conservation	48,400	2,000	1,900	COE	Sept	1950
Hudson Lake	Butler Creek	FC, P	244,200	0	0	GRDA		1964
Hugo Lake	Kiamichi River	WS, FC, WQ, R, FW	809,100	121,500	165,800	COE	Jan	1974
Hulah Lake	Caney River	WS, FC, low flow regulation	257,900	27,000	19,000	COE	Sept	1951
Kaw Lake	Arkansas River	WS, FC, WQ, R, FW	866,000	203,000	230,700	COE	May	1976
Keystone Lake	Arkansas River	WS, FC, P, FW	1,218,500	20,000	22,400	COE	Sept	1964
Lake Lawtonka	Cache Creek	WS, R	0	64,000	8,500	City of Lawton		1905
McAlester Lakes	Coal Creek	WS, FC, R	25,000	24,300	10,500	City of McAlester		1923
McGee Creek Lake+	McGee Creek	WS, FC, R	85,000	109,800	71,800	BR	Oct	1985
Lake McMurtry	North Stillwater Creek	WS, FC, R	5,000	13,500	3,000	City of Stillwater		1971
Lake Murray	Tributary of Hickory Creek	R	0	0	0	State of Oklahoma		1937
Oologah Lake	Verdigris River	WS, FC, N	965,600	342,600	172,500	COE		1974
Optima Lake	North Canadian River	WS, FC, R, FW	71,800	76,200	5,400	COE	Sept	1978
Lake Overholser	North Canadian River	WS, R	0	17,000	5,000	City of Okla. City		1919
Pine Creek Lake	Little River	WS, FC, WQ, FW	388,100	70,500	134,400	COE	Jun	1969
Lake Ponca	Big and Little Turkey Creeks	WS, R	0	15,300	9,000	City of Ponca City		1935
Robert S. Kerr Lake	Main Stem Arkansas River	N, P, R	0	0	0	COE	Oct	1970
Shawnee Lakes	South Deer Creek	WS, R	0	34,000	4,400	City of Shawnee		1935
Skiatook Lake+	Hominy Creek	WS, FC, WQ, R, FW	182,300	304,800	85,100	COE	Oct	1982
Sooner Lake	Greasy Creek	P, FC, R	47,500	149,000	3,600	Okla. Gas & Elect.	Jul	1976
Spavinaw Lake	Spavinaw Creek	WS, R	0	30,600	—[1]	City of Tulsa		1924
Tenkiller Lake	Illinois River	FC, P, WS, R	576,700	25,400	17,900	COE	Jul	1953
Lake Texoma	Red River	WS, FC, P	2,669,000	22,100	23,700	COE	Jan	1944
Lake Thunderbird	Little River	WS, FC, R	76,600	105,900	21,700	BR	Mar	1965
Tom Steed Lake	Otter Creek	WS, FC, R	19,500	88,160	16,000	BR		1977
Waurika Lake	Beaver Creek	WS, FC, WQ, R, FW, I	131,900	170,200	44,800	COE	Aug	1977
Webbers Falls Lock & Dam	Arkansas River	N, P, R, FW	0	0	0	COE	Dec	1970
Wister Lake	Poteau River	WS, FC, R, FW	400,000	9,600	6,700	COE	Oct	1949
SUBTOTAL			13,801,090	3,771,290	1,894,280			

AUTHORIZED

				CONSERVATION STORAGE		
Boswell Lake	Boggy Creek	WS, FC, R, FW	1,095,000	1,243,800	621,400	COE
Lukfata Lake	Glover Creek	WS, FC, R, FW	208,600	37,500	59,400	COE
Sand Lake	Sand Creek	WS, FC, WQ, R, FW	51,700	35,000	13,450	COE
Shidler Lake	Salt Creek	WS, FC, R, FW	49,050	54,900	16,800	COE
Tuskahoma Lake	Kiamichi River	WS, FC, R, FW	138,600	231,000	223,900	COE
SUBTOTAL			1,543,950	1,602,200	934,950	
TOTAL			15,345,040		2,829,230	

*WS-Municipal Water Supply, FC-Flood Control, WQ-Water Quality, P-Power, R-Recreation, FW-Fish and Wildlife, I-Irrigation, N-Navigation
+ Under Construction
☐BR-Bureau of Reclamation, COE-Corps of Engineers, GRDA-Grand River Dam Authority
[1]Lake Stanley Draper is a terminal storage reservoir for the existing pipeline from Atoka Lake and McGee Creek Lake (under construction). The 86,000 acre-feet per year yield shown is the capacity of the Atoka Pipeline (980 mgd) minus evaporation from Draper Lake. The 86,000 acre-feet per year yield is not included in the total.
[2]Combined yield of both lakes
[3]Includes irrigation storage

FIGURE II- MAJOR GROUND WATER BASINS



natural salt springs and salt flats emit large quantities of chlorides, which are carried downstream, ultimately polluting such major streams as the Cimarron, Arkansas, Salt Fork of the Arkansas and Red Rivers. In populous central and eastern Oklahoma, municipal and industrial effluents have degraded many streams, thereby restricting their beneficial uses. However, many of the streams in eastern Oklahoma are of excellent quality, and consistently provide large quantities of pure fresh water.

STREAM WATER DEVELOPMENT

Over the past three decades, Oklahoma has developed an impressive system of man-made lakes through the efforts of the Corps of Engineers, Bureau of Reclamation, Soil Conservation Service, Grand River Dam Authority and several state agencies and cities. The McClellan-Kerr Arkansas River Navigation System, the largest civil works project ever undertaken by the Corps of Engineers, was extended to the Tulsa area in the 1970's, opening the way for extensive commercial and industrial development along the entire waterway.

More stream water development has occurred in the eastern portion of Oklahoma than in the west, where the drier climate limits potential, and available waters are scarce, fully appropriated or of inferior quality.

Most major lakes in Oklahoma have been designed as multipurpose projects, allocating storage for flood control and conservation purposes such as municipal and industrial water supply, irrigation, water quality control, recreation, fish and wildlife, navigation and hydropower. Figure I presents pertinent data on the major developed and authorized lakes in Oklahoma.

Ground Water

Ground water is water that has percolated downward from the surface, filling the voids or open spaces in rocks. A rock formation or group of formations (generally sand, gravel, limestone, dolomite, shale, sandstone and gypsum) that contains sufficient saturated permeable material to yield significant quantities of water is a ground water basin.

Ground water is available in almost every part of the state, occurring in 12 major ground water basins containing an estimated 320 million acre-feet of fresh water in storage, half of which is estimated to be recoverable. (See Figure II.) Less significant amounts are available in at least 150 minor basins. Ground water furnishes 61 percent of the total water reported as being used in Oklahoma, providing for over 80 percent of the state's irrigation and meeting the municipal needs of approximately 300 towns and cities.

Due to lack of available stream water, ground water development is greatest in the western part of the state, where it is extensively used for irrigation, municipal and industrial purposes. Development is not as widespread in central and eastern Oklahoma, although great potential exists for further use if supplies remain unpolluted.

MAJOR GROUND WATER BASINS

Alluvium and terrace deposits were laid down by streams in an irregular pattern and occur throughout the state. The alluvium underlies the bottomlands along streams, while terrace deposits are higher and usually adjacent to the alluvium. Thickness of the deposits typically ranges from 40 feet to 170 feet, with well yields averaging 100 to 300 gallons per minute.

The Ogallala Formation covers an area of about 10,000 square miles, including all or parts of 10 western Oklahoma counties. The Ogallala is the major source of water in the Oklahoma Panhandle, with over 2,000 irrigation wells drilled in that area alone. Wells in the Panhandle may yield from 500 to 1,000 gallons per minute, while those in the southeast portion of the aquifer may yield 200 gallons per minute or less.

Ground water in the Ogallala is being used at a rate greatly exceeding that of recharge. As the water table continues to be lowered by pumping and the saturated thickness is reduced, well yields will continue to decline. Depletion of the aquifer is expected to exert serious economic pressures on the area in the foreseeable future.

The Antlers Sandstone outcrops in a 10-mile wide belt in parts of Atoka, Bryan, Choctaw, Johnston, McCurtain and Pushmataha Counties. The aquifer ranges in thickness from 180 feet in the west to more than 880 feet in the southeast. Average yields are from 100 to 150 gallons per minute. Due to the availability of surface water in the area, water from the Antlers Sandstone is not being extensively used at the present time.

The Rush Springs Sandstone outcrops in an area of 1,900 square miles in Caddo, Custer, Washita and small parts of Comanche, Dewey and Grady Counties. Thickness ranges from less than 200 feet in the south to 330 feet in northern areas. Well yields average about 400 gallons per minute, and the good quality of the water has led to its wide use for municipal supplies.

The Garber-Wellington Formation consists of two formations deposited under analogous conditions, the Garber Sandstone and the Wellington Formation, which are similar in composition, and thus considered a single water-bearing unit. Total thickness of the formations varies from 800 to 1,000 feet, and the average yield of wells is 250 gallons per minute. The Garber-Wellington yields water of very good quality, making it the principal source of water for many towns and industries in central Oklahoma.

Other ground water aquifers shown in Figure II are important local sources of water, but are not as extensive as those previously mentioned. These formations include the Elk City Sandstone in west central Oklahoma; Dog Creek Shale and Blaine Gypsum in the southwest corner of the state; Oscar Formation in the south central; Vamoosa from Osage County in the north to Seminole County in the south; the Simpson Group and Arbuckle Group in the south central and southwest; and the Roubidoux in northeastern Oklahoma.

Present Water Uses And Future Requirements

Sharp escalations in population, industrial development and irrigated agriculture, along with increased affluency and the consequent rise in standards of living, have placed heavy demands on Oklahoma's water resources. Projections by the Oklahoma Employment Security Commission forecast a state population of 4.4 million by the year 2040 and over six million by 2090. As the population grows, so will water demands in all categories of water use continue to escalate. It is imperative that Oklahoma plan for the optimum use of all potential supplies in order to assure adequate water to all parts of the state.

Municipal water use, currently estimated at 402,000 acre-feet per year, is expected to rise to 1,060,700 acre-feet per year by 2040. Industrial use, currently estimated at 388,300 acre-feet, is projected to reach 833,400 acre-feet per year by 2040; and the annual 110,900 acre-feet presently used for cooling water is expected to climb to 955,500 acre-feet by 2040. Current irrigation water use is estimated at 1.5 million acre-feet per year, with a projected increase to over four million acre-feet annually by the year 2040. Total water use is predicted to be 6,939,500 acre-feet per year by 2040. Figure III shows present and projected water requirements for municipal, industrial, power and irrigation uses by planning region.

Agriculture, the state's leading economic activity, is flourishing, with 80 percent of the total irrigated land lying in western Oklahoma. The recent and rapid growth of irrigated agriculture, which is highly dependent on the Ogallala aquifer as a source of water, threatens to deplete the basin in the readily foreseeable future. If additional water supplies are not made available to sustain the agricultural stability of this productive region, the entire state appears destined to face severe economic consequences.

The most practical solution to the problem of natural inbalance of water supplies between east and west appears to be the conveyance of surplus water from eastern portions of the state to the water-deficient west. The Oklahoma Comprehensive Water Plan has been developed to meet the state's projected needs through the year 2040, a planning period of sufficient duration to maximize the return of the tremendous investment required for water development projects.

Methodology For Future Water Requirements

The methodology used in estimating Oklahoma's future water requirements was developed by the Oklahoma Comprehensive Water Plan Planning Committee. Population projections utilized in the development of the Plan were provided by the Oklahoma Employment Security Commission (OESC). By combining projected births, survival of the base year population and migration of the population, the projections were derived to the year 2040. Per capita use rates (gallons per day) were applied to the forecasts to determine the total municipal, domestic and rural water use projections.

FIGURE III—STATEWIDE PRESENT AND PROJECTED WATER REQUIREMENTS (1,000 AF/YR)

PLANNING REGION	Use	Present	1990	2000	2010	2020	2030	2040
SOUTHEAST								
	Municipal	16.5	21.0	24.4	29.1	32.3	37.4	56.1
	Industrial	71.3	88.7	103.6	119.8	137.4	154.9	172.2
	Power	—	10.7	16.2	21.6	27.1	32.6	38.0
	Irrigation	13.9	46.9	94.3	141.1	188.2	235.5	282.4
	Total	101.7	167.3	238.5	311.6	385.0	460.4	548.7
CENTRAL								
	Municipal	113.7	167.2	191.8	228.0	264.1	324.5	351.6
	Industrial	55.6	88.8	119.2	149.5	179.9	226.3	272.6
	Power	18.5	39.5	59.6	79.6	99.7	110.1	120.4
	Irrigation	39.8	43.3	49.6	56.0	62.4	68.7	75.1
	Total	227.6	338.8	420.2	513.1	606.1	729.6	819.7
SOUTH CENTRAL								
	Municipal	20.4	24.7	27.3	30.8	34.3	36.0	37.8
	Industrial	34.0	34.5	35.4	36.5	37.6	38.1	38.7
	Power	1.0	1.8	2.9	3.6	4.2	4.5	4.9
	Irrigation	42.6	69.5	87.8	107.7	127.5	137.4	147.4
	Total	98.0	130.5	153.4	178.6	203.6	216.0	228.8
SOUTHWEST								
	Municipal	36.0	45.2	52.0	56.7	61.5	63.9	66.2
	Industrial	50.6	55.7	61.7	63.9	66.2	67.3	68.4
	Power	5.6	14.8	23.0	28.4	33.7	36.4	39.1
	Irrigation	504.4	576.4	631.3	827.4	1,023.0	1,121.0	1,219.1
	Total	596.6	692.1	768.0	976.4	1,184.4	1,288.6	1,392.8
EAST CENTRAL								
	Municipal	33.8	42.0	47.9	54.7	58.7	66.1	70.8
	Industrial	9.3	10.9	11.5	12.3	12.9	13.3	16.9
	Power	20.8	66.7	103.7	140.7	177.7	204.2	230.8
	Irrigation	9.5	29.3	32.7	36.0	39.4	42.9	46.6
	Total	73.4	148.9	195.8	243.7	288.7	326.5	365.1
NORTHEAST								
	Municipal	119.4	179.2	219.4	248.5	278.6	309.0	349.0
	Industrial	104.9	140.1	158.6	172.8	177.9	183.1	187.5
	Power	57.0	146.1	197.0	241.4	285.6	311.7	338.9
	Irrigation	26.0	51.0	60.4	70.3	80.0	87.9	95.6
	Total	307.3	516.4	635.4	733.0	822.1	891.7	971.0
NORTH CENTRAL								
	Municipal	45.6	58.1	67.4	77.3	85.5	93.9	101.6
	Industrial	47.6	48.9	49.4	51.5	53.0	54.1	59.3
	Power	4.6	42.9	66.7	90.6	114.4	138.3	162.1
	Irrigation	28.6	82.8	133.5	179.4	238.2	282.3	336.9
	Total	126.4	232.7	317.0	398.8	491.1	568.6	659.9
NORTHWEST								
	Municipal	16.8	19.1	20.6	22.9	24.4	26.0	27.6
	Industrial	15.0	15.2	15.3	15.9	16.3	16.3	17.8
	Power	3.4	5.6	8.7	11.9	15.0	18.2	21.3
	Irrigation	850.0	1,077.6	1,205.4	1,377.8	1,557.0	1,724.4	1,886.8
	Total	885.2	1,117.5	1,250.0	1,428.5	1,612.7	1,784.9	1,953.5
STATEWIDE TOTAL								
	Municipal	402.2	556.5	650.8	748.0	839.4	956.8	1,060.7
	Industrial	388.3	482.8	554.7	622.2	681.2	753.4	833.4
	Power	110.9	328.1	477.8	617.8	757.4	856.0	955.5
	Irrigation	1,514.8	1,976.8	2,295.0	2,795.7	3,315.7	3,700.1	4,089.9
	Total	2,416.2	3,344.2	3,978.3	4,783.7	5,593.7	6,266.3	6,939.5

The economic data which provided a basis for the industrial water requirement projections are disaggregates of the U.S. Water Resources Council's regional forecasts. Employment rates were multiplied by population predictions to arrive at Oklahoma's share of future employment by industrial activity according to Standard Industrial Classifications. Appropriate industrial water use coefficients for Standard Industrial Classifications were applied to employment projections to arrive at a total industrial requirement. The industrial requirement was then disaggregated to arrive at individual county projections by applying the ratio of county population to the total state population. It was also assumed that about seven percent of industrial and cooling water requirements would be fulfilled by recycled wastewater by the year 2040.

In determining future agricultural needs it was assumed that import water would be available sometime around the year 2000; irrigation would increase; ground water would continue to be mined; and import water would be available before the ground waters were effectively depleted. Irrigation water requirements were determined by subtracting the consumptive water use for a general cropping pattern in each region from the effective precipitation and allowing for losses occurring between sources of supply and the farm. It was determined that two acre-feet of water per land acre in the Northwest and Southwest Planning Regions; 1.5 acre-feet per acre in the North Central, Central and South Central Planning Regions; and one acre-foot per acre in the Northeast, East Central and Southeast Planning Regions would be required at terminal reservoir sites in each region. The significant reuse of wastewater for irrigation was assumed feasible in central Oklahoma, where irrigation is widespread and industry makes available a large volume of wastewater. Therefore, a portion of the irrigation water requirements of the Central Planning Region is proposed to be met from that source.

Consumptive water use by utilities for power generation was computed at a rate of 2.5 acre-feet of water per million kilowatt hours of energy produced. The consumptive use rate was applied to projected energy requirements to determine total utility water requirements.

Water requirements for nonconsumptive uses such as recreation, fish and wildlife, low flow augmentation, navigation and water quality control were assumed to be fulfilled by potential reservoir development planned to meet the consumptive needs, i.e., the nonconsumptive use needs would be met at no additional cost as a result of meeting the consumptive use needs.

REGIONAL WATER DEVELOPMENT PLANS

Preliminary to the development of the Oklahoma Comprehensive Water Plan, the state was divided into eight planning regions composed of counties naturally grouped and demonstrating homogeneity of climate, hydrology, geography, economics and demography. (See Figure IV.) The Planning Committee took into consideration these similarities, but at the same time, recognized the uniqueness of each region in its water resources and requirements, and accordingly formulated a local water development plan for each planning region. After stream and ground water resources were inventoried and water requirements were projected to the year 2040, future requirements were compared with local development potential in order to design a local plan based on optimum poten-

tial development. A summary of these regional plans, as well as their estimated costs, follows. Figure V indicates the proposed projects contained in the local plans of development.

Comparisons of fully developed stream and ground water resources with the future requirements for the Northwest, Southwest, North Central, Central and South Central Planning Regions project water shortages of varying degrees, and show surplus water greatly exceeding foreseeable demands in the Northeast, East Central and Southeast Planning Regions. These distribution variances are demonstrated by the fact that each year an estimated 34 million acre-feet of water flows unused out of eastern Oklahoma to the Gulf of Mexico, while at the same time, inadequate water supplies limit central Oklahoma's industrial development, and depleting ground waters in western Oklahoma portend what could be a disastrous return to dryland farming.

Figure IV summarizes local water resources and requirements projected to the year 2040.

The total first cost of development for all the local plans is estimated at approximately $3 billion at January 1978 prices.

Southeast Planning Region

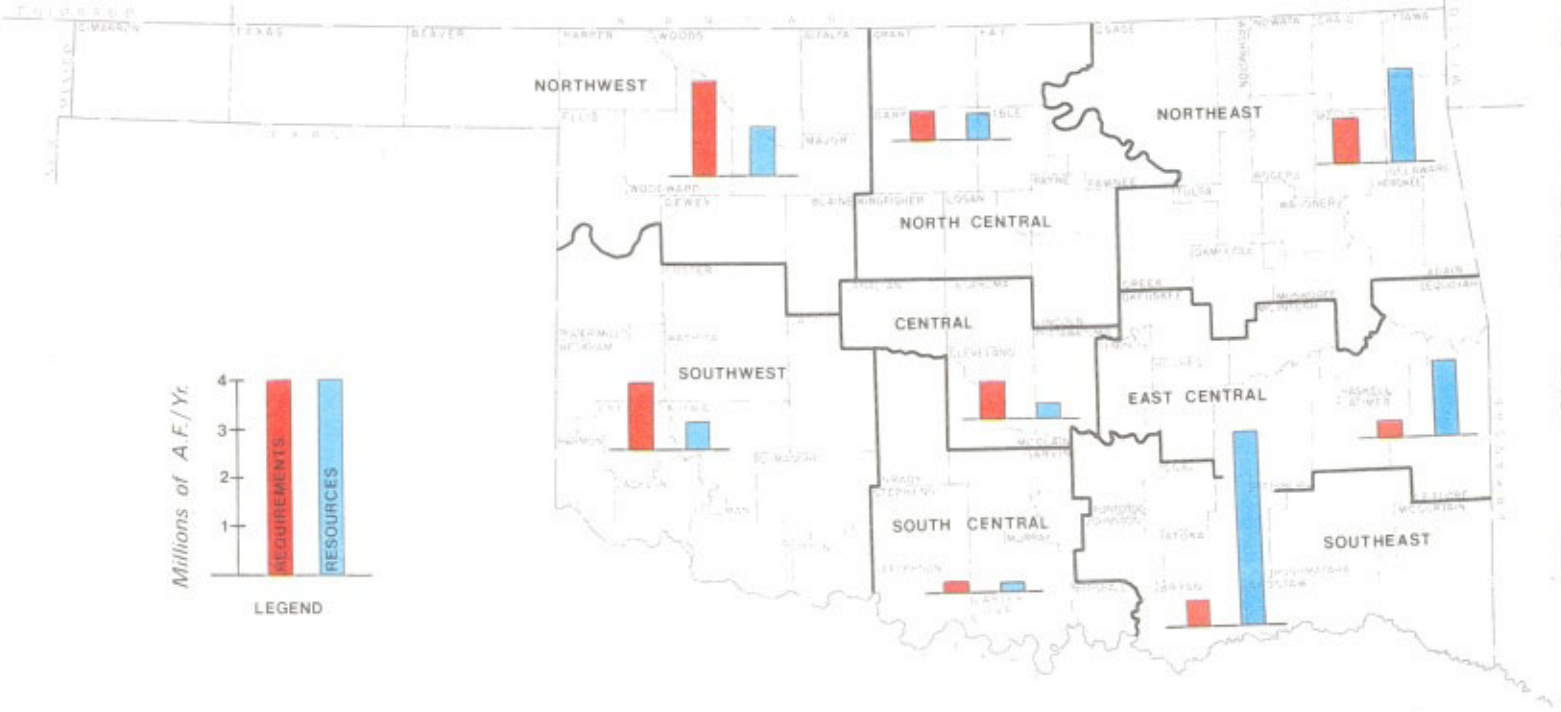
The Southeast Planning Region enjoys abundant rainfall and runoff, providing the area with a potential for extensive water resource development. The 8-county region currently has three existing major reservoirs, Broken Bow, Hugo and Pine Creek; and two additional reservoirs under construction, Clayton and McGee Creek, making available abundant supplies of good quality water. However, much of the region suffers from inadequate distribution systems and severe flooding problems which limit its potential economic development.

A local plan proposed for this region utilizes existing surface and ground water sources, along with several proposed reservoirs and increased ground water development, capable of fulfilling the region's projected future water supply needs. The local plan includes construction of the authorized Tuskahoma Reservoir, development of potential dam sites at Tupelo, Albany and Parker, and construction of municipal, industrial and irrigation distribution facilities. With the completion of these facilities, the Southeast Planning Region would have an annual surplus of approximately 1.6 million acre-feet of water. However, with construction of the authorized Boswell Reservoir, modification to the existing Hugo Lake and development of other potential dam sites not included in the local plan, the region could have a total surplus of 3.5 million acre-feet of water per year.

Central Planning Region

The Central Planning Region, the

FIGURE IV- YEAR 2040 STATEWIDE WATER RESOURCES AND REQUIREMENTS



Data-Oklahoma Water Resources Board
Mapping-Oklahoma Water Resources Board

most populous of the eight regions, is expected to continue its recent rapid growth, particularly in Oklahoma City and its suburban areas. Poor water quality of the region's streams, a result of natural and man-made pollutants, restricts the development of additional reservoir sites. Existing major reservoirs are Hefner, Overholser, Shawnee, Stanley Draper and Thunderbird.

The plan of development proposed for this region includes use of existing sources, as well as Arcadia Reservoir, which is currently under construction; increased use of ground water; and construction of new Soil Conservation Service lakes. The Garber-Wellington ground water aquifer underlying most of the area offers a good quality source for some communities. However, increasing populations and additional industrial development in the Central Planning Region will strain existing supplies, requiring the importation of 487,000 acre-feet of water each year by 2040.

South Central Planning Region

Water quality constraints and nominal rainfall levels have limited water development in the South Central Planning Region. Inadequate distribution of the water that is available plagues much of the region, and potential agricultural and agribusiness activities have been hindered by the lack of dependable water supplies. Only two major reservoirs, Arbuckle and Waurika, are located in the region.

Two additional proposed reservoirs, Purdy and Courtney, and new Soil Conservation Service lakes will meet a portion of the region's future water needs. Additional municipal, industrial and irrigation distribution facilities are also included in the plan for local development, but by 2040 the region will still experience a deficit of approximately 28,000 acre-feet per year which will have to be supplied with imported water.

Southwest Planning Region

The development of stream water supplies in the Southwest Planning Region has been limited by poor water quality and inadequate rainfall. Existing lakes are Altus, Fort Cobb, Foss and Tom Steed. Ground water presently provides most of the region's water supply, however depletion and pollution pose a threat to further development, and inadequate distribution facilities deprive many rural areas of water.

The plan of development proposed for the Southwest Planning Region includes construction of new reservoirs with distribution facilities and reliance on new Soil Conservation Service lakes to partially fulfill future needs. Cookietown, Hydro and Weatherford are major reservoirs proposed to serve the local area, but even with their construction, the region will have a projected water deficit of approximately 800,000 acre-feet by the year 2040, which will have to be supplied from sources outside the region.

East Central Planning Region

Although extensive development has occurred with the completion of Eufaula, Tenkiller and Wister Lakes in the East Central Planning Region, its major rivers and generous rainfall present a potential for substantial additional water resource development. Many residents are deprived of good quality water supplies by inadequate distribution systems or poor quality sources. To meet the area's future water requirements, east central Oklahoma will have to develop new sources and expand existing supplies.

The plan of development for this region includes construction of four new reservoirs, modification of the existing Wister Lake and increased ground water development. Atwood, Sasakwa, Weleetka and Wetumka are proposed to supply additional water, primarily for cooling water purposes. Tenkiller and Eufaula have water presently available, with Tenkiller's use contingent upon Congressional reallocation of hydropower and inactive storage so it may be used for water supply storage. Distribution facilities to convey the water to appropriate demand centers are also included in the local plan. The East Central Planning Region is projected to have a water surplus in excess of 880,000 acre-feet per year by 2040. However, development of other potential dam sites could provide the region with an annual surplus of 1.4 million acre-feet of water.

Northeast Planning Region

The Northeast Planning Region experiences abundant rainfall and runoff, thus presenting excellent potential for water resources development. Although the region has many major reservoirs and smaller lakes which provide an abundant supply of good quality water, it continues to suffer from inadequate distribution facilities, and many people remain unserved by a dependable water system. Major reservoirs existing or under construction include Birch, Candy, Copan, Eucha, Fort Gibson, Grand, Heyburn, Hulah, Oologah, Spavinaw and Skiatook. In addition, Sand and Shidler Reservoirs are authorized for construction. Flooding frequently occurs, and although remarkable progress has been made in the control of flood waters, many areas require additional flood protection, as well as additional supplies of water if future consumptive uses are to be satisfied.

The regional plan of development includes construction of two additional lakes, Welty and Sid, as well as utilization of existing sources which are not currently authorized for water supply, i.e., Fort Gibson, Grand and Tenkiller. Reallocation by Congress of hydropower and inactive storage to water supply storage in Tenkiller and Fort Gibson would be required in order to make additional supplies available. An agreement with the Grand River Dam Authority would need to be reached to provide additional quantities of municipal and industrial water from the power pool in Grand Lake. These sources would supply the local area's projected 2040 water needs, and at the same time provide a surplus of over 1.3 million acre-feet per year. Additional development not included in the local plan could provide 735,000

acre-feet per year, for a total annual surplus of over two million acre-feet.

North Central Planning Region

The North Central Planning Region's water resources are generally of poor quality due to high natural chloride concentrations in the upper reaches of the area's streams. Such pollution has severely restricted stream water development and forced increased reliance on ground water resources. Major existing reservoirs are Kaw and Keystone, however the latter cannot be used for most beneficial purposes due to poor water quality. Availability and water quality problems in many of the region's ground water basins limit their potential for future development.

The plan of development proposed for this region includes development of additional stream water supplies to fulfill a portion of the area's future water requirements. Hunnewell, Lela, Otoe, Seward and Hennessey are major reservoirs proposed for construction along with pertinent distribution facilities to increase local supplies. However, by 2040 the North Central Planning Region will still experience a water deficit of about 100,000 acre-feet per year to be met with imported water.

Northwest Planning Region

Due to low rainfall and runoff, stream water development in the Northwest Planning Region has remained extremely limited. Ground water provides most of the present water supply, with the Ogallala aquifer, underlying eight of the 11 counties, being the most productive and most highly utilized of the ground water sources. However, recent evidence indicates that the water table is dropping due to significant overdrafting of the aquifer. It is apparent that ground water resources alone cannot be relied upon as a future source of long-term supplies.

Major existing reservoirs in the region include Canton, Fort Supply, Optima and Great Salt Plains, although the latter is not suitable for most beneficial uses due to high chloride concentrations.

The regional plan of development includes construction of two proposed reservoirs, Englewood and Hydro, additional Soil Conservation Service structures and limited additional ground water development. Also included are pertinent municipal, industrial and irrigation facilities. Even with this increased development, it is estimated that the Northwest Planning Region will still experience a deficit of approximately 950,000 acre-feet of water per year by 2040, which would have to be supplied from areas outside the region.

ALTERNATIVES TO WATER TRANSFER

In the development of the Oklahoma Comprehensive Water Plan, various nontransfer alternatives considered even remotely capable of meeting Oklahoma's projected water demands were analyzed. These alternatives were of both a structural and nonstructural nature and included weather modification, artificial recharge, desalination, wastewater reuse, chloride control and improved water management. In addition, a no-action scenario was evaluated to project the consequences if present trends were permitted to continue into the future without material alteration.

Conclusions from such analyses strongly indicate that, while these alternatives may individually and/or collectively provide some additional water, the amount is insignificant compared to Oklahoma's total future water needs. Therefore, nontransfer alternatives must be considered only as supplemental sources of water incapable of wholly fulfilling the state's long-range water requirements. Nonetheless, these alternatives should receive continued emphasis on a local basis and remain part of the state's overall planning efforts.

One of the options available to Oklahoma is simply to take no action in regard to implementing a comprehensive statewide water plan. Such a scenario assumes the state will make no new efforts to reduce demands or augment supplies, and that all water users will continue to rely on available local ground and stream water resources, regardless of the quantity and/or quality of those waters.

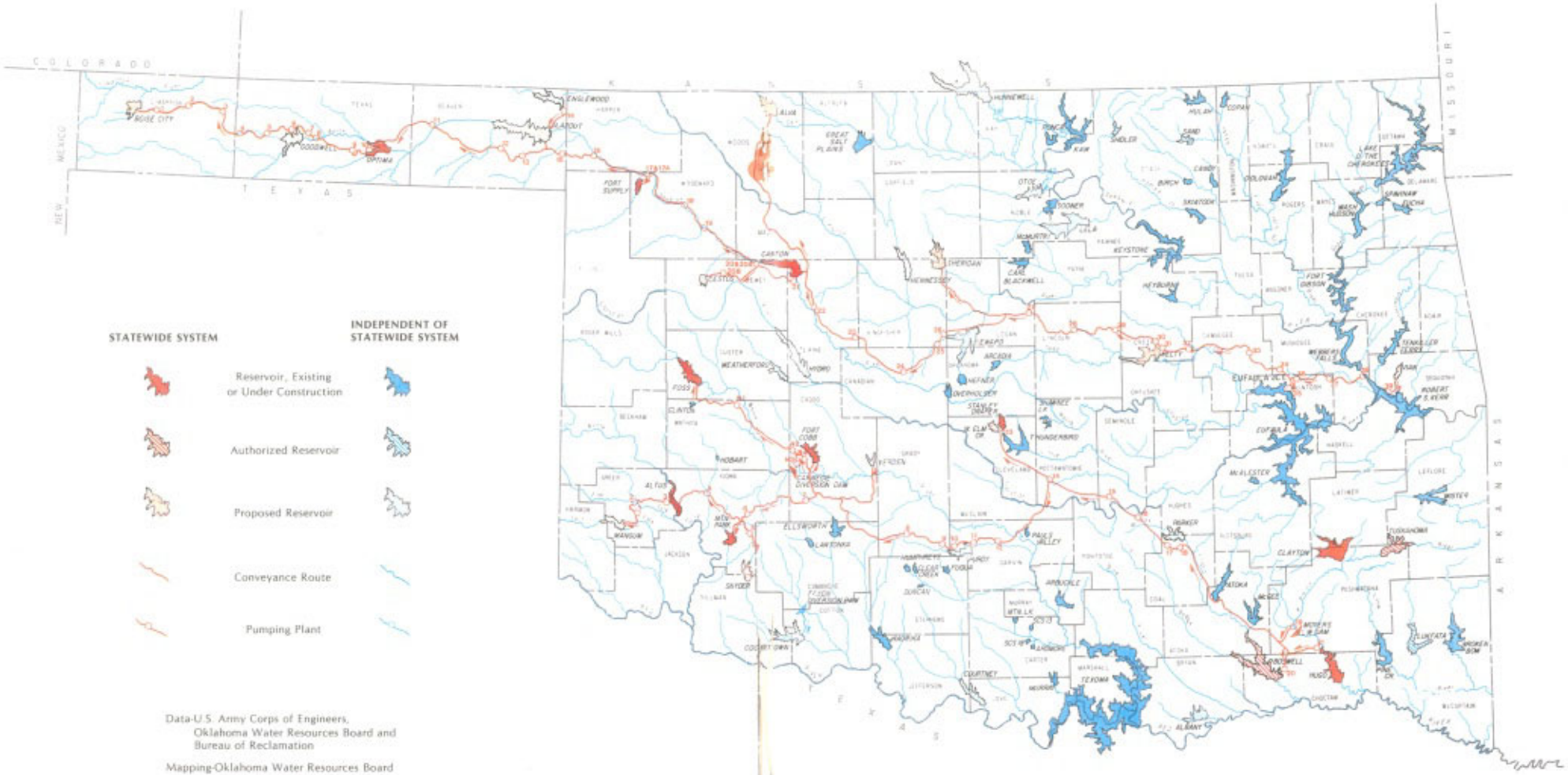
The no-action scenario further predicts that the larger cities which can afford to construct independent water transfer systems will continue to obtain water from other areas of the state, possibly at the expense of smaller cities, towns and rural areas. Such short-range development is of a piecemeal nature and will be more costly in the long run than a regional plan. Areas which presently lack adequate fresh water supplies would be denied the opportunity for expansion of business and industry, and irrigation farmers in western Oklahoma forced to revert to dryland farming as depleting ground water supplies either become too expensive or unavailable at any price. Those areas of the state with adequate water resources would continue to grow until the population became as great as could be supported by the water available, at which time their economic growth would be curtailed.

It is obvious from the rate at which water consumption is exceeding supply in some areas that by the turn of the century, these areas could decline into an economic recession of profound consequences to the entire state.

THE STATEWIDE WATER CONVEYANCE SYSTEM

State and federal studies to date indicate that the only viable means of providing additional water to Oklahoma's water-deficient areas is by transferring surplus water from eastern Oklahoma. The two water conveyance systems proposed as integral parts of the Oklahoma Comprehensive Water Plan would accomplish this redistribution.

Specific assumptions upon which the statewide water conveyance system are based include: (1) existing multipurpose reservoirs are tied into the system to maximize the use of existing development; (2) all good quality ground and stream water resources



Data-U.S. Army Corps of Engineers, Oklahoma Water Resources Board and Bureau of Reclamation

Mapping-Oklahoma Water Resources Board

FIGURE V- STATEWIDE WATER CONVEYANCE SYSTEM

Including Proposed Local Projects

in western Oklahoma are developed to the maximum extent practical; and (3) all proposed local projects are encouraged for development so that the import requirements of a region are minimized.

In the formulation of the statewide water conveyance system, it was determined that the Corps of Engineers would be the lead agency in developing draft plans and cost estimates for the central and eastern parts of the state, and the Bureau of Reclamation would have the responsibility for planning conveyance facilities in western Oklahoma. During the course of work, the Planning Committee coordinated the activities of all participants and worked together closely to utilize the results of their studies to formulate the water conveyance system presented herein.

GENERAL DESCRIPTION

Figure V shows the two conveyance systems proposed as a means of assuring the entire state of adequate amounts of water through the year 2040.

The northern conveyance system would utilize surplus flows at Lake Eufaula and Robert S. Kerr Reservoir. Off-stream regulating storage would be provided at Welty and Vian Creek Reservoirs. The surplus water would then be conveyed to nine terminal reservoirs in north central and northwestern Oklahoma. The total amount of water transferred through the northern conveyance system would be 1.2 million acre-feet annually, primarily for irrigation purposes.

The southern water conveyance system, updated from Phase I of the Oklahoma Comprehensive Water Plan, would direct surplus water from existing and authorized reservoirs in southeastern Oklahoma to central and southwestern Oklahoma. The Central Planning Region would receive 487,000 acre-feet per year for municipal and industrial use, with the proposed West Elm Creek Reservoir serving as a terminal reservoir. A turnoff near Wayne would carry 823,000 acre-feet of largely irrigation water per year southwestward to seven terminal reservoirs. Total water delivered would be 1,310,000 acre-feet per year.

STAGING

In order to minimize the unit cost of transporting water, each conveyance system is proposed to be built in stages coordinated with the increased water needs of the import regions. The initial stage of development of each system would include construction of a portion of the source components and a major segment of their conveyance canals, so that water would be available for use in some areas of the import regions at the end of the first stage.

In succeeding stages additional sources of water would be developed and the import capabilities of terminal reservoirs in western Oklahoma increased until the ultimate capacity of each system is achieved. The northern water conveyance system is proposed for construction in three stages over a 30-year period, while the southern system would be completed in four stages over the same period. The systems have been designed so that by the end of the thirteenth year after initiation of construction, all counties requiring imported water would have sufficient amounts available to meet their projected demands.

ENVIRONMENTAL CONSIDERATIONS

Although any construction of the magnitude of the proposed statewide water conveyance system can be expected to affect the natural environment, appropriate mitigation procedures can minimize these effects. As more detailed planning continues, mitigation/compensation of environmental consequences due to construction of specific reservoirs and distribution canals will be thoroughly considered in order to minimize potential adverse effects.

COSTS OF THE STATEWIDE SYSTEM

Preliminary cost estimates for the statewide water conveyance system are based on January 1978 price levels and a 100-year period of analysis. They include: (1) construction costs of proposed dams and terminal reservoirs and modifications of existing dams; (2) cost of water supply storage in existing, under construction and authorized federal reservoirs; (3) construction costs of conveyance facilities, irrigation distribution facilities, and municipal and industrial transmission lines; (4) average annual operation, maintenance, replacement and energy (OMR & E) costs; (5) mitigation/compensation costs to allow for unavoidable losses to fish and wildlife habitat; and (6) average annual equivalent cost which discounts the cost of all project features, including future phases (if developed) to a common time period, allowing their assessment on a comparative basis.

The average annual equivalent cost includes interest and amortization, as well as annual OMR & E costs and mitigation/compensation costs. This cost reflects the average annual expenses necessary to repay the construction cost and interest during construction, along with OMR & E over the 100-year period of analysis. Interest during construction is computed at the federal discount rate of 6 5/8 percent. No costs are included for local distribution and/or treatment of municipal and industrial water.

As shown in Figure VI, total construction cost of the northern and southern conveyance systems is approximately $7.8 billion (assuming the authorized Arkansas River chloride control projects are operational), with an average annual equivalent cost of $555 million.

An accurate cost of municipal and industrial water conveyed through the system can be calculated only when an actual repayment schedule is agreed upon and appropriate contracts negotiated. However, a rough estimate of the value or average unit cost of water for the 50-year repayment period can be obtained by dividing the average annual equivalent cost attributable to municipal and industrial water by the ultimate municipal and industrial capacity of the system. This method indicates an

FIGURE VI
SUMMARY OF COSTS
STATEWIDE WATER CONVEYANCE SYSTEM
($1,000)

WATER CONVEYANCE SYSTEM	CONSTRUCTION COST	TOTAL AVERAGE ANNUAL EQUIVALENT COST[1]
Northern System[1]		
Reservoirs[2]	$ 600,000	$ 10,200
Conveyance Facilities	3,440,000	95,600
Irrigation Distribution	1,100,000	220,100
M & I Distribution	71,000	33,300
Mitigation/Compensation	85,000	5,600
Subtotal	$5,296,000	$364,800
Southern System		
Reservoirs[2]	$ 225,000	$ 3,400
Conveyance Facilities	1,425,000	75,000
Irrigation Distribution	765,000	95,000
M & I Distribution	75,000	15,200
Mitigation/Compensation	18,000	1,300
Subtotal	$2,508,000	$189,900
TOTAL	$7,804,000	$554,700

[1]Cost estimates shown for northern system assume Arkansas River Basin Chloride Control Projects operational. Costs without the chloride control projects would be $5.6 billion for construction and $375 million for average annual equivalent costs.

[2]Reflects cost of proposed reservoirs, modifications to existing lakes and water supply storage in existing, under construction and authorized federal reservoirs.

[3]Includes interest and amortization at 6 5/8 percent interest and 100-year period of analysis. Also includes average annual OMR&E expenses and mitigation/compensation costs.

average cost per thousand gallons of 30 cents in the southern system and $1.60 in the northern system. However, this represents only the average cost of water, and does not reflect the high unit cost during the early years of the project, when a substantial portion of the first cost would be incurred and the capacity of the system would be relatively small. The cost of water would increase as distance from the source increases, and the consumer cost of water would further increase as charges for local distribution and treatment are included.

A rough estimate of the cost of irrigation water can be obtained by dividing the cost attributable to irrigation by the amount of water conveyed through the system for irrigation purposes. This crude estimation indicates a cost per acre-foot of $200 in the southern system and $335 in the northern system. This cost includes the allocated cost for irrigation water to the main conveyance, as well as irrigation distribution facilities from the terminal reservoirs to the irrigated areas. Again, this cost reflects merely an average over the life of the project, and would vary depending on the point of diversion from the canal and the distance from reservoir to farm. During the initial phases of the project, the cost would be substantially higher.

BENEFITS OF THE STATEWIDE SYSTEM

To determine the feasibility of the system, the benefits accruing to the project must be estimated, then compared to the project cost. At this early planning stage, a detailed benefit evaluation to determine the overall economic feasibility of the project has not been prepared. However, a rough approach can be utilized to estimate project benefits. This approach assesses only primary benefits, while in reality, secondary and tertiary benefits would also accrue from a water conveyance system.

Average annual equivalent benefits from both systems are $122.6 million, with municipal and industrial benefits totalling $97.9 million and irrigation benefits $24.7 million.

Municipal and Industrial Benefits

The assumption utilized in determining an estimate of municipal and industrial benefits is that the benefits equal the average annual equivalent cost of the least costly alternative capable of providing the amount of water necessary to fulfill user requirements. This assumption reflects the philosophy that delivered municipal and industrial water is worth at least the cost of developing and delivering it to the users. Therefore, the average equivalent costs and benefits are assumed to be equal, giving the municipal and industrial component of both systems a 1:1 benefit-cost ratio. More detailed municipal and industrial benefit analysis may indicate that benefits would actually exceed cost, in which case, the benefit-cost ratio would be greater than 1:1.

Irrigation Benefits

Irrigation benefits were estimated according to federal guidelines, which involves determining net farm incomes without water conveyance (dryland farming) and with water conveyance (irrigation farming). The difference between the two represents the primary benefits attributable to the conveyance systems, and although secondary and tertiary benefits would also occur, they are not included in this analysis.

BENEFIT-COST ANALYSIS

A comparison of benefits with costs enables the economic feasibility of a project to be determined. Under federal guidelines, benefits must equal or exceed costs in order for a project to be considered economically justified and thus eligible for construction. Average annual equivalent benefits accruing from the northern water conveyance system and the southern conveyance system indicate that neither system is economically justified under federal criteria, which recognize only primary benefits.

Indirect benefits from the system will also most assuredly occur, but are not included in this analysis. In-

direct benefits would be in the form of increased employment, greater recreational opportunities, increased state and local retail sales and generally expanded economic activity. A Statewide Economic Impact Study currently underway by the University of Oklahoma and Oklahoma State University, under the direction of the Oklahoma Water Resources Board, will quantify these indirect impacts, thus increasing the benefits of the system. Evaluation may show the system to be of sufficient economic benefit to justify the state's subsidizing that portion of the project's cost which is not considered feasible under federal guidelines, or perhaps to wholly assume the cost of the water conveyance system.

The Northern Water Conveyance System

WATER REQUIREMENTS

As discussed in the "Regional Water Development Plans," two of the four regions in the northern 44 counties of Oklahoma are expected to experience future water deficits. Projections for the Northwest and North Central Planning Regions indicate an import need of approximately 1,050,000 acre-feet per year by 2040. Nearly 1.2 million acre-feet of water would be imported annually via the northern conveyance system to meet this demand and provide for conveyance losses.

The projected water supply needs of northeastern and east central Oklahoma indicate that the majority of the water supply storage in existing, under construction and authorized lakes, as well as other potential lakes, will be utilized locally by the year 2040, thus offering only limited prospect as a source of water for transfer to north central and northwestern Oklahoma. The scattered locations and relatively small dependable yields of other potential lakes limit their viability as sources for the large amounts involved in any transfer plan. Preliminary work revealed that only those reservoirs with large amounts of hydroelectric power and inactive storage appropriate for reallocation to water supply storage, and the surplus flows on the Arkansas River and its tributaries, offered viable sources for the projected 1.2 million acre-feet annual requirements of northwestern and north central Oklahoma.

EVALUATION OF ALTERNATIVE PLANS

Prior to the selection of a plan, the Planning Committee assessed various alternatives for both the source and conveyance components of the system.

For the source component of the system, 14 alternatives were assessed, eight of which assumed the Arkansas River chloride control projects to be operational, and six without such assumption.

Each alternative was formulated to provide an ultimate diversion of approximately 1.2 million acre-feet annually, and was based on preliminary estimates of net dependable yield available from the various source reservoirs and the size of required conveyance facilities. The time frame of construction of each alternative was based on the assumption that the import demands of the northwest would increase over time, and that further refinements in designs and cost estimates will be made upon selection of the most desirable plan.

Because the Arkansas River and its major tributaries in eastern Oklahoma have been extensively developed for navigation, hydroelectric power and other purposes, no suitable sites remain on these streams for development of additional large-scale reservoirs. Therefore, any new reservoirs required to serve as sources of water for northwestern Oklahoma would have to be constructed in watersheds of minor tributaries. Storage provided in these reservoirs would be used to regulate surplus flows diverted from alternative sources. Potential reservoir sites were inventoried and the sites screened according to their proximities to potential diversion points, storage capacities and potential environmental effects.

Fourteen alternatives were coordinated with the members of the Oklahoma Comprehensive Water Plan Planning Committee, including representatives of the U.S. Fish and Wildlife Service and the Oklahoma Department of Wildlife Conservation. The U.S. Fish and Wildlife Service used a nonmonetary matrix analysis on the alternatives to rank them in terms of their environmental impacts.

The preliminary costs of each alternative were assessed on the basis of January 1978 price levels. The costs reflect staging of project components to meet preliminary estimates of northwestern Oklahoma import demands.

Although the estimated construction cost of the selected alternative was only the second lowest, it displayed the fewest adverse environmental effects of any of the 14 options, and was chosen by the Planning Committee for further refinement and development.

The alignment of conveyance facilities from eastern Oklahoma to terminal reservoirs in northwestern Oklahoma was selected from alternative conveyance routes previously developed by the Bureau of Reclamation. The conveyance route selected to pick up surplus water from source facilities in eastern Oklahoma then convey it westward was based on modifications to the alternative determined to best serve the area's projected water supply needs.

THE SELECTED NORTHERN WATER CONVEYANCE SYSTEM

The selected northern conveyance system is based on modifications and refinements of the alternative chosen, which was then developed under the assumption of an operational Arkansas River chloride control project and under present conditions without chloride control.

The selected system would include major modification of an existing reservoir (Fort Supply); construction of eight proposed reservoirs; approximately 710 miles of canals and inverted siphons; approximately 140 miles of pipeline; 42 pumping plants, including six with reservoir intakes;

municipal and industrial delivery systems and irrigation distribution systems with appurtenances. At ultimate development, the northern conveyance system would provide north central and northwestern Oklahoma with an additional dependable water supply of 1,034,400 acre-feet annually and allow for conveyance losses of approximately 177,700 acre-feet.

Sources of water would be surplus flows from the Canadian River at Eufaula Lake and the Arkansas River at Robert S. Kerr Lake, requiring a maximum combined diversion of 5,000 cfs with an operational chloride control project, or 6,500 cfs without. Construction of Welty and Vian Creek Lakes would eventually be necessary for regulating purposes. Up to 4,000 cfs, depending upon available surplus and unused storage in Welty Lake during pumping periods, would be diverted at Eufaula. Diversions of up to maximum capacity could also be made at Robert S. Kerr Lake, depending on available surplus flow, quantities diverted at Eufaula and unused regulating storage.

West of Pumping Plant 28 in central Lincoln County, the system would consist of three existing reservoirs: Optima, Fort Supply and Canton; and six proposed reservoirs: Boise City, Goodwell, Slapout, Cestos, Alva and Sheridan. Fort Supply Dam would be raised three feet to provide additional terminal storage. The six new reservoirs which are proposed would be exclusively terminal reservoirs designed to receive import water. Englewood Reservoir, a proposed local project, would tie into the main water conveyance system by providing supplemental water to Slapout Reservoir as well as providing irrigation storage for area use. Approximately 500,000 acres would be irrigated with import water.

The northern water conveyance system would deliver an average of 1,030,900 acre-feet of water annually, which, along with the firm yield of the terminal reservoirs, would meet northwestern and north central Oklahoma's projected water deficits through 2040.

COSTS

Preliminary cost estimates for the northern water conveyance system indicate total cost of construction for the system to be around $5.3 billion, with the chloride control projects in operation. This cost includes $600 million for construction of new proposed reservoirs, $3.44 billion for the conveyance canal from eastern Oklahoma to the extreme western Panhandle, $1.1 billion for pertinent irrigation distribution facilities, $71 million for municipal and industrial facilities and $85 million for mitigation/compensation costs. The average annual equivalent cost would be approximately $365 million, which includes $117 million in annual OMR & E expenses and $5.6 million in annual mitigation/compensation costs. OMR & E costs consist primarily of energy or pumping costs computed at a 30-mil power rate with annual requirements estimated to be 6.4 billion KWH.

Without implementation of the authorized chloride control projects, the construction cost and average annual equivalent cost of the northern system would increase to $5.6 billion and $375 million, respectively.

BENEFITS

Direct benefits accruing from the northern system were estimated to be $58 million annually, consisting of $17 million of irrigation benefits and $41 million of municipal and industrial benefits. Municipal and industrial benefits were assumed to equal the average annual equivalent costs attributable to the municipal and industrial component of the system. Annual irrigation benefits, calculated as the difference between dryland farming and irrigation farming, are estimated at $32.60 per acre.

BENEFIT-COST ANALYSIS

A rough comparison of annual benefits ($58 million) and costs ($365 million) indicates the northern water conveyance system exhibits a benefit-cost ratio of .16. Under federal planning guidelines, such a ratio renders a project economically infeasible and construction cannot be justified. However, considerable indirect benefits, particularly those due to agricultural and agribusiness impacts, would result from the transfer system, and would also need to be considered before the feasibility of the project is ultimately determined.

Southern Water Conveyance System

As indicated earlier, three of the four planning regions in the southern 33 counties of Oklahoma are projected to face severe water shortages in the foreseeable future. Even with full development of the proposed local water sources outlined for these three regions, they may still experience a combined deficit of almost 1,240,000 acre-feet per year by 2040 which will have to be supplied from other areas of the state. Studies show that existing, planned and potential stream water development and ground water sources in southeastern Oklahoma could easily supply that region's projected water needs and produce an annual surplus of approximately 2.2 million acre-feet. (See Figure III.)

WATER REQUIREMENTS

Water requirement projections by the Planning Committee indicate that by the year 2040, central Oklahoma will need to import 487,000 acre-feet annually for municipal and industrial purposes; and southwestern and south central Oklahoma will require 728,500 acre-feet and 28,000 acre-feet per year, respectively, primarily for irrigation purposes.

EVALUATION OF ALTERNATIVE PLANS

An analysis was undertaken to identify potential water sources in southeastern Oklahoma and to evaluate alternative canal alignments to carry the water to central and southwestern regions. The abundance of water in southeastern Oklahoma provided many potential sources for evaluation. It was determined that four reservoirs — Hugo, Clayton, Boswell and Tuskahoma — offered the greatest potential to form the

source component of the system. Hugo is an existing reservoir; Clayton is under construction and scheduled for completion in 1981; and Boswell and Tuskahoma are authorized for construction. These sources could provide 1,320,000 acre-feet, which would be more than capable of meeting the import demand of the three regions with projected deficits and allow for attendant conveyance losses.

The conveyance facility to central Oklahoma is a modification and expansion of alternative plans developed by the Corps of Engineers in conjunction with their Central Oklahoma Project (COP) investigations. One initial COP alternative consisted of a system designed to provide municipal and industrial water to central Oklahoma. It has been redesigned to provide additional water for south central and southwestern Oklahoma at a pickup point near Wayne. Alternative plans were prepared by the Bureau of Reclamation to convey the water to terminal points in south central and southwestern regions. An assessment of these alternatives indicated one route had certain cost advantages over others, so that alternative was selected for further study.

THE SELECTED SOUTHERN WATER CONVEYANCE SYSTEM

The selected conveyance system for the southern 33 counties of Oklahoma is a modification of the Corps' Central Oklahoma Plan with a distribution segment furnished by the Bureau to transport water to the southwest. The conveyance system consists of a network of canals, pipelines, conduits and pumping plants to transport surplus water from Hugo, Clayton, Tuskahoma and Boswell Reservoirs from a pickup point on the Kiamichi River near Moyers, Oklahoma, to central and southwestern Oklahoma. Water for central Oklahoma would be conveyed into Lake Stanley Draper and the proposed West Elm Creek Reservoir, which is immediately adjacent to Draper. Annual delivery to this region would be 487,000 acre-feet for municipal and industrial purposes through the 200-mile open canal, with the total lift of 800 feet requiring six pumping plants.

The western segment of the system would pick up water at the Wayne turn-off and carry it via a similar open canal to seven terminal reservoirs in southwestern Oklahoma. Four of the reservoirs are existing and three are proposed: Mangum, Snyder and Verden. The canal would be 327 miles in length with a capacity ranging from 46 to 1,250 cfs requiring 16 pumping plants. Average annual water delivered to the region from the canal would be around 748,500 acre-feet. Conveyance losses of 74,500 acre-feet per year bring the average annual conveyance of the system to 823,000 acre-feet. The imported water combined with the firm yield of the terminal reservoirs would supply 887,300 acre-feet per year to the area — 796,900 for irrigation purposes and 90,400 for municipal, industrial and cooling water purposes. An estimated 420,000 acres would be irrigated from the conveyance system. Irrigation facilities to distribute the water from terminal reservoirs are included in the plan. In addition, municipal and industrial transmission lines conveying water to demand centers are also included, however, local distribution facilities are not included.

Total water supplied by the southern water conveyance system to meet the future water deficits of central and southwestern Oklahoma would be around 1,320,000 acre-feet per year.

COSTS

Cost estimates for the southern water conveyance system indicate a total construction cost of approximately $2.5 billion for proposed new reservoirs, conveyance facilities, water supply storage in existing and authorized reservoirs, and pertinent distribution facilities. The average annual equivalent cost would be approximately $190 million, which includes $78 million for annual OMR & E costs and $1.3 million for annual mitigation/compensation costs. A major portion of these costs consists of energy/pumping costs calculated at a 30-mil power rate with annual requirements estimated at 2.4 billion KWH. The first cost includes $120 million for new dams and reservoirs, $105 million for water supply storage in existing and authorized reservoirs, $1.425 billion for conveyance facilities, $765 million for irrigation distribution facilities, $75 million for municipal and industrial transmission lines and $18 million for mitigation/compensation costs.

BENEFITS

Direct benefits accruing from the southern water conveyance system are estimated at $64.6 million, with $8 million attributable to irrigation and $56.6 million to municipal and industrial benefits. Annual irrigation benefits are estimated at $20.20 per acre.

BENEFIT-COST ANALYSIS

A comparison of annual benefits ($64.6 million) with costs ($190 million) indicates that the southern water conveyance system has a benefit-cost ratio of .34. Under federal planning guidelines, such a ratio renders a project infeasible and it cannot be constructed. The substantial indirect economic impacts which would occur, but which are not included in the analysis, would also need to be considered in any final feasibility determination.

RED RIVER ALTERNATIVE WITH CHLORIDE CONTROL

The high cost of irrigation water under the proposed southern conveyance system prompted a cursory assessment of an alternative utilizing water sources closer to the area of use. This alternative basically separates the proposed southern water conveyance system into two independent systems. One would furnish municipal, industrial and irrigation water to south central and southwestern Oklahoma from the Red River in south central Oklahoma. The other system would have the same alignment from southeastern to central Oklahoma as that previously discussed.

Utilization of the Red River and Lake Texoma as water sources for south central and southwestern Oklahoma is contingent upon several factors, among which are: (1) the chloride control projects would have to be completed and operational for the water in Lake Texoma to be of quality suitable for use; (2) Congressional reallocation of the hydropower and inactive storage in the reservoir to water supply storage would be necessary; (3) storage allocation provisions of the Red River Compact would have to be met; and (4) an assessment of a reduction in downstream releases would be required.

Preliminary studies indicate that the potential Gainesville dam site, located about 70 miles upstream from Lake Texoma, could be developed to operate in conjunction with Texoma to provide sufficient water of suitable quality to meet the import needs of southwestern Oklahoma.

Apparent advantages of a Red River alternative are multifaceted. Water obtained nearer the area of use would not only substantially reduce reliance on transfers from southeastern Oklahoma, but should result in cost savings. In addition, with two independent systems, each conveyance element could be evaluated on its own merits. Preliminary studies by the Corps of Engineers indicate that a plan for the conveyance of surplus water from southeastern to central Oklahoma for municipal and industrial use may presently be economically feasible, and removal of the irrigation features could facilitate the planning for the Central Oklahoma Project (COP). Projections indicate that existing water supply sources for central Oklahoma, including Arcadia and McGee Creek Lakes currently under construction, will only satisfy the area's water needs until the mid-1990's. With the lead time necessary for planning, design and construction, it appears unlikely, even if work resumed today, that the COP could be completed in time to forestall water shortages in central Oklahoma.

Further studies to assess the merits of this alternative and determine the appropriateness of its inclusion as part of the Oklahoma Comprehensive Water Plan appear warranted.

THE EASTERN OKLAHOMA WATER SUPPLY SYSTEM

An Eastern Oklahoma Water Supply System is included in the Oklahoma Comprehensive Water Plan in order to incorporate the desires expressed by several eastern Oklahoma legislators, economic development organizations and segments of the general public, regarding water resource development and to reassure those interests that any system proposed to convey water to the west would utilize only water exceeding the future water needs of eastern Oklahoma.

The system was prepared as a response to criticism voiced following publication of Phase I of the Oklahoma Comprehensive Water Plan in 1975. Some eastern Oklahomans stated that the water requirement projections underestimated their area's potential for growth and industrial development. Concern was expressed that water necessary to meet the future needs of the area might be transported to other areas of the state, and thereby preclude future growth and economic development of eastern Oklahoma.

The 34 easternmost counties were chosen for the study area, which includes the Southeast, East Central and Northeast Planning Regions, plus Lincoln and Pottawatomie Counties. Coordination throughout the study was accomplished through meetings sponsored by the Southern Oklahoma Development Association (SODA), Kiamichi Economic Development District of Oklahoma (KEDDO), Eastern Oklahoma Development District (EODD), North Eastern Counties of Oklahoma (NECO), Central Oklahoma Economic Development District (COEDD) and the Economic Resource Development Association (ERDA). The Economic Resource Development Association is an organization with a membership from 24 counties formed in 1975 to promote and assist in the development of economic, social and industrial potential in southeastern Oklahoma.

Population and water requirement projections for the Eastern Oklahoma Water Supply System are based upon meetings conducted by the Oklahoma Water Resources Board, the Corps of Engineers and the substate planning districts. Projections for the Indian Nations Council of Governments (INCOG) area are those developed in the Tulsa Urban Study by the Corps of Engineers, in coordination with INCOG and other study participants. Following finalization of these projections, alternative water supply plans were developed and submitted to ERDA and the substate planning districts for their review.

A system was selected from the alternatives and is included as part of the Oklahoma Comprehensive Water Plan. Full coordination and development of the water supply system for eastern Oklahoma are incomplete, pending agreement on details of the selected plan by EODD's Board of Directors. These details concern the reallocation of hydropower and inactive storage in Tenkiller Lake to water supply storage. The Tenkiller Lake restudy currently underway by the Corps of Engineers will be completed in 1982, and as it progresses, the issues raised by EODD will be addressed and the system considered for inclusion in future revisions of the Oklahoma Comprehensive Water Plan.

Water Supply Sources

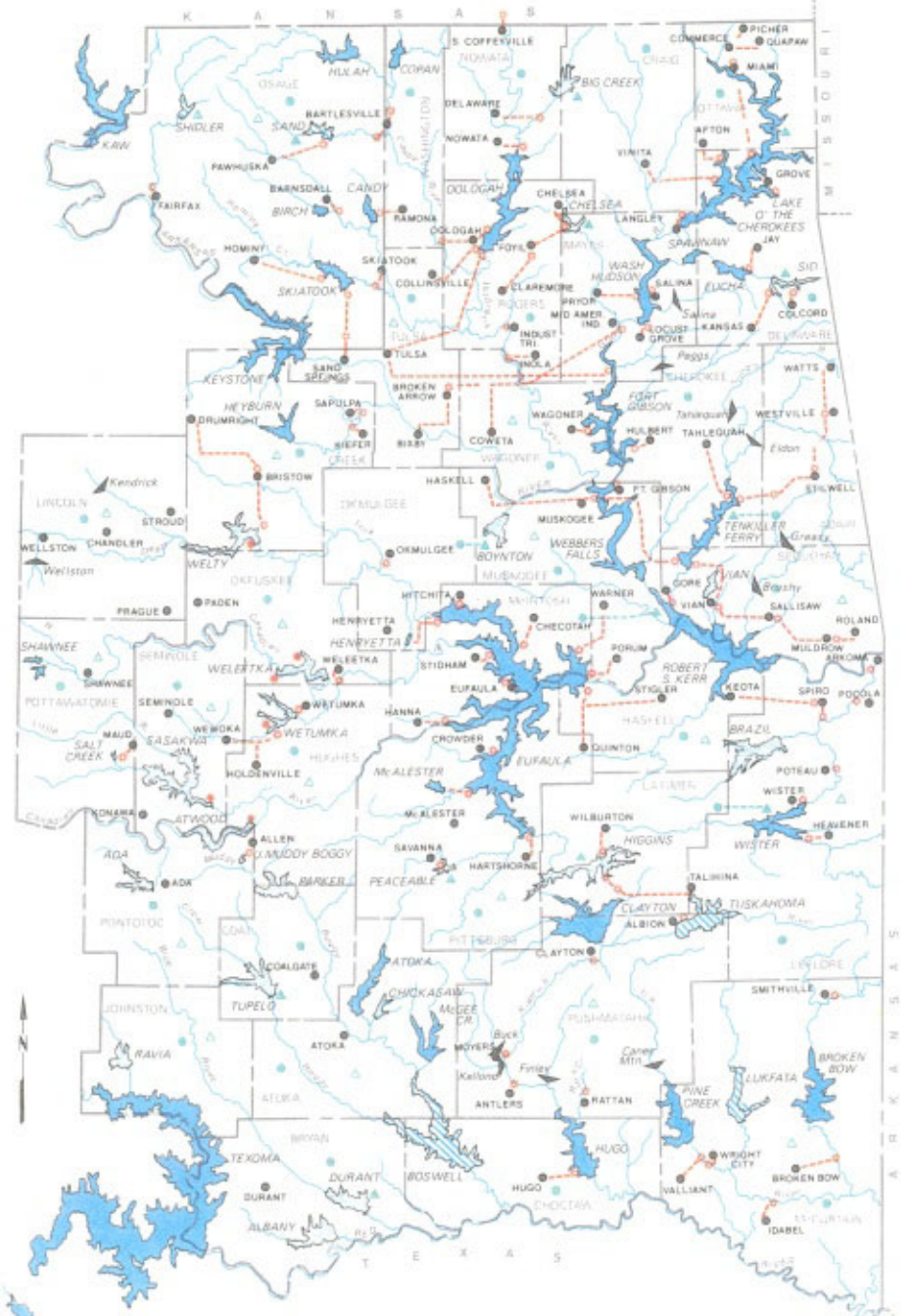
Both stream and ground water were considered as sources of supply in the study. Stream water resources include the existing, under construction, authorized and potential lakes as shown in Figure V. The Arkansas River below Keystone Lake was also considered to be a usable water supply source, upon the assumption that the Arkansas River chloride control projects would be operational and economically feasible. Waters of the Arkansas could be utilized even without chloride control, but water of suitable quality would be available less frequently and at a greater cost. Sources of ground water were iden-

tified as the Vamoosa, Roubidoux, Arbuckle, Antlers Sandstone ground water basins and various terrace and alluvium deposits.

Projected Water Requirements

Projections of water requirements by the Corps of Engineers, based on data provided by the substate planning districts and ERDA, totalled 4.2 million acre-feet annually by the year 2040. This compares with the approximate two million acre-feet per year forecast by the Oklahoma Comprehensive Water Plan Planning Committee and used in developing the regional water development plans previously discussed. The major difference in the projections is the extensive amount of irrigation forecast by the substate planning districts and ERDA which is not projected by the Planning Committee.

FIGURE VII- EASTERN OKLAHOMA WATER SUPPLY SYSTEM



Data-U.S. Army Corps of Engineers Mapping-Oklahoma Water Resources Board

Demand Centers

It was considered appropriate to identify certain demand centers within each county which would become terminal locations for water conveyance facilities. A demand center was identified as a city, a group of communities using a common water supply source, or an industrial or utility demand area having a projected water requirement of 1.0 mgd or greater by the year 2040. Exceptions were entities which were geographically isolated or located closer to a source than to a demand center.

Irrigation demands were developed on a countywide basis, and no specific demand centers or terminal points were identified. It was assumed that irrigation demands would first be met by utilizing ground water where supplies are available. Where ground water is not a viable source, stream water sources were considered, and the costs of irrigation water from stream water sources are included in the cost estimates. If the supply should be a stream water source outside the county, the cost of a transmission system to move the water is included in the cost estimates.

Description

The Eastern Oklahoma Water Supply System would require development of both ground water and stream water resources beyond that proposed in the regional water development plans in order to meet the future water needs forecast by local planners.

Figure VII illustrates the water supply system proposed to meet the municipal, industrial and irrigation water demands forecast by the local interests. The municipal and industrial water supply system would require the construction of 10 reservoirs and appropriate distribution facilities in addition to those proposed by the Planning Committee in the regional plans. These reservoirs are: Big Creek and Chelsea in the Northeast Planning Region; Brazil, Higgins and Peaceable in the East Central Planning Region; and Ada, Chickasaw, Durant, Lukfata (authorized) and Ravia in the Southeast Planning Region. Additional ground water supplies would also have to be developed to meet a portion of the municipal and industrial water needs. Municipal and industrial distribution facilities from water sources to appropriate demand centers are also shown in Figure VII.

The irrigation component of the Eastern Oklahoma Water Supply System would utilize the Arkansas River, requiring the construction of Boynton Lake as an off-stream storage reservoir, as well as utilizing irrigation storage in several of the proposed reservoirs and reallocation of storage in existing lakes. Distribution facilities for irrigation water supplied by reservoirs in adjacent counties are included. In cases where downstream releases could be made, the water would be diverted at the points shown in Figure VII. A few counties would supplement irrigation water supplies with water conveyed from major reservoirs, while Coal, Nowata and Latimer Counties would rely solely on major reservoirs for irrigation water.

Costs

Preliminary cost estimates for the Eastern Oklahoma Water Supply System indicate the first cost could be over $3 billion, with an average annual equivalent cost of almost $190 million. The first cost of projects contained in the "Regional Water Development Plans" for this area is $870 million, with an average annual equivalent cost of $74 million. Thus the costs of developing the resources necessary to supply the higher projections are about three-and-a-half times greater than those for the regional plans of development proposed by the Planning Committee. This is primarily a result of the great amount of irrigation forecast in the substate planning projections.

Surplus Water Availability

Although development plans for eastern Oklahoma remain at a conceptual level, the studies have progressed sufficiently to show that major water transfers from eastern Oklahoma to western Oklahoma would not interfere with those plans. Furthermore, development of the regional plans would not preclude eventual expansion to the larger system if local projections were to indeed prove accurate. In fact, studies show that existing, planned and potential stream water development and available ground water sources could easily supply the higher projected needs of the study area, meet the import requirements of 2.5 million acre-feet of water per year to central and western Oklahoma, and still leave a surplus exceeding 3.7 million acre-feet annually.

CONSIDERATIONS RELATED TO FUTURE DEVELOPMENT

Financing Water Resources Development

Oklahoma has traditionally relied on federal funding and support from the private sector for the financing of large-scale water development projects, but changing criteria make federal money increasingly difficult to secure as well as placing stringent controls on its use. Under the administration's proposed new national water policy regarding state cost sharing, Oklahoma would be required to make substantial investments in water development, and local interests to shoulder their share, prior to Congress's authorizing or funding otherwise eligible projects.

Although various options are open in securing federal money once local entities have succeeded in establishing eligibility, only one state loan program is specifically available for the development or expansion of local water projects. Title 82 O.S. 1979, Section 1085.31, et. seq., effective October 1, 1979, (Senate Bill 215 of the First Session of the 37th Legislature) is designed to provide cities, towns and rural water districts with funding to assist in the construction of water storage projects, distribution systems and treatment facilities.

This legislation authorizes the Oklahoma Water Resources Board to issue investment certificates in the form of revenue bonds and to establish a Water Resources Fund from the bond proceeds. The Board is authorized to loan money from this fund to qualified entities, i.e., all political subdivisions of the state, special-purpose water resource districts and public trusts or authorities. Revenues from the completed projects will be used to repay the loan, and the Board will retire the bond issues from loan repayments.

The legislation sets no limit on the amount of bonds to be issued, but does limit each loan to $1.5 million per project. Although this program is an innovative step in funding water development, certain provisions such as the $1.5 million loan ceiling preclude the financing of a major reservoir or any water development project of the scope necessary for implementation of the Oklahoma Comprehensive Water Plan. If the program is to finance the comprehensive development necessary to meet the state's long-range water requirements, enhanced funding levels will have to be considered by the Oklahoma Legislature.

Continued Water Planning Studies

Inadequacies in funding and personnel will continue to limit the Oklahoma Water Resources Board in accomplishing its immense task of developing, updating and implementing a state water plan. Unless the

Board is provided with enhanced funding, Oklahomans must accept the probability that future water development goals will not be achieved in time to avert the dire consequences which threaten the state's economic well-being.

The escalating costs and long lead time necessary for planning water projects of the magnitude described in the Oklahoma Comprehensive Water Plan make it imperative that the state begin now to adequately fund the appropriate studies.

Research

Additional research and the expansion of ongoing investigations to develop new techniques for more efficient utilization of existing data, increase the general knowledge of present water resources and aid in overcoming the problems of water resource development are vital if the state's future water needs are to be fulfilled.

Six-State High Plains-Ogallala Aquifer Area Study

The Oklahoma Water Resources Board has been designated by the Governor as the lead state agency charged with fulfilling Oklahoma's responsibilities under the Six-State High Plains-Ogallala Aquifer Area Study. The $6 million study funded by the Economic Development Administration is assessing the rapidly depleting water and energy resources of the 225,000 square mile High Plains area, which includes 10 western Oklahoma counties, as well as parts of Colorado, Kansas, Nebraska, New Mexico and Texas.

The study, scheduled for completion in July 1982, provides research complementary to the Oklahoma Comprehensive Water Plan by addressing the problem of western Oklahoma's inadequate water supplies and by taking a regional approach to water resources planning.

Statewide Economic Impact Study

The water conveyance system proposed in the Plan will have numerous direct and indirect economic benefits to all Oklahomans. Identification and assessment of these total benefits in relation to the cost of the water conveyance system are vital if a knowledgeable determination of the Plan's feasibility is to be made.

A study under the direction of the Oklahoma Water Resources Board by the University of Oklahoma and Oklahoma State University will utilize specific, interrelated computer models to evalutate the impact of future water shortages on the state and regional economic activity through the year 2040; to evaluate the direct and indirect benefits of the statewide water conveyance system to the economy of the state through 2040; and to evaluate the direct and indirect benefits of the system to areas outside Oklahoma.

Economic impacts data derived from the models and the costs provided by cooperating federal agencies will make information available upon which decisionmakers can base educated choices regarding future courses of action.

Chloride Control Projects

Successful implementation of the chloride control projects proposed for the Arkansas and Red River Basins would make water of better quality available to eastern Oklahoma and a greatly expanded supply of good quality water within the reach of western Oklahoma. Because such projects possess the potential for increasing supplies in water-deficient areas, their successful completion is an essential part of the Oklahoma Comprehensive Water Plan.

Although preliminary reviews of project economics indicate costs in the Arkansas River Basin may not be justified at this time, an extensive reevaluation currently underway may utlimately establish project feasbility. However, the chloride control projects currently under construction in the Red River Basin do appear justified. Continued support of both these projects is vital if the future water needs of Oklahoma are to be fulfilled.

Environmental Considerations

Environmental considerations reflect society's concern for and emphasis on the values of the natural environment. Prior to the construction of any major water conveyance system, comprehensive environmental impact statements will be necessary to assess future impacts on rare or endangered plants or animals, aesthetic values, archaeological sites, cemeteries and populations displaced by project development.

CONCLUSIONS

The following significant conclusions can be drawn from the information contained in the Oklahoma Comprehensive Water Plan and the research upon which the Plan is based:

- All areas of Oklahoma have great potential for future economic expansion, if adequate supplies of good quality water can be developed and properly distributed.
- Present water use for all purposes in Oklahoma is estimated to be 2.4 million acre-feet annually, while projections of future water use indicate over 6.9 million acre-feet per year may be needed by the year 2040.
- The Oklahoma Comprehensive Water Plan identifies approximately 4.7 million acre-feet per year of water supply yield in existing, authorized and proposed reservoirs and from ground water sources in eastern Oklahoma surplus to that area's future needs, with additional quantities of water available throughout eastern Oklahoma from streams not even considered for development in this Plan.
- Development of the projects necessary to meet the 2040 water needs of the state is estimated at

January 1978 price levels to cost approximately $11 billion, which does not include local distribution and treatment facilities.

- Regional plans of development show maximum local water development could cost $3 billion, but despite optimum local development, five of the eight planning regions will face future water deficits.

- An assessment of nontransfer alternatives indicates they can provide only supplemental water supplies and cannot be relied upon to provide the quantities of water required to meet Oklahoma's future needs.

- To meet the projected water deficits of central and western Oklahoma, construction of a statewide water conveyance system consisting of a northern system for the Arkansas River Basin, and a southern system for the Red River Basin should be considered. The cost for the northern conveyance system is $5.3 billion and for the southern conveyance system, $2.5 billion. At ultimate development, an annual 1.2 million acre-feet of water would be transferred through the northern system, and 1.3 million acre-feet through the southern system for municipal, industrial and irrigation purposes.

- The systems would be independent, with each being built in stages in order to minimize the necessary investment costs as water demands increase. A total of 12 proposed and two authorized reservoirs would be constructed as part of the conveyance systems. The northern system would be 630 miles in length and the southern system, 500 miles long.

- Over 900,000 acres would be irrigated with imported water in northwestern and southwestern Oklahoma. The average annual equivalent benefits of irrigation water from the system are estimated to be $25 million. These benefits reflect only primary impacts and do not include indirect benefits accruing from the water conveyance system.

- Neither conveyance system's irrigation component is economically justified under federal guidelines, which assess only primary benefits. The Statewide Economic Impact Study scheduled for completion in 1981 will quantify the indirect benefits, and through inclusion of secondary and tertiary benefits, could prove the systems feasible.

- The municipal and industrial component of each system is economically justified under the assumption that municipal and industrial benefits will equal costs.

- Even if future water needs escalate to levels projected by local planners in eastern Oklahoma, there will be enough water to meet such needs, as well as the import needs of central and western Oklahoma, and still have a surplus exceeding 3.7 million acre-feet per year. Existing Oklahoma statutes provide adequate and positive assurances to eastern Oklahoma that its future water requirements will be met prior to implementation of any large-scale water conveyance project.

- If ground water pumping in the Oklahoma Panhandle continues at present rates, it is unlikely that the northern conveyance system could be completed in time to prevent virtual cessation of ground water irrigation, forcing area farmers back to dryland farming. Nor is it likely that the southern water conveyance system could be finished in time to furnish municipal and industrial water to central Oklahoma before severe water shortages and attendant social and economic reactions become apparent.

- Inadequate distribution systems are a statewide problem requiring immediate attention. Numerous cities, towns and rural water districts do not have the fiscal capability to finance needed water systems and require assistance in constructing these facilities from federal programs and/or state financial assistance program provided by 82 O.S. 1979, Section 1085.31, et. seq.

- The citizens of Oklahoma must unite in molding their future through endorsement of local and statewide water development plans that are capable of providing the water they need.

RECOMMENDATIONS

Based upon analyses of the detailed studies documented in the Oklahoma Comprehensive Water Plan, the Oklahoma Water Resources Board offers the following recommendations:

- that the Governor and Legislature accept the Oklahoma Comprehensive Water Plan as a general guidance document assuring the orderly control, protection and management of the water and related land resources of Oklahoma.

- that all state agencies and political subdivisions of the state involved in water-related activities take due cognizance of the Oklahoma Comprehensive Water Plan in carrying out their duties and responsibilities.

- that the Federal Government recognize the Oklahoma Comprehensive Water Plan as a guide in establishing priorities for planning, authorizing and funding of federal water development projects in Oklahoma.

- that the U.S. Army Corps of Engineers resume currently suspended feasibility-level investigations on the water conveyance portion of the Central Oklahoma Project (COP).

- that the Federal Government recognize that primary authority and responsibility for water resources planning, development

and regulation in Oklahoma rest with the state.

- that the Governor and Legislature support continuation and expansion of the state's water development financial assistance program.

- that the Governor, the Legislature and the Oklahoma Congressional delegation continue to support the Arkansas-Red River Basin Chloride Control Projects as the most practical and economical means of achieving needed water quality improvements in Oklahoma.

- that the Legislature adopt floodplain management legislation adequate to insure that every Oklahoma community can qualify for federally subsidized floodplain insurance.

- that the Governor and Legislature strengthen the state's water programs by supporting the Oklahoma Water Resources Board in carrying out its statutory duties and responsibilities.

- that the Governor and Legislature support the development and implementation of a comprehensive weather modification program for the State of Oklahoma.

- that the Governor and Legislature take appropriate measures to promote water conservation in the state in order to lessen the impact of projected future shortages.

- that the Governor and Legislature take appropriate measures to insure that the citizens of Oklahoma are educated and informed in all matters pertaining to water in order that the state's water resources are adequately protected and placed to maximum beneficial use.