THE NATION'S WATER RESOURCES 1975-2000

Volume 4: Missouri Region

Second National Water Assessment by the U.S. Water Resources Council

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Foreword

The Water Resources Planning Act of 1965 (Public Law 89-80) directs the U.S. Water Resources Council to maintain a continuing study of the Nation's water and related land resources and to prepare periodic assessments to determine the adequacy of these resources to meet present and future water requirements. In 1968, the Water Resources Council reported the results of its initial assessment. The Second National Water Assessment, a decade later, provides a comprehensive nationally consistent data base for the water resources of the United States. The results of the Second National Water Assessment were obtained by extensive coordination and collaboration in three phases.

Phase I: Nationwide Analysis

The Council member agencies researched, analyzed, and prepared estimates of current and projected water requirements and problems and the implications of the estimates for the future.

Phase II: Specific Problem Analysis

Regional sponsors, one for each of the 21 water resources regions, surveyed and analyzed State and regional viewpoints about (1) current and future water problems, (2) conflicts that may arise in meeting State and regional objectives, and (3) problems and conflicts needing resolution.

Phase III: National Problem Analysis

The Council conducted this final phase in three steps: (1) An evaluation of phases I and II, (2) an analysis that identified and evaluated the Nation's most serious water resources problems, and (3) the preparation of a final report entitled "The Nation's Water Resources--1975-2000."

The final report of the Second National Water Assessment consists of four separate volumes as described below. These volumes can assist Federal, State, local, and other program managers, the Administration, and the Congress in establishing and implementing water resources policies and programs.

Volume 1, Summary, gives an overview of the Nation's water supply, water use, and critical water problems for "1975," 1985, and 2000 and summarizes significant concerns.

Volume 2, Water Quantity, Quality, and Related Land Considerations, consists of one publication with five parts:

Part I, "Introduction," outlines the origin of the Second National Water Assessment, states its purpose and scope, explains the numerous documents that are part of the assessment, and ident-

ifies the individuals and agencies that contributed to the assessment.

II, "Water-Management Problem Profiles," identifies ten general water problem issues and their implications and potential consequences.

Part III, "Water Uses," focuses on the national perspectives regarding existing ("1975") and projected (1985 and 2000) requirements for water to meet offstream, instream, and flow-management needs. State-regional and Federal perspectives are compared.

Part IV, "Water Supply and Water Quality Considerations," analyzes the adequacy of fresh-water supplies (ground and surface) to meet existing and future requirements. It contains a national water budget; quantifies surface- and ground-water supplies, reservoir storage, and transfers of water within and between subregions; describes regional requirements and compares them to supplies; evaluates water quality conditions; and discusses the legal and institutional aspects of water allocation.

Part V, "Synopses of the Water Resources Regions," covers existing conditions and future requirements for each of the 21 water resources regions. Within each regional synopsis is a discussion of functional and location-specific water-related problems; regional recommendations regarding planning, research, data, and institutional aspects of solving regional water-related problems; a problem-issue matrix; and a comparative-analysis table.

Volume 3, Analytical Data, describes the methods and procedures used to collect, analyze, and describe the data used in the assessment. National summary data are included with explanatory notes. Volume 3 is supplemented by five separately published appendixes that contain data for the regions and subregions:

Appendix I, Social, Economic, and Environmental Data, contains the socioeconomic baseline ("1975") and growth projections (1985 and 2000) on which the water-supply and water-use projections are based. This appendix presents two sets of data. One set, the National Future, represents the Federal viewpoint; the other set, the State-Regional Future, represents the regional sponsor and/or State viewpoint.

Appendix II, Annual Water Supply and Use Analysis, contains baseline water-supply data and baseline and projected water withdrawal and water-consumption data used for the assessment. Also included are a water adequacy analysis, a natural flow analysis, and a critical-month analysis.

Appendix III, Monthly Water Supply and Use Analysis, contains monthly details of the water-supply, water-withdawal, and water-

consumption data contained in Appendix II and includes an analysis of monthly water adequacy.

Appendix IV, Dry-Year Conditions Water Supply and Use Analysis, contains both annual and monthly baseline and projected water-withdrawal and water-consumption data for dry conditions. Also, a dry conditions water-adequacy analysis is included.

Appendix V, Streamflow Conditions, contains detailed background information on the derivation of the baseline streamflow information. A description of streamflow gages used, correction factors applied, periods of record, and extreme flows of record, are given for each subregion. Also included is the State-Regional Future estimate of average streamflow conditions.

Volume 4, Water Resources Regional Reports, consists of separately published reports for each of the 21 regions. Synopses of these reports are given in Volume 2, Part V.

For compiling and analyzing water resources data, the Nation has been divided into 21 major water resources regions and further subdivided into 106 subregions. Eighteen of the regions are within the conterminous United States; the other three are Alaska, Hawaii, and the Caribbean area.

The 21 water resources regions are hydrologic areas that have either the drainage area of a major river, such as the Missouri Region, or the combined drainage areas of a series of rivers, such as the South Atlantic-Gulf Region, which includes a number of southeastern States that have rivers draining directly into the Atlantic Ocean and the Gulf of Mexico.

The 106 subregions, which are smaller drainage areas, were used exclusively in the Second National Water Assessment as basic data-collection units. Subregion data point up problems that are primarily basinwide in nature. Data aggregated from the subregions portray both regional and national conditions, and also show the wide contrasts in both regional and national water sources and uses.

The Second National Water Assessment and its data base constitute a major step in the identification and definition of water resources problems by the many State, regional, and Federal institutions involved. However, much of the information in this assessment is general and broad in scope; thus, its application should be viewed in that context, particularly in the area of water quality. Further, the information reflects areas of deficiencies in availability and reliability of data. For these reasons, State, regional, and Federal planners should view the information as indicative, and not the only source to be considered. When policy decisions are to be made, the effects at State, regional, and local levels should be carefully considered.

In a national study it is difficult to reflect completely the regional variations within the national aggregation. For example, several regional

reviewers did not agree with the national projections made for their regions. These disagreements can be largely attributed either to different assumptions by the regional reviewers or to lack of representation of the national data at the regional level. Therefore, any regional or State resources-management planning effort should consider the State-regional reports developed during phase II and summarized in Volume 4 as well as the nationally consistent data base and the other information presented in this assessment.

Additional years of information and experience show that considerable change has occurred since the first assessment was prepared in 1968. The population has not grown at the rate anticipated, and the projections of future water requirements for this second assessment are considerably lower than those made for the first assessment. Also, greater awareness of environmental values, water quality, ground-water overdraft, limitations of available water supplies, and energy concerns are having a dramatic effect on water-resources management. Conservation, reuse, recycling, and weather modification are considerations toward making better use of, or expanding, available supplies.

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Description

The Missouri Region encompasses one-sixth of the conterminous United States. The Missouri River and its tributaries drain about 511,000 square miles in the United States and about 9,700 square miles in Canada. The region includes all of Nebraska and parts of Montana, Wyoming, North Dakota, South Dakota, Colorado, Iowa, Minnesota, Kansas, and Missouri. For purposes of this national water assessment, the Missouri River below the mouth of the Gasconade River is included in the Upper Mississippi Region. The Missouri Region is bounded on the west by the Rocky Mountains, on the north by Canada, on the northeast by the Souris-Red-Rainy River Basins, on the east by the Upper Mississippi River Basin, and on the south by the Arkansas-White-Red River Basins. From the junction of the Jefferson, Gallatin, and Madison Rivers at Three Forks, Montana, the Missouri River flows north to Great Falls, Montana, east to Bismarck, North Dakota, and then generally southeasterly to its junction with the Mississippi River near St. Louis, Missouri, a distance of about 2,300 miles. In downstream order, the major tributaries from the south and west are the Yellowstone, Little Missouri, Cheyenne, Niobrara, Platte, Kansas, Osage, and Gasconade Rivers; and from the north and east are the Milk, James, Big Sioux, Little Sioux, Grand, and Chariton Rivers. Figure 10-1 is a map of the region.

There are three major physiographic divisions within the Missouri Region--the Rocky Mountains, the Interior Plains, and the Interior Highlands. The rugged Rocky Mountains form the western boundary of the region. Extending eastward from the Rocky Mountains are the Interior Plains, which constitute the major portion of the basin. Within the plains area are isolated mountains, principal among which are the Black Hills in western South Dakota and northeastern Wyoming. Another distinctive area is the Sand Hills of north-central Nebraska. Although the Interior Plains are generally characterized as flat, the terrain is largely rolling hills and valleys. In the eastern part, abundant rainfall and stream development have created a more hilly topography. The Ozark Plateaus province of the Interior Highlands physiographic division in the southeastern part of the region is characterized by rough topography underlain by sedimentary formations, largely limestone, with cavernous underground channels and many flowing springs.

The plains area is made up of cultivated lands (where there is irrigation or adequate rainfall), rangeland, and pastureland. Trees in the plains area are generally limited to the areas along the streambanks, although a number of shelter-belts were planted to reduce wind erosion following the severe drought of the 1930's. The Rocky Mountains and the Black Hills contain 72 percent of the region's 29 million acres of forests, consisting mainly of western softwoods. The remaining 28 percent are located in the Ozarks and consist mainly of hardwoods (Figure 10-2).

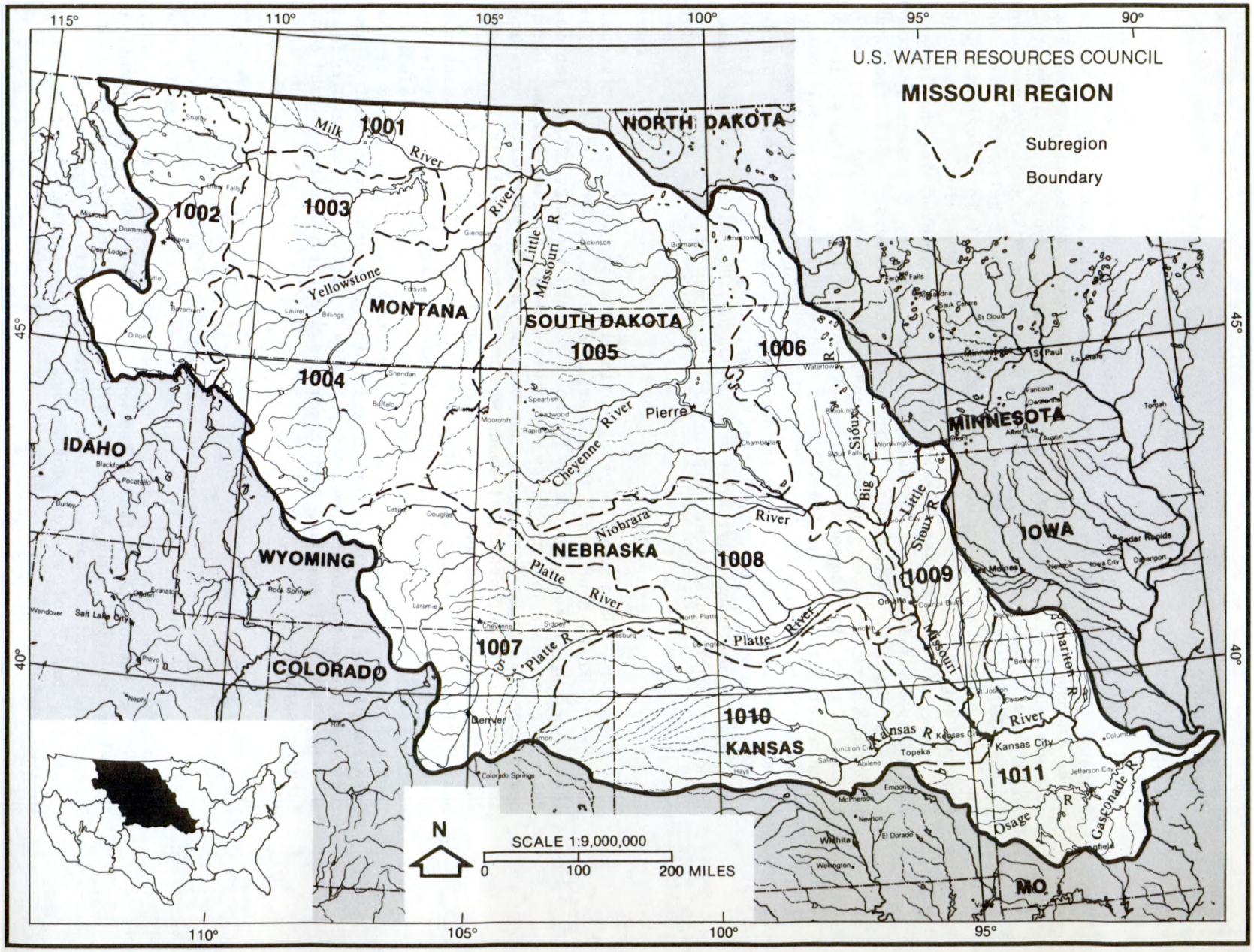


Figure 10-1. Region Map

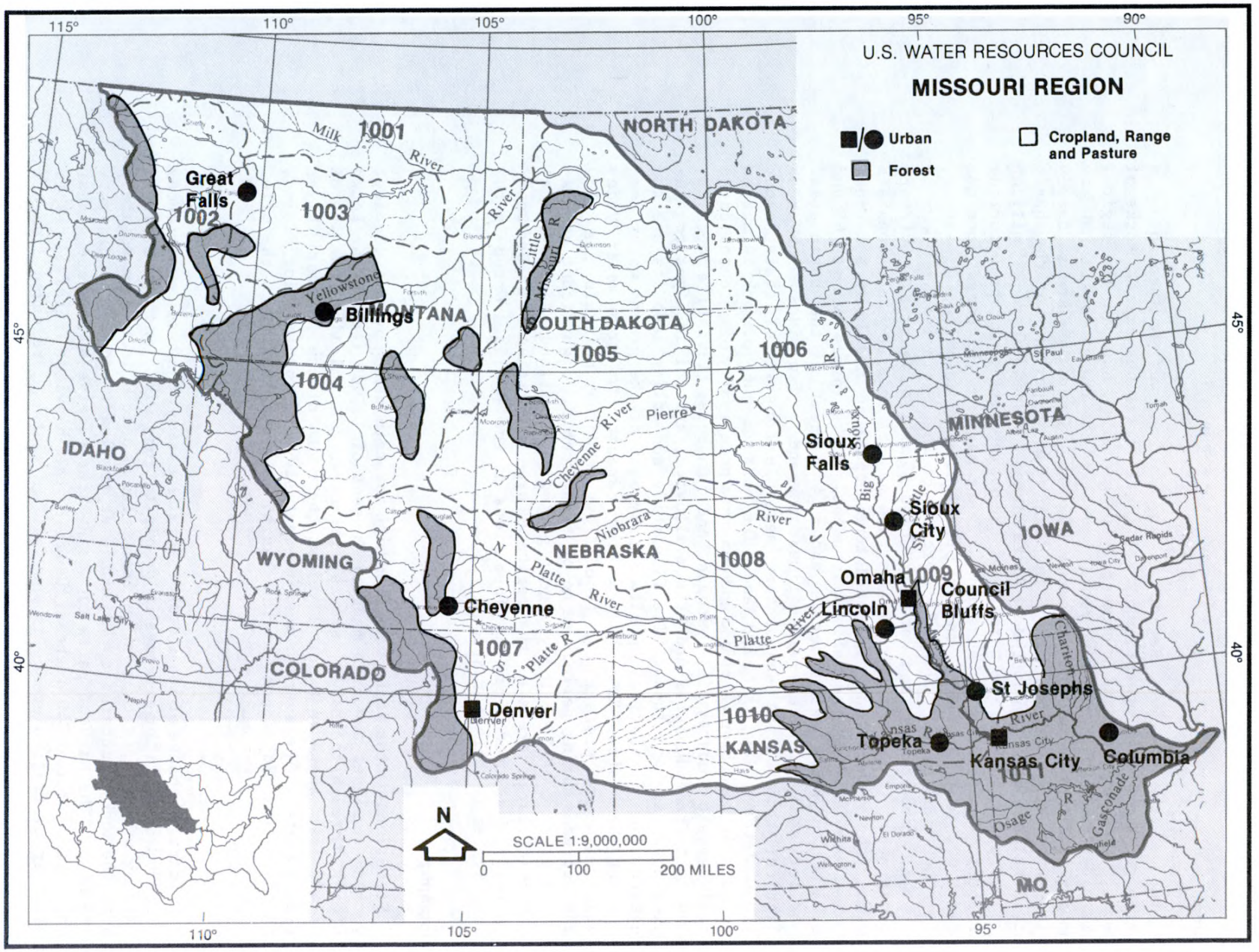


Figure 10-2. Present Land Use

Geology

Because the Missouri Region is so vast and was influenced by a diverse geologic development, many sectional variations exist. Rocks of igneous, metamorphic, and sedimentary origin are found in the region. Rocks older than 570 million years underlie the entire basin and are commonly referred to as the basement complex. Since they are so deeply buried and their outcrops occur in less than 4 percent of the basin area, little is known about them. Rocks formed between 570 and 225 million years ago underlie about 87 percent of the basin, with outcrops occurring over about 14 percent of the region. Their maximum thickness does not exceed 5,000 feet, and they consist principally of dolomite, limestone, shale, and sandstone. About 83 percent of the basin is underlain by the rocks formed or deposited between 225 and 65 million years ago. Outcrops occur in about 48 percent of the basin, and much of this sequence consists of shale, shaly sandstone, and sandstone deposited mostly in a marine, but sometimes in a continental, environment. Rocks formed between 65 and 2 to 3 million years ago underlie about 34 percent of the basin area. Except for some thin fresh-water limestones and a few widespread areas of lignite, this entire sedimentary sequence consists of shale, sandy shale, sandstone, clay, silt, and sand. The next sequence of rock formation occurred 2 to 3 million years ago and consists principally of unconsolidated glacial deposits, mostly till, outwash, and lake beds; fluviatile deposits, including terrace deposits and stream alluvium; and eolian deposits, including dune sand and loess. The fluviatile and eolian deposits are the youngest. The fluviatile deposits supply much of the ground water used throughout the basin. They have a high capacity to store water, they provide temporary storage for flood flows, and they maintain the flow of many streams during periods of no overland runoff. Significant ground-water supplies come from the youngest geologic formations (Cenozoic Era) that blanket large areas of the region. Large quantities of ground water are already developed from the formations of the Ogallala Group in the Neocene System of this formation.

Topography

Elevations in the basin vary from high mountain peaks over 14,000 feet above mean sea level and high mountain passes of 11,000 feet in the Rocky Mountains through foothills, plains, and river bottomlands to a low of about 450 feet above mean sea level at the mouth of the Missouri River near St. Louis. The average west-to-east slope of the Interior Plains, which constitute 86 percent of the basin, is about 10 feet to the mile.

Climate

Primarily because of its midcontinental location, the basin experiences weather that is known for extremes in precipitation, wind, and temperature. Average annual precipitation varies from as low as 6 to 12 inches immediately east of the Rocky Mountains to 40 inches at the lower end of the Missouri River Basin. The highest parts of the Rockies receive an average annual precipitation of over 40 inches. Usually, the heaviest rainfall is in spring. Precipitation occurs as snowfall in winter. Prolonged droughts

lasting several years are usually interspersed with periods of abundant precipitation and periodic flooding.

Average annual temperatures range from 55° F in the southeast to less than 40° F in the northwest. Except in the highest mountains, all localities have experienced summer temperatures over 100° F. Below-zero winter temperatures occur throughout the region. Extremes range from -60° F in Montana to summer highs up to 120° F over much of the plains area. Excluding the mountainous areas in the west, the freeze-free period ranges from about 90 days in the northern parts of the region to over 180 days in the southern portions.

Winds are the rule rather than the exception, particularly in the plains area. Average wind velocities of 10 miles per hour are prevalent over much of the basin. In the plains area, strong winds of 30 to 60 miles per hour accompanied by snow often create blizzards dangerous to both man and livestock. High winds occasionally prevail during periods of high temperatures and deficient moisture and can then destroy crops and desiccate rangeland within a few days.

People and the Resources

Although the Missouri Region is primarily oriented toward agriculture in both its economy and water use, it is essential to analyze other current and projected activities as well for a full understanding of the water- and related land-resource problems. Estimates and projections of the population, economy, land and water resources, and other parameters were made as explained in another volume of the National Assessment. These data are for the Nation, region, and aggregated subregions (ASR's) and are referred to as the National Future (NF). The Missouri River Basin Commission also prepared estimates, called the State/Regional Future (SRF). A discussion of the differences between these sets of data and their implications is presented at the end of this section. Unless identified as SRF, all data presented herein are NF data.

Population

Many sections of the northern and western parts of the region are thinly populated. Large areas have population densities of less than one person per square mile. Most of the people live in the southern part of the region, including the Rocky Mountain front-range area of Colorado. The region has only 12 Standard Metropolitan Statistical Areas. The three largest are Kansas City, Denver, and Omaha-Council Bluffs. The rural population has been declining dramatically over the last 40 years. Many people have migrated to the larger cities in the region and also outside the region. The region's population was 8.8 million in 1975, about 4 percent of the national total. The population is projected to reach 10.0 million by the year 2000, with an expected growth rate about 58 percent that of the Nation.

Economy

The 1975 total personal income was about $52.6 billion or about $5,977 per person, which is slightly below the national average. Major earnings were widely distributed among the various categories, with no one outstanding category. Although agricultural earnings are shown to be only about 11 percent of the total, a considerable part of the earnings for manufacturing, transportation, and wholesale and retail trade is related directly to the agricultural industry. The region produces about 33 percent of the Nation's wheat, 25 percent of the sorghum, 22 percent of all corn grown for grain, and 20 percent of the livestock and poultry. Agriculture is expected to continue to dominate the region's economic activity. With about 55 percent of the Nation's strippable coal reserves, mining and energy production are expected to increase dramatically by the year 2000.

Both total earnings and per capita income are projected to double over the next 25 years. It is anticipated that all categories will share about equally in the projected increases in earnings, except that earnings from mining may increase several times over current amounts if coal production accelerates. Table 10-1 presents selected earnings projected for the region.

Table 10-1.--Missouri Region earnings--1975, 1985, 2000
(million 1975 dollars)

Earnings sector	1975	1985	2000
Manufacturing	6,791	9,643	15,521
Agriculture	4,386	4,378	5,159
Mining	416	491	597
Other	29,372	42,412	71,165
Total	40,965	56,924	92,442

Natural Resources

The Missouri Region, although largely oriented toward agricultural production, has several land uses (Table 10-2 and Figure 10-2). The Rocky Mountains on the western border, the Black Hills in western South Dakota, and the Ozarks area in the southeastern part of the region include most of the forests, scenic attractions, and other outdoor recreation opportunities. The vast plains area, comprising 87 percent of the region's land, contains the pasturelands and croplands for the production of livestock and small grains. There are few natural lakes. Most of the water area is provided by manmade reservoirs. The largest reservoirs in the region are the U.S. Army Corps of Engineers reservoir projects located on the Missouri River main stem. The reservoirs provide storage for flood waters, hydroelectric power production, and irrigation; maintain flows for navigation, water-quality management, and water supply needs; and serve other multiple-purpose functions, such as fish and wildlife enhancement and recreation.

The Yellowstone River basin and adjacent areas in Wyoming, Montana, and North Dakota contain large deposits of low-sulfur coal and lignite. Demand for the coal for electric power production has escalated rapidly during the last several years and probably will continue to increase.

Table 10-2.--Missouri Region surface area and 1975 land use

Surface area or land use type	1,000 acres	Percentage of total surface area
Surface area		
Total	327,133	100.0
Water	3,399	1.0
Land	323,734	99.0
Land use		
Cropland	105,660	32.3
Pasture & range	161,774	49.5
Forest & woodland	29,937	9.2
Other agriculture	4,006	1.2
Urban	1,397	.4
Other	20,960	6.4

Land Ownership

Of the 327.1 million acres of land in the Missouri Region, over 43 million acres, or about 14 percent, are in Federal ownership. Most of these Federal lands are in Montana, Wyoming, North and South Dakota, and Colorado. The largest tracts are managed by the Forest Service (19.4 million acres), Bureau of Land Mangement (18.5 million acres), National Park Service (2.3 million acres), Corps of Engineers (2.2 million acres), and Bureau of Reclamation (1.0 million acres). Almost all of the Corps of Engineers and Bureau of Reclamation lands were acquired for the construction and operation of large Federal reservoirs. Lesser acreages are managed by the military, the Fish and Wildlife Service, the Bureau of Indian Affairs, and the Agricultural Research Service.

Included in the nearly 284 million acres of private lands are about 12 million acres of Indian lands on 23 reservations. The majority of the Indian holdings are in Montana, Wyoming, and North and South Dakota.

Agriculture

Harvested cropland acreage is expected to increase over the next 25 years, while the total number of harvested and unharvested cropland acres will slightly decrease. Irrigated land is expected to increase by 19 percent by the year 2000, or change the 1975 total of 9,695,000 acres to about 11,505,000 acres (Table 10-3).

Table 10-3.--Projected changes in cropland and irrigated farmland in the Missouri Region--1975, 1985, 2000
(1,000 acres)

Land category	1975	1985	2000
Total cropland----------	105,660	105,271	105,050
Cropland harvested--------	73,286	77,246	82,639
Irrigated farmland--------	9,695	10,957	11,505

Energy

The two nuclear and 52 fossil-fueled electric powerplants in the region generated nearly 56,000 gigawatt-hours (gWh) in 1975. The hydroelectric power system of the Missouri Region, made up mostly of Federal projects operated by the Bureau of Reclamation and the Corps of Engineers, generated over 19,000 gigawatt-hours in 1975. The steam electric generating capability is expected to be increased by 11 nuclear and 7 fossil-fueled plants by 2000, with an output of about 435,000 gigawatt-hours. On the other hand, the output of the hydroelectric system is expected to decrease to about 14,000 gigawatt-hours. Table 10-4 presents these projections. Operation of the hydroelectric plants will be shifted more to meeting the increasing peak loads.

Table 10-4.--Missouri Region electric power generation--1975, 1985, 2000 (gigawatt-hours)

Fuel source	1975	1985	2000
Fossil	49,935	137,914	208,709
Nuclear	5,916	34,711	225,843
Conventional hydroelectric power	19,384	14,066	14,066
Total generation	75,235	186,691	448,618

Mining of the large deposits of low-sulfur coal lying close to the earth's surface in the northern Great Plains has been increasing at a steady rate. If greater reliance is placed on coal in meeting the Nation's energy requirements, mining of these coal deposits could escalate rapidly. As national energy policies unfold, production of synthetic gas and oil from the coal are also possibilities.

Eastern Wyoming now produces a large share of the Nation's uranium requirements for nuclear-fueled electric powerplants and contains much of the known reserves. The western part of the region also produces oil and natural gas, although the quantity of production has been decreasing recently.

Navigation

The Missouri River from Sioux City, Iowa, to its confluence with the Mississippi River near St. Louis (Figure 10-3) provides an 8-month navigation season from March through November, the ice-free period. The banks of this 732-mile stretch of the river have been stabilized by rock revetments to provide open river navigation at a 9-foot depth. Flows are maintained by a system of six large reservoirs. The navigation project to provide a 9-foot channel from Sioux City to the mouth of the Missouri was authorized in 1945 and is now nearing completion.

The development of modern commerce on the waterway started in 1954. Yearly tonnages of commercial products have increased rather uniformly, reaching a peak of about 3.3 million tons in 1976. Shipments are dominated by farm products, and little discernible change is projected.

In addition to providing a 9-foot navigation channel, the bank stabilization works prevent the river from returning to its previously meandering patterns. The bank stabilization works thus protect the many highway and railroad bridges and other improvements and permit farming the wide and fertile flood-plain lands.

Environment

The mountains, valleys, and plains with their forests, grasslands, brushlands, badlands, croplands, streams, reservoirs, and lakes combine to make this a scenic region with diverse plant and animal species.

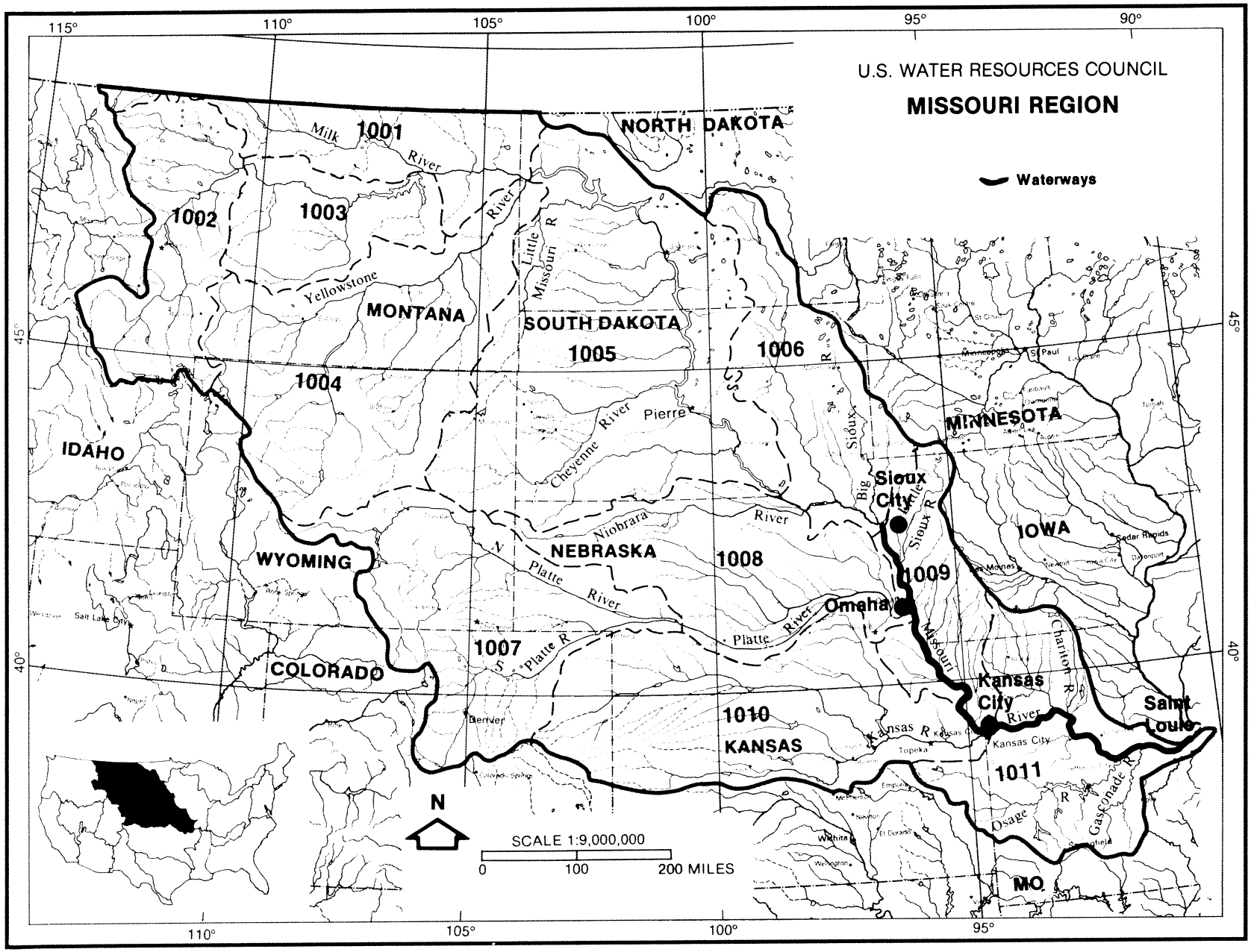


Figure 10-3. Navigation System

While some land-use, water pollution, and air pollution problems exist, especially near urban and mining areas, most of the basin is free from serious environmental problems.

Three National Parks--Rocky Mountain in Colorado, Yellowstone in Wyoming, and Glacier in Montana--provide nationally significant areas of scenic beauty. Many interesting National Monuments are scattered throughout the region. The most famous are Custer in Montana and Mt. Rushmore and the Badlands in South Dakota. Also of historical interest are many of the old mining towns and so-called "cow" towns and sod houses of the West, as well as the Lewis and Clark Trail up the Missouri River and the overland Santa Fe and Oregon Trails leading to the Far West. The Harry S. Truman Library at Independence, Missouri, and the boyhood home of Dwight D. Eisenhower at Abilene, Kansas, provide interesting attractions.

There are numerous State parks, forests, and monuments, as well as local parks distributed throughout the region. There are about 3.4 million acres of water area, mostly at the large federally constructed reservoirs. Most of the water-oriented recreation opportunities are provided by these water bodies, which have developed recreation areas and are open to the public. The Corps of Engineers and the Bureau of Reclamation reported nearly 33 million visitor-days for their projects in 1975.

The Bureau of Outdoor Recreation (BOR) estimated 62 million water-dependent recreation activity occasions for 1975, with an additional 33 million water-enhanced recreation activity occasions. The participation in these activities is expected to increase by about 25 percent by the year 2000. At that time, BOR estimates that about 22,000 acres of water surface more than is currently available will be needed. The additional areas will be needed in the South Platte River Basin (subregion 1007) and the area bordering the Missouri River on the east side from Sioux City, Iowa, to Kansas City (subregion 1009). All other areas of the region are reported by BOR to have a surplus of water areas for current recreation needs as well as the projected 2000 needs.

Twenty-four areas within the region are currently under protective designation--15 wilderness areas containing over 2.2 million acres, four special interest areas containing 57,500 acres, and five research-natural areas containing 4,000 acres. An additional 95 areas are being studied for possible inclusion in the wilderness system. The Little Missouri River has been designated by North Dakota as a wild and scenic river, and several States are considering similar designations of streams within their respective States. The U.S. Fish and Wildlife Service has identified 1,160 miles of nationally significant streams for preservation in a free-flowing state.

The region provides about 60 species of big game, small game, and waterfowl sought by hunters. The 1971 Framework Report identified 65 national and State wildlife refuges containing 410,000 acres. In 1975, six species of wildlife in the region had been designated as endangered. The cold mountain streams provide most of the cold water fisheries, and

the manmade reservoirs provide most of the warm-water fisheries.

Water

The primary purpose of this assessment is to determine the current and projected water uses and availability and the problems related to those water uses. The water withdrawals and consumption data presented are for average-year conditions unless otherwise stated.

Surface Flows

The total surface flow currently leaving the region is estimated to be about 44.1 billion gallons per day (bgd) under 1975 conditions of average water use and development. The flows fluctuate widely from wet years to dry years. However, the many reservoirs constructed on the streams within the region and, particularly, the six large, main-stem projects located above Yankton, South Dakota, reduce the flood flows and increase the dry-year and late summer flows. The mountain snowmelt in late spring and early summer provides much of the streamflow in the western and northern parts of the region and most of the reservoir inflow. These streamflows are usually much lower during the remainder of the year. Many of the streams in the Great Plains dry up completely during average and dry years, since their flow almost completely depends on the runoff from precipitation. In the areas immediately east of the Rocky Mountains, precipitation averages only 6 to 12 inches annually. Floods usually occur during the spring or early summer and may result from rapid snowmelt, violent thunderstorms, or stalled frontal movements, like those that occurred over the Kansas River Basin in 1951. Figure 10-4 illustrates flows under conditions of 1975 development and water use.

Ground Water

The importance of ground-water resources to the people of the region can hardly be overemphasized. Over 85 percent of the municipalities having central water systems rely on ground water as their source of supply. They serve about 30 percent of the region's people. About 85 percent of the rural households are served from ground water. Over 70 percent of the industries with separate water systems use ground-water sources. The use of ground water for irrigation, brought on largely by improvements in center-pivot sprinkler systems, has been increasing rapidly. Recent estimates indicate that about 85 percent of all ground water pumped is for irrigation. These same estimates show that over 85 percent of the region's ground-water usage occurs in the Platte and Kansas River Basins (subregions 1007, 1008, and 1010). With the recent large increases in irrigation use of ground water, it is not surprising that some aquifers are showing signs of a declining water table. Figure 10-5 shows the region's major productive aquifers. As discussed subsequently under Individual Problem Areas, the Ogallala aquifer is experiencing severe problems.

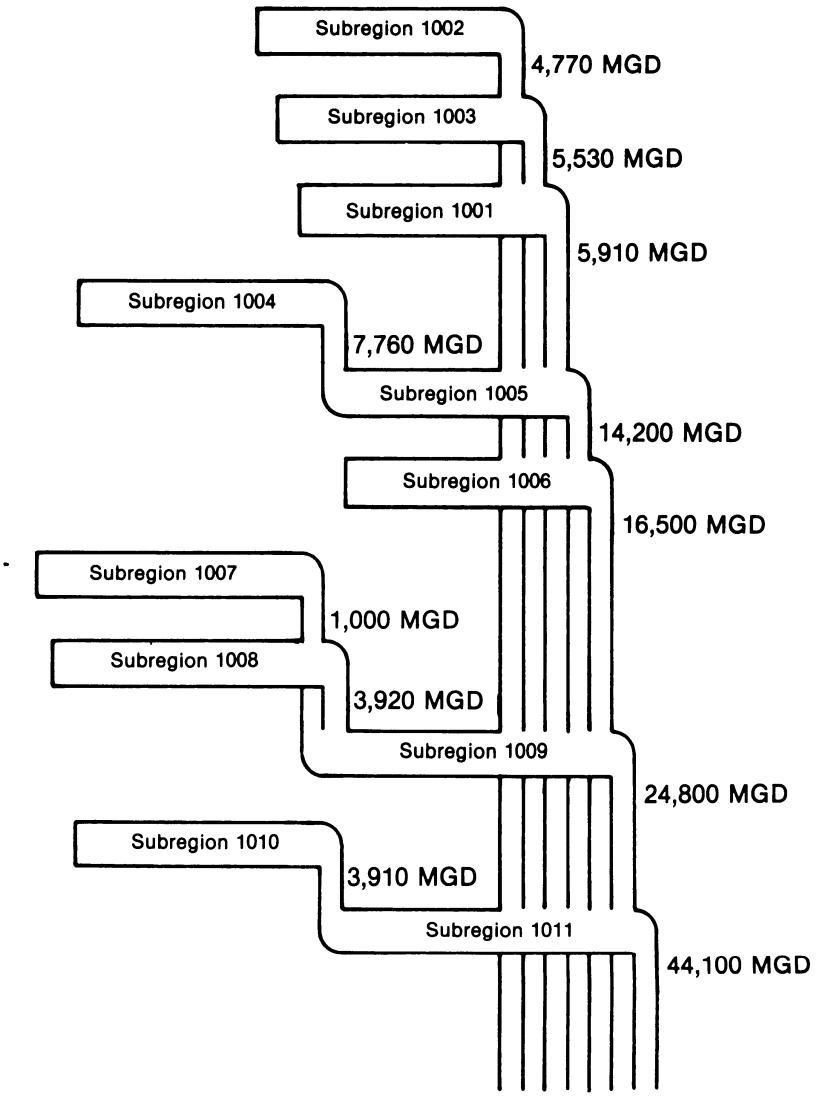


Figure 10-4. Streamflow

Water Withdrawals

Total fresh-water withdrawal requirements from streams and ground water in 1975 were estimated to be about 38.0 bgd. The irrigation requirement was about 31.6 bgd, or about 83 percent of the total. Cooling water for steam electric plants required about 3.5 bgd, or 9 percent of the total.

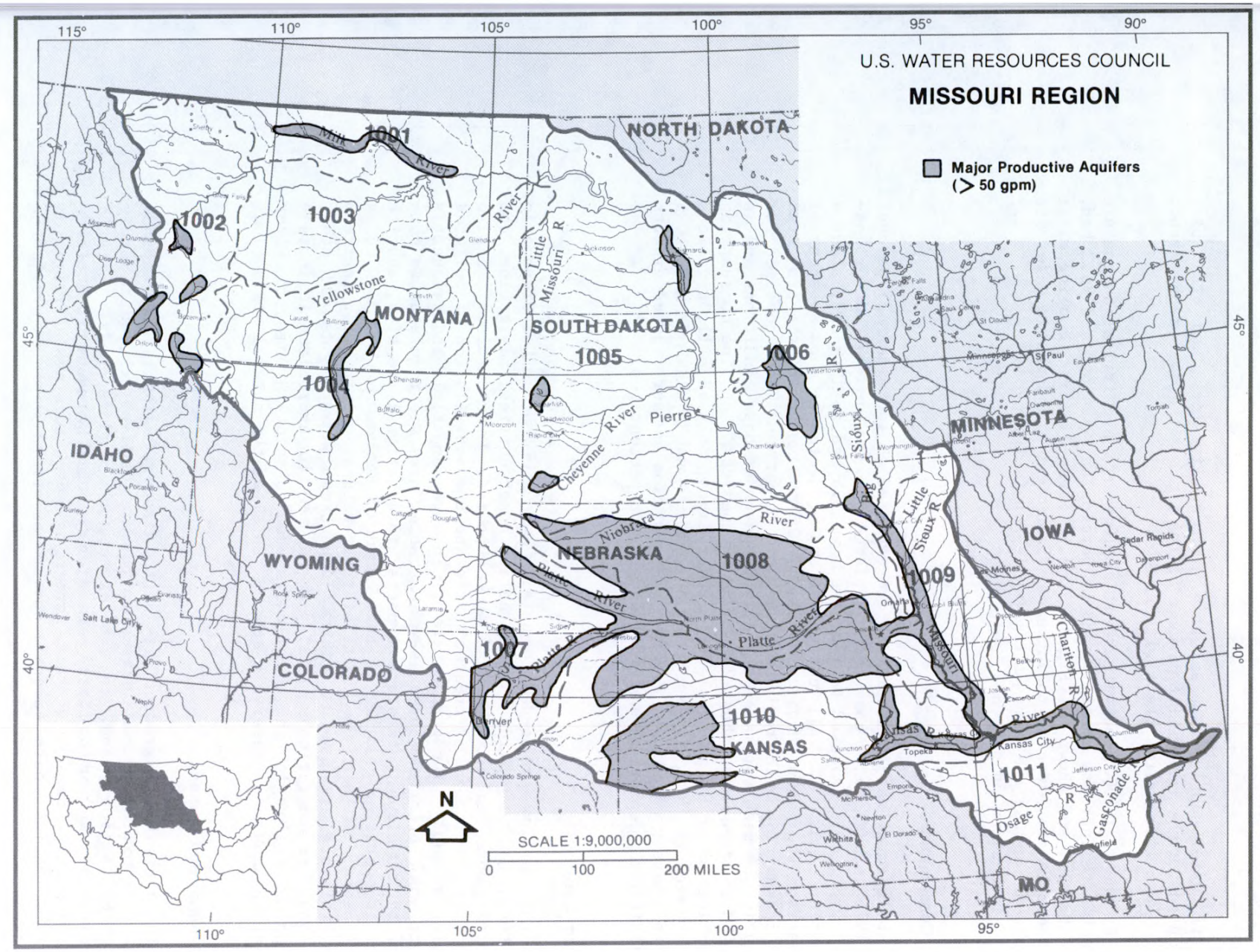


Figure 10-5. Major Aquifers

Domestic water supply, manufacturing, mining, livestock, and other uses accounted for the remaining 8 percent of the total withdrawal requirement. Figure 10-6 illustrates these withdrawals.

By the year 2000, the withdrawal requirements and irrigation use are projected to increase about 17 and 15 percent to 44.4 bgd and 36.2 bgd, respectively, as shown in Figure 10-6. Steam-electric cooling water requirements are expected to increase 39 percent and domestic water use 21 percent during the same period, while manufacturing water use is expected to decline 56 percent.

Water Consumption

While total water withdrawals are expected to increase by 17 percent from 1975 to 2000, water consumed or depleted from the surface- and groundwater supplies is expected to increase from 15.5 bgd to 19.9 bgd, about a 29-percent increase. All categories are projected to show substantial increases in the amount of water consumed. Over 90 percent of the projected water consumption in the region will be for irrigation. Water consumed for irrigation has been estimated to be 14.2 bgd under base conditions and is expected to increase by about 24 percent by the year 2000. The consumption of cooling water by steam electric powerplants, only 68 million gallons per day (mgd) in 1975, is expected to reach 637 mgd by 2000. Figure 10-6 depicts these projections. Reservoir evaporation and anticipated exports are additional depletions not included in the percentages.

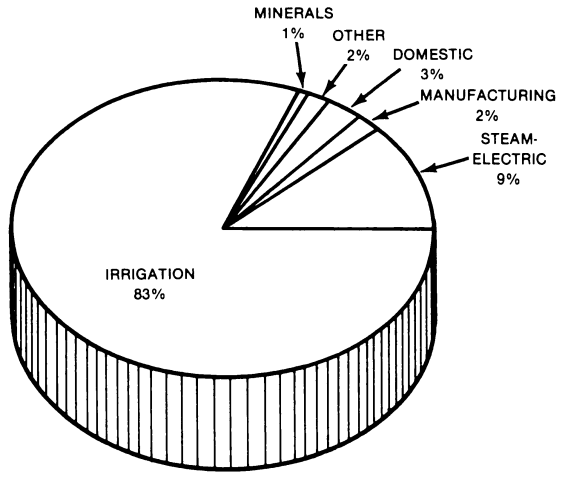
Instream Uses

Instream flows are needed to sustain fish, wildlife, and other aquatic life forms and to provide for recreation opportunities, navigation, and municipal, domestic, and livestock water supplies. Instream flows are also needed for the disposal of treated wastes and the assimilation of polluted nonpoint runoff. These uses are not always compatible and frequently compete with offstream uses as well. Water uses are regulated to some extent by State laws, interstate compacts, international treaties, and the reservoir operating policies of the Bureau of Reclamation and the Corps of Engineers. Within the limits of their natural occurrences, instream flows available are used to satisfy downstream water rights and other functions. The generation capability of the existing hydroelectric installations in the region and the flows needed to maintain Missouri River navigation depend on reservoir storage to alter the natural streamflow.

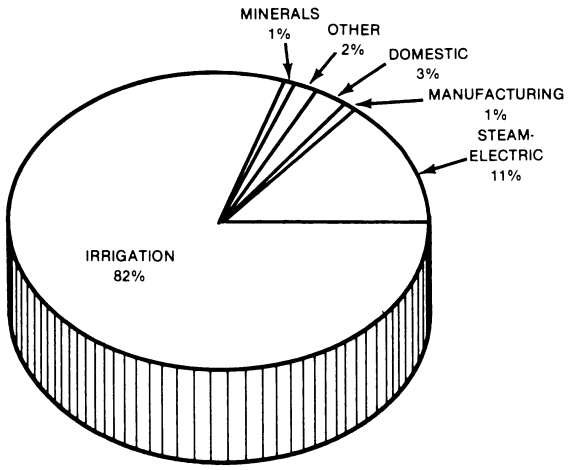
Water Supply and Demand

The agricultural productivity of the Missouri Region largely depends on rainfall to produce small grains and pasture for livestock, which supply part of the Nation's and, to some extent, the world's needs. Erratic patterns of too much or too little rain often drastically reduce productivity and farm income. Because of this, farmers have been turning to irrigation to improve yields where adequate surface or ground water is available.

ANNUAL FRESHWATER WITHDRAWALS

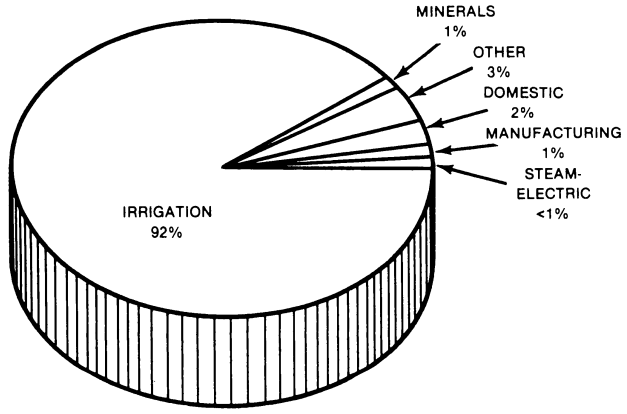


1975
Total Withdrawals — 38,016 MGD

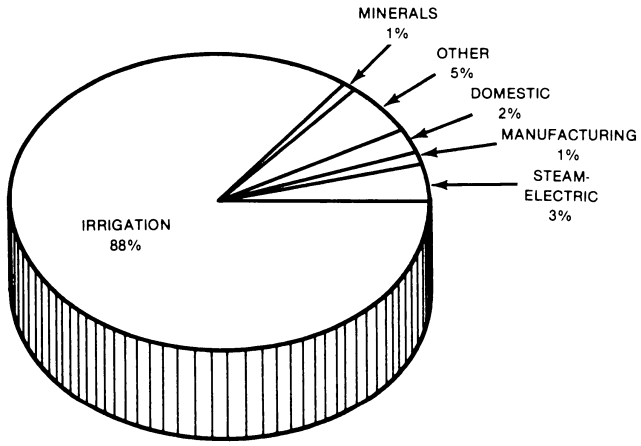


2000
Total Withdrawals — 44,359 MGD

ANNUAL FRESHWATER CONSUMPTION



1975
Total Consumption — 15,469 MGD



2000
Total Consumption — 19,913 MGD

Figure 10-6. Withdrawals and Consumption

Total water consumption is projected to increase by 29 percent between 1975 and 2000. In 1975, it was estimated that 27 percent of the total surface supply was being consumed. This is expected to increase to about 35 percent of the supply by the year 2000. These percentages may be somewhat lower, since the estimates of water consumed include ground-water use, some of which is depleting stored ground-water supplies. The effects of ground-water use on streamflows are complex, and estimates of the effects are not generally available.

No serious shortages of water to meet needs along the main stem of the Missouri River are anticipated. The six large main-stem dams above Sioux City, Iowa, can store three times the average annual flow occurring at Sioux City. This permits large carryovers of stored water for use during low-flow periods. While the total regional water supply is adequate to supply all needs up to the year 2000, seasonal and geographic maldistribution of precipitation and runoff causes some severe water supply deficiencies. Water shortages can also occur at several locations in the Upper Missouri Basin, especially because of the need to satisfy large hydroelectric power water rights and Indian and Federal reserved rights. During droughts, many municipalities throughout the region suffer water supply shortages; many wells and stock ponds go dry, and many streams do not contain enough water to supply irrigation and other needs.

Much concern has been expressed about providing adequate water supplies to develop the coal fields of the northern Great Plains while maintaining supplies needed for other purposes, particularly irrigation. Although water is not always available in this arid to semiarid region in the amounts or at the point of need, reservoirs, diversion by aqueduct or pipeline from existing reservoirs, and development of ground-water sources could supply much of the needed water. Current estimates for coal field development show a need for up to 500 mgd annually, which is less than 4 percent of the average annual flow of the Missouri River at the confluence of the Yellowstone River with the Missouri River.

Comparative Analysis

Table 10-5 compares the National Future (NF) and State-Regional Future (SRF) estimates of streamflows and water use in the Missouri Region. The SRF data were developed by the 10 States and the 10 Federal agencies represented on the Missouri River Basin Commission (MRBC) to reflect the needs and objectives of management, conservation, and development of the water and related land resources in the region. The amounts of water needed to meet the SRF projected irrigation and manufacturing requirements for the year 2000 are greater than those required in the NF projections. The amounts of water included in offstream developments are significant throughout the region. These amounts could seriously affect the instream flows needed for power generation at the Federal hydroelectric projects, the Missouri River navigation project, riverine recreation, fish and wildlife, and water quality.

Table 10-5.--Socioeconomic and volumetric data summary: the Missouri Region

Category	"1975"		1985		2000	
	NF	SRF	NF	SRF	NF	SRF
SOCIOECONOMIC DATA (1000)						
Total population	8,832	9,066	9,298	10,046	10,044	11,762
Total employment	3,695	3,936	4,084	5,061	4,573	5,759
VOLUMETRIC DATA (mgd)						
-Base conditions-						
Total streamflow	57,012	NE	57,012	NE	57,012	NE
Streamflow at outflow point(s)	44,100	44,193	37,428	41,341	35,880	37,956
Fresh-water withdrawals	38,016	34,434	48,037	43,227	44,359	48,216
Agriculture	32,086	28,461	39,935	34,231	36,894	39,325
Steam electric	3,540	3,540	5,834	5,834	4,938	4,938
Manufacturing	669	650	315	910	292	1,166
Domestic	961	1,264	1,045	1,666	1,161	2,055
Commercial	285	[a]	306	[a]	336	[a]
Minerals	269	313	356	340	424	418
Public lands	159	159	198	198	266	266
Fish hatcheries	47	47	48	48	48	48
Other	0	0	0	0	0	0
Fresh-water consumption	15,469	15,832	19,206	20,327	19,913	25,740
Agriculture	14,664	14,750	18,156	18,741	18,265	23,342
Steam electric	68	68	239	239	637	637
Manufacturing	136	205	122	337	202	527
Domestic	262	537	280	695	302	831
Commercial	69	[a]	72	[a]	78	[a]
Minerals	111	113	139	117	163	137
Public lands	159	159	198	198	266	266
Fish hatcheries	0	0	0	0	0	0
Other	0	0	0	0	0	0
Ground-water withdrawals	10,407	4,196	NE	5,941	NE	8,371
Evaporation	4,924	2,621	5,324	2,621	5,595	2,621
Instream approximation						
Fish and wildlife	33,958	NE	33,958	NE	33,958	NE

NE - Not estimated.

[a] SRF domestic water use includes commercial and institutional requirements.

Problems

The total amounts of water annually leaving the Missouri Region at the mouth of the Missouri River are not indicative of the water availability and the many water-related problems confronting most of the region. Except for Missouri, Iowa, and Minnesota, the remaining seven States of the region are among the 17 Western or Reclamation States generally considered to have large water-short areas and climates ranging from dry subhumid to arid. The three eastern States also have water problems since they too suffer from occasional droughts and periods of too much rainfall that often last a few days.

As a part of the national assessment, the Missouri River Basin Commission through its member States and Federal agencies conducted a study to identify the major water and related land problems and specific individual problem areas. This study identified 58 specific problem areas. After initial screening, 32 areas with the most severe, urgent, and complex problems and issues remained for further analysis. All but 10 of these areas were found to have been covered by recently completed or ongoing studies of various Federal agencies or States. The broad major problems and issues identified by the Missouri River Basin Commission are described in the following pages. The individual problem areas are described near the end of this report.

Indian Water Rights

Twenty-three Indian reservations in the region contain about 12 million acres of land, which is less than 4 percent of the total land area in the basin. These reservations are concentrated largely in the four upper basin States. They comprise 15 percent of Montana, 8 percent of Wyoming, 6 percent of North Dakota, and 20 percent of South Dakota. The Indian rights to water are generally based upon treaties with the United States, case law, and interpretations of previous court rulings. The Indian tribes of the northern Great Plains recently declared that they have prior and paramount rights to the waters of all rivers, streams, or other bodies of water, including all tributaries thereto, which flow through, arise upon, underlie, or border upon their reservations. These water rights have not been quantified in the Missouri Region.

Uncertain about Indian water rights, water resource planners do not know how much water is, or will be, available for use outside the Indian reservations. Indian water rights may affect a number of important tributaries in the four upper basin States as well as the entire main stem of the Missouri River below the Fort Peck Reservoir in Montana. They also could significantly affect a number of existing Federal reservoirs which are operated primarily for hydroelectric Federal reservoirs which are operated primarily for hydroelectric power generation, irrigation, flood control, navigation, water supply, and water-quality management.

Federal Reserved Water Rights

The problems associated with Federal reserved water rights on Federal lands are similar to those of the Indian lands. They are unquantified and unknown. Although about 45 million acres, or about 14 percent of the total basin area, are in Federal ownership, current total water use on these lands is quite small. The Bureau of Land Management and the Forest Service manage about 38 million acres primarily for outdoor recreation, range, timber, watershed, and fish and wildlife habitat. One viewpoint holds that when lands were reserved from the public domain, the United States, by implication, reserved water sufficient for use in accordance with the purposes for which the lands were reserved and as of the date of land withdrawal. The Property Clause of the Constitution, which gives Congress the power "to make all needful rules and regulations respecting the territory or other property belonging to the United States..." is the basis for Federal control of waters on Federal lands.

The large Federal land holdings in the Western States pose a particularly vexing problem. Although there is little development and current water use on most Federal lands is small, added uses, such as leasing of Federal lands for coal mining, may not conform with the State water-right structures, and there the validity of State-granted rights may be contested. Thus, there is a need to determine the Federal reserved water doctrine. Means should be developed to quantify the water-use requirements of lands reserved from the public domain so that other water rights can be safely and firmly established. Several pending court suits concerning specific Federal land areas may clarify reserved water rights on Federal lands.

Alternative Uses of Water

As water use in the Missouri River Basin increases, competition for the remaining supplies will intensify. Some tributary basins are already short of water, the available water having been overappropriated. In the upper South Platte River Basin in Colorado, some cities and industries have purchased irrigation water rights to satisfy their needs. Serious questions have been raised concerning the construction of thermal power-plants in some localities, the extent of their water use, and their effects on downstream flows. The viability of some proposed Federal irrigation projects has been questioned, particularly with regard to whether needed water supplies are available. Additional questions are being raised concerning the adequacy of some existing streamflows to maintain fisheries, riverine recreation, and wetlands used by migrating waterfowl. Thus, competition for available water supplies in some areas is already intense.

Concern for water availability and use reaches every area of the region. What happens upstream affects the downstream areas. There is concern about recent estimates of growing water use in many parts of the region and an even greater concern for what the future may bring. The recent drought that affected large areas and is still affecting some areas has accentuated this concern.

Current Water Availability and Use

Although the national assessment is concerned primarily with two sets of estimates, the SRF and the NF, the estimates shown in the 1971 Missouri Comprehensive Framework Study Report, under the assumed 1970 and earlier levels of development, are also of particular significance. There are wide ranges in the basic data and in the derivations of estimates for water use and availability in the Missouri Region. These occur primarily because of a lack of firm data on irrigated areas, on unit requirements for withdrawals, and on net depletions to surface- and ground-water sources. Together with differences in assumptions and procedures, these ranges make impossible any consensus on water supplies used historically or currently, those presently available, and the probable uses and streamflow or ground-water depletions under projected increased usage.

A study of current and historical water usage and availability is basic to any other studies which may be undertaken in the Missouri River Basin. This study should be a cooperative effort by the States and concerned Federal agencies with an understanding that the study will produce mutually acceptable estimates. This study is direly needed for proper management of the region's water supply, for all planning related to water use, and for optimizing operation of the reservoir system.

Water for Energy

Probably the most widely discussed topic in the Nation today is energy. Water is an important component of energy conversion. Today's electric power industry could not function nearly as efficiently without adequate water for cooling purposes. If synthetic gas and oil are to be produced from coal, water will be necessary. Hydroelectric power, although only a small part of total energy production, is important and completely depends on water which passes through the hydroelectric plants.

Estimates of current and projected water needs for the electric power industry are based on existing plants and projected plant construction and are generally considered reliable. Future water needs for other types of energy production in the region, however, are uncertain. At this writing, there is no unified national energy policy; however, it appears that the national policy now taking shape will place greater emphasis on coal and less reliance on natural gas and oil, with primary emphasis on conservation and efficiency.

The large deposits of low-sulfur coal lying close to the earth's surface in the northern Great Plains have received considerable attention. Mining of this coal has increased steadily. Future increases greatly depend on such matters as national energy policies, economics, changing technologies, and environmental and social concerns.

A Level B study covering the Yellowstone River Basin and adjacent coal areas was completed under the direction of MRBC in late 1977. The study examined the critical issues confronting a 127,000-square-mile area in southeastern Montana, northeastern Wyoming, and southwestern North Dakota. Potential energy and agricultural developments could place large

water consumption demands upon the study area's water supplies. Maintenance of streamflows to meet esthetic, environmental, and recreation potentials is the major nonconsuming water demand. Agriculture and energy will compete to some extent over uses that divert and/or consume the water and uses that require the water to be left in the streams. However, the Yellowstone Level B study concluded that the expected competition between agricultural and energy uses of water will not be as great as earlier studies indicated.

Ground-water and Surface-water Interrelationships

Ground-water hydrology is one of the more difficult components of total water resource management and planning. While there is considerable knowledge concerning ground-water resources in some areas of the basin, there is a notable lack of information for other areas. The interrelationships of ground water with surface water are even more complex than either resource alone. Available information shows that in some areas ground-water levels are declining, which indicates that pumpage rates have outstripped aquifer recharge rates. In most areas, infiltrating precipitation is the major source of replenishment to the aquifer. In other areas, stream channels intercept aquifers and there may be an interchange of water depending on the local relationships of water levels, soils, rock formations, etc.

The total water supply, both ground and surface, should be viewed as a single resource. Many questions need to be answered, such as the extent and quality of underground water supplies and aquifer recharge rates; how increased ground-water use affects surface water and how increased surface-water use affects ground-water supplies; whether these effects are short term or long term; whether a time lag occurs before the effects show up; and whether this time lag can be measured in days, months, or years. Because of variances, study areas need to be established and special criteria unique to each area need to be determined.

Interbasin and Interstate Water Transfers

Interbasin water transfers or diversions have always been viewed with considerable caution, and, when State lines are involved, caution grows. Consequently, while many interbasin diversions have been proposed, few proposals have been adopted. Authorized and currently under construction are the Garrison Diversion and Oahe Units in North and South Dakota, which will divert water to the Souris-Red and James River drainages. Colorado and Wyoming import water from the Colorado River Basin to the South and North Platte River Basins. The International Treaty of 1910 with Great Britain apportions between the United States and Canada waters of the St. Mary and the Milk Rivers. Other interstate compacts and court decrees provide for only limited diversions, except that the Yellowstone compact forbids diversion from the basin unless agreed to be all three signatory States. Net basin imports are about 411 mgd.

Areas that suffer from a lack of rainfall and short water supplies look toward diversions from areas and streams with a seemingly more plentiful water supply. Consequently, there is much discussion about interbasin

water transfers, but little legislation has resulted to permit their realization. Two of the more serious current proposals are (1) diversion of Oahe Reservoir water by pipeline to western South Dakota for municipal and industrial uses and possible irrigation use and to the coal fields in northeastern Wyoming for mining use and (2) slurry pipelines to transport coal for long distances to export from the Missouri Region, as well as for enroute delivery.

Interbasin water transfers within State boundaries are usually quite complex, involving legal questions and policy issues. Taking water from a basin in one State and transferring it for use in another basin in a different State is even more complex. Interbasin water transfers may, in the future, fulfill needs so serious that States will approach the subject with less apprehension. Certainly, this option should be kept open since it may be the only viable solution to particularly vexing problems.

Legal, Policy, and Institutional Problems

To overcome some water supply deficiencies and limitations, water storage reservoirs have been constructed, water is being imported and exported, interstate compacts have been negotiated, and other measures have been undertaken. The legality of some past actions has not been tested, and a host of upcoming actions will be subject to adjudication through the court system. At least some of the probable adjudications could be circumvented by appropriate legislative action.

As competition for available water supplies has increased, so have questions and arguments pertaining to jurisdictional control. This is particularly evident concerning jurisdiction over water impounded in the federally-constructed reservoirs. Jurisdictional questions were raised by several basin States in commenting on the extension of a Memorandum of Understanding between the Secretary of the Interior and the Secretary of the Army concerning water marketing for industrial purposes from the six Missouri River main stem reservoirs.

Although currently there are no active, formal water compact negotiations underway for division of interstate surface waters, there are indications that requests may be forthcoming to clarify or renegotiate some existing compacts. Some States feel that existing compacts do not properly or adequately fulfill all their current water needs. An example is the Yellowstone River Compact, approved on October 30, 1951, which provides that the signatory States (Wyoming, Montana, and North Dakota) must consent to any proposed diversion of waters outside the Yellowstone River Basin. Thus, if Wyoming's share of Yellowstone River Basin water were proposed for use outside the basin, the diversion would require the unanimous consent of the three compacting States.

Generally, a State exercises control of the water originating within or flowing through the State, although it is also generally recognized that for interstate streams the upstream State or States do not have the right to appropriate all the available waters to the detriment of downstream States. Interstate compacts and, in some cases, negotiations or court decrees are used in an effort to attain an equitable distribution of

the available waters and to avoid litigation. The western States in the basin have recently experienced a significant increase in requests for adjudication of water rights and related problems, which probably results from increasing water use, competition for available water, and recent droughts. Either the Federal courts or Congress or both must be called on to settle some of the water problems facing the Missouri Region. Among these important issues are Indian water rights, Federal reserved rights, water use for interstate coal slurry pipelines, and regional water allocations. What is important in these issues is to determine the quantities of water involved, the existing water rights (both active and otherwise), how much water is or would be depleted from the streams and ground-water reservoirs, and how much is or will be available for future uses. It cannot be overemphasized that planning for water resource development needs or reservation for instream flow needs or other purposes is very difficult without quantification of water allocations to various purposes and locations.

Funding Arrangements (Cost-sharing)

Funding arrangements or cost-sharing for development and for operation and maintenance of water resource projects generally means: how much will be supplied by the Federal Government; and how much or what part from non-Federal sources. Historically, the Federal Government has provided most of the waterway improvements for navigation in the United States. In the Missouri Region, most other improvements or developments prior to World War II were accomplished by local entities. All the major projects and programs since World War II have been financed by the Federal Government, with limited repayment by non-Federal entities for some services.

Federal involvement in water resources planning and development in the West resulted largely from a desire to settle and develop this part of the Nation and to control floods and from the inability of State and other government entities to undertake comprehensive, coordinated development projects and to provide the large amount of capital required. Projects and programs to satisfy water resource needs often include more than one State. The United States Government must continue to develop the water resources of the Nation on a timely basis. To do so, optimum use must be made of the capabilities and financial resources of the Federal Government in partnership with the States and other institutional entities, such as river basin commissions and compact organizations.

Instream Flow Needs

The desirability of maintaining certain instream flows for various purposes is becoming more widely recognized with increasing water uses. For many years, the need to maintain streamflows for municipal and industrial purposes, mining, irrigation, livestock, electric power generation, and inland navigation has been recognized. More recently, the need to maintain minimum streamflows for fisheries, wildlife, ecosystems, recreation, and esthetic reasons has been recognized.

Water rights for instream flow use are dependent on State laws, interstate compacts, international treaties, Supreme Court decrees, and

uses developed thereunder. Only two States in the Missouri Region, Colorado and Montana, legally recognize instream flow needs for fish and wildlife, although Kansas has procedures whereby establishment of minimum flows can be accomplished. Other States have considered such legislation.

In the more arid parts of the region, existing water rights are largely held by irrigators, cities, and industry, and many of the tributary streams are already overappropriated. While most States recognize the desirability of maintaining instream flows for fish, wildlife, recreation, and other uses, these uses are recognized as subordinate to those established under State water right laws. Currently no Federal laws require or establish minimum streamflows, although certain authorities reserved to the Federal Government in the Constitution might be interpreted in this light--the Commerce Clause, the General Welfare Power, and the Supremacy Clause. Also, laws concerning the preservation of rare and endangered species may preclude Federal actions if changes in streamflows would adversely affect these species.

The U.S. Department of the Interior's Fish and Wildlife Service recently established the Cooperative Instream Flow Service Group. Its purpose is to make assessments of instream flow needs and to develop information on these needs. The information will be used to assist biologists and recreation planners in establishing instream flow requirements and management strategies for riverine and stream environments. Previous instream flow requirements have been largely estimates. The Cooperative Instream Flow Service Group will attempt to develop scientific bases for determining instream flow needs to maintain fisheries, recreation, wildlife, and ecosystems.

Competition will continue between those desiring to divert streamflow for consumptive uses and those desiring to maintain or, in some cases, increase streamflow for nonconsumptive uses.

Water-related Recreation Needs

The SRF estimates of water-related outdoor recreation demands were taken from State Comprehensive Outdoor Recreation Plan (SCORP) reports. Lack of uniformity of data and of information presented in these reports made it difficult to prepare uniform data at the subregion level for recreation participation estimates, particularly by uniform activity classifications. While some of the SCORP reports included data on water and land areas available for recreation, others did not. The nonuniformity of the SCORP reports also makes it difficult to determine the adequacy of available water-oriented recreation opportunities. Therefore, there is a need to establish uniform criteria and procedures for defining recreation opportunities and needs and for evaluating recreation benefits and associated data.

Navigation Flow Requirements

The Missouri River navigation project extends 732 miles from Sioux City, Iowa, to the mouth of the river near St. Louis, Missouri. It is an open river channel nine feet deep with the banks secured by stabilization

structures. A system of six large main stem reservoirs regulates the river flow to provide water for several purposes, including navigation during the eight-month ice-free season from April through November. The flow rates needed to maintain nine-foot depths are 30,000 cfs at Sioux City, 32,500 cfs at Kansas City, and 35,000 cfs at the mouth of the river.

The upstream reservoir storage system provides a capacity equal to about three times the average annual flow at Sioux City. During extended droughts, because of increasing upstream depletions, inflows into the reservoir system would likely fall considerably below the average. The first requirement in releases would be to maintain adequate streamflows for water quality and municipal and industrial needs. With increased depletions as projected beyond the year 2000, there may not always be enough water for a full eight-month navigation season. It is difficult to assess the effect of a shortened navigation season for several years on shippers and on the barge lines. However, it would reduce the total tonnage shipped, and it would dampen the interest of shippers and barge line owners in Missouri River navigation.

Land Conservation and Erosion Control

The Missouri River Basin Comprehensive Framework Study Report stated that about 45 percent of the 324.7 million acres of basin lands have been adequately managed or treated by needed vegetative and/or mechanical practices. Some progress, probably quite limited, in land conservation has no doubt been made on the remaining 55 percent, although the extent was not ascertained during national assessment studies. While most Federal lands are adequately treated or managed, well over 50 percent of the lands in private ownership need conservation treatment or improved management practices. Without assistance from the U.S. Department of Agriculture programs, it is very doubtful that all needed conservation practices will be implemented on private lands.

A basic requirement for widespread attainment of land conservation is the proper use and management of all cropland, pasture and range, forest and woodland, and other agricultural lands for safe and continuous production without deterioration. In the eastern part of the region, water erosion is the dominant problem on croplands, with sheet and gully erosion being the major hazards to tilled soils with slopes exceeding two percent. Vegetated waterways, terraces, contour farming, strip cropping, proper use of crop residues, adequate use of fertilizers, and conversion of marginal croplands to permanent vegetation are the major treatments needed to control water erosion and protect croplands. Some agricultural lands with excess water need drainage. In the western and northern parts of the region, both wind and water erosion are dominant problems on croplands.

Agribusiness is the principal industry of the region; hence, the private interest of the residents is the land and its productivity. While historically most farmers were concerned primarily with the current year's crops and gave little thought to the future of their land, education

and concerns for the future have changed attitudes and outlooks. Today, there is widespread interest in land treatment and management to allow for safe and continuous production without causing land deterioration. Even untrained individuals can easily understand improved management practices and can institute them with limited guidance. However, watershed improvements, such as those provided for under Public Law 566, require planning and technical study by trained individuals. Also, the laying out of contours, terraces, and gully erosion controls often exceeds landowner capabilities. Thus, there is a need for increased funding to accelerate Department of Agriculture programs that provide needed assistance.

Streambank Erosion and Channel Aggradation and Degradation

Streambank erosion is relatively serious throughout most of the Missouri Region. Critical problems occur at many bridge crossings, particularly during high flood flows. High flows often cause erosion around bridge abutments and cut through streambanks, thus undercutting highway approaches. Bank deterioration has occurred immediately below many of the large dams and is particularly serious below the Garrison and Gavins Point Dams on the Missouri River. The most extensive erosion problems occur in subregions 1004, 1005, 1009, 1010, and 1011. The greatest average annual dollar damage is done in subregions 1009 and 1010. Channel degradation and aggradation affect the water intakes of many municipalities, electic powerplants, industries, and irrigators.

In their natural state, prior to stream alterations, reservoir construction, and other manmade controls and improvements, the rivers and streams maintained a balance over the years between the destruction of valley lands by erosion and the building of new valley lands by sedimentation. This process resulted in a continual migration of the stream channels within their valleys. Due to the balance between the erosion and the deposition, however, there was no appreciable long-term net loss of high valley lands. Since the dam closures, operation of the reservoirs has eliminated or greatly reduced both the floods and the sediment that were essential for the building process. On the other hand, the erosion of high banks continues. Consequently, bank erosion results in a permanent net loss of high valley lands that are never replaced elsewhere in the valley as in the era before the reservoirs. High valley lands are being converted to river channel and sandbar areas, while the distance between high banks continues to widen. This process, unless halted, will eventually transform present river beds. Wide areas of sand bars and channels will occupy an increasing proportion of the valley widths. The navigation and bank stabilization project from Sioux City to the mouth of the Missouri has largely alleviated such problems in that reach of the main stem.

Flooding Problems and Flood-plain Management

Flood damages are increasing despite large public expenditures for flood-protection projects. Historic settlement and development patterns help explain the continued increase in flood damages. Early settlers built their homes and businesses in the flood plains largely because the rivers provided transportation and water supplies. The railroads located in the

flood plains because industry and people were there and construction of the rail lines there was much simpler and less costly. Subsequently, industry and the people continued to build near available transportation routes. Congress, in the Flood Control Act of 1936, declared that flood control was in the national interest and subsequently authorized and funded many projects to reduce the damages and to alleviate human suffering resulting from floods. In many instances, the flood-control projects resulted in more intensive use of the flood plains, and many of the projects did not provide complete protection.

Following the trend of increasing annual flood damages, Congress instituted a National Flood Insurance Program in an effort to reduce annual disaster assistance outlays through the increased availability of flood insurance. This program includes extensive mapping programs of flood plains and classification of flood-prone areas to assist local interests in the control of developments permitted in the flood-prone areas. Studies by the Corps of Engineers and the Soil Conservation Service currently offer several means to reduce or control floods and flood damage. These include structural measures (upstream reservoirs, levees, floodwalls, floodways, and channels improvements); flood-plain management, including zoning and regulation; floodproofing of existing and any proposed buildings; and evacuation. River and flood forecasting by the National Weather Service supports flood-control projects and considerably reduces flood damage and loss of life. This nonstructural method will continue to grow in importance with increases in population, flood-plain development, complexity of water management projects, water usage, interbasin diversion, and improvements in river forecasting and warning systems.

Estimates of average annual flood damages made for the national assessment reveal that flooding is a major problem throughout much of the region. Numerous cities and communities have severe flood problems, and large agricultural areas are subject to frequent flooding. Since many severe flooding problems remain in the region, water resources development planning should consider all means to reduce the flood damages. Efforts should also be made to improve flood warning systems so as to reduce or eliminate the loss of lives and human suffering such as that which occurred at Rapid City, South Dakota, in 1972 and in the Big Thompson Canyon in Colorado in 1976.

Municipal and Industrial Water Needs

The Safe Drinking Water Act of 1974 authorizes the Environmental Protection Agency to regulate the contaminant levels in public water systems and to promulgate standards for drinking water. The regulation applies to all public systems with 15 or more connections and serving 25 or more persons, excluding systems used primarily for storage. The States are given primary enforcement responsibility. Many small communities in the region do not have water sources that can pass standard public health requirements, nor do they have the financial means to obtain acceptable water supplies. Without considerable Federal assistance, many of these communities may never have acceptable public water supplies.

Many communities and even several large cities in the region lack adequate water supplies to meet their current and projected needs. The recent drought has affected many areas. Many communities and livestock raisers, particularly in the Dakotas, were forced to haul water, and many others instituted water rationing. Far below normal winter snowpack in the Rocky Mountains has caused great concern, particularly in Colorado, where plans for water rationing and water-use restrictions have been readied. While rural water districts are meeting some of the needs, many other districts are needed. However, in the more thinly populated areas, these types of solutions are far too costly. It is apparent that solutions are not easy, they are generally quite costly, and in many cases, are beyond the financial capability of local governments.

Water Quality and Low Streamflow Augmentation

Overall, the water quality objectives for the Missouri Region are dictated by Public Law 92-500. Section 101(a)(2) states: "...it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water shall be achieved by July 1, 1983." In general, it can be assumed that effluents from municipalities, industries, and feedlots that are causing some degradation immediately downstream from outfalls will be treated as required by P.L. 92-500.

Increasing emphasis is being placed on management of irrigation water use and on education in the use of farm chemicals. It may be possible to reduce somewhat the salinity of irrigation return flows in some areas, although to what extent is not now determinable. One of the more significant stream pollutants throughout most of the Missouri Region is sediment resulting from sheet, gully, and streambank erosion. This problem is most prevalent throughout subregion 1009 and the northern part of subregion 1011 in northwestern Missouri and southwestern Iowa. Although improving land conservation, controlling grazing, taking some lands out of cultivation, and installing control structures will probably lessen the pollution, stream sediment will always be a major problem. There are no apparent feasible solutions to the naturally-occurring pollution in such areas as the Badlands of South Dakota in subregion 1005.

Inadequate data is available on the quality of surface waters in the region. More sampling stations and a reliable method to transmit the available data are needed. Records at existing stations are not available for a period long enough to define accurately the changing quality of water. Data concerning the biological quality of surface waters are particularly deficient. The staff report to the National Commission on Water Quality recognized the lack of data as a nationwide problem. Therefore, the effect of point-source treatment, as required by Public Law 92-500, on the complex aquatic ecosystem or the extent to which waters have been restored to a presettlement status will never really be known. While it appears that practically all point sources in the region will be treated by 1983 to meet the requirements of Public Law 92-500, water quality problems resulting from nonpoint sources will remain. Also, in some areas, it is

doubtful that the low, erratic streamflow can adequately assimilate even properly treated wastes. Particularly in those areas and possibly in other areas where advanced treatment would be quite costly, consideration and study should be given to additional reservoir storage to augment low streamflows, not only for water-quality management but also for quantitative needs.

Individual Problem Areas

Initially, the Missouri River Basin Commission identified 58 problem areas in its region. Through a screening process, this number was reduced to 32 areas which have severe, urgent, and complex problems and issues. In the last stages of the assessment, 22 of the 32 problem areas were deemed to be adequately covered by recently completed or ongoing studies, and, thus, ten were retained for further analysis. The selected problem areas described herein for assessment purposes are as follows:

Problem Area Number	Name of Area
1.	Bad River Basin
2.	White River-Medicine Creek Basin
3.	Big Sioux River Basin
4.	Middle North Platte River Basin
5.	Nebraska Panhandle
6.	Upper Republican River Basin
7.	Big and Little Blue River Basins
8.	Tri-Cities Area, Missouri
9.	Lake of the Ozarks, Missouri
10.	Ogallala Ground Water Area

The locations of the areas numbered in the matrix are shown on the map (Figure 10-7a). Figure 10-7b presents the type of problems found in each problem area. Summary sheets describing the ten selected areas, their problems, and the effects of the problem follow.

Problem Area 1: Bad River Basin

The Bad River Basin is located in west-central South Dakota. The major problems identified relate to inadequate quantity and quality of water to meet municipal and rural needs; poor quality of the ground and surface waters; intermittent and, at times, no streamflows; flooding at two communities and in agricultural areas; land surface and gully erosion; sedimentation of small stock ponds and reservoirs; because of a general lack of adequate rainfall, the need to develop storage and more surface-water irrigation; and a general lack of local water-oriented recreation areas.

Problem Area 2: White River-Medicine Creek Basins

The White River and Medicine Creek Basins are located in southwestern South Dakota. The headwaters of the White River Basin extend into northwestern Nebraska. Major problems identified in these two basins include water supplies of inadequate quantity and poor quality for many municipalities and much of the rural area; unquantified water rights for the large Pine Ridge and Rosebud Indian Reservations in South Dakota, including the uncertainty of their needs and potential impact on water supplies generally; frequent flooding of agricultural lands; streambank and gully erosion as well as surface land erosion; poor quality of much of the surface- and ground-water supplies, although the headwaters area in Nebraska has high quality water; intermittent and low streamflows; lack of adequate

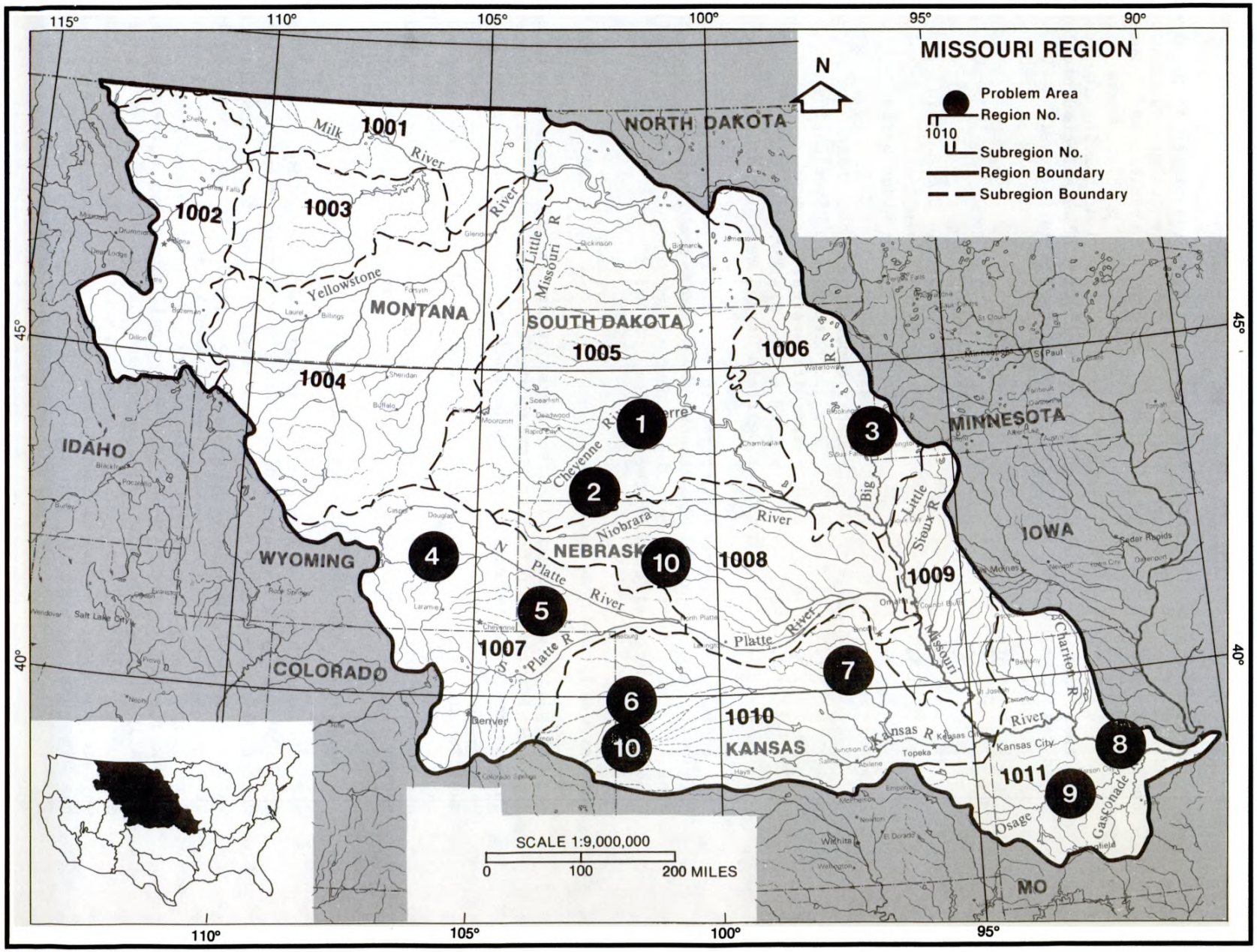


Figure 10-7a. Problem Map

MISSOURI REGION (10)

PROBLEM MATRIX

Problem area		Problem issues O= Identified by Federal Agency Representatives X= Identified by State-Regional Representative													
		Water quantity				Water quality				Related lands					
No. on map	Name	Fresh surface	Ground	Marine and estuarine	Surface/depth	Fresh surface	Ground	Marine and estuarine	Surface/depth	Flooding	Drainage	Erosion and sedimentation	Dredge and fill	Water related use conflicts	Other
Subregion 1001	Missouri-Milk-Saskatchewan	O				O					O			O	O
Subregion 1002	Missouri–Marias	O				O								O	O
Subregion 1003	Missouri-Musselshell	O				O					O			O	O
Subregion 1004	Yellowstone	O				O	O				O			O	O
Subregion 1005	Western Dakotas	O				O	O				O	O		O	O
Area 1	Bad River Basin	X	X			X	X			X		X			X
2	White River – Medicine Creek Basins	X	X			X	X			X				X	X
Subregion 1006	Eastern Dakotas	O	O			O	O					O		O	O
Area 3	Big Sioux River Basin	X	X			X	X			X	X			X	X
Subregion 1007	North and South Platte	O	O			O				O	O			O	O
Area 4	Middle North Platte River Basin	X			X	X	X			X		X		X	X
5	Nebraska Panhandle	X	X			X	X								
Subregion 1008	Niobrara-Platte-Loup	O	O			O					O			O	O
Subregion 1009	Middle Missouri	O	O			O	O			O	O		O	O	O
Subregion 1010	Kansas	O	O				O			O	O	O	O	O	O
Area 6	Upper Republican River Basin	X	X			X	X			X				X	X
7	Big and Little Blue River Basins	X	X			X	X			X	X	X		X	X
Subregion 1011	Lower Missouri	O					O			O		O	O	O	O
Area 8	Tri-Cities Area, Missouri					X	X			X					X
9	Lake of the Ozarks, Missouri					X	X		X					X	X
10	Ogallala Ground Water Area		X				X							X	

Figure 10-7b. Problem Matrix

fishing water and water-oriented recreation areas; pollution of the White River by erosion from the Badlands area; sedimentation of stockwater ponds; deterioration and inefficiency of many of the diversion, storage, and distribution structures of the Whitney Irrigation District in Nebraska; and a shortage of adequate irrigation water because of inadequate rainfall and streamflow and generally poor quality ground water and surface water.

Problem Area 3: Big Sioux River Basin

The Big Sioux River Basin is located in eastern South Dakota, northwestern Iowa, and southwestern Minnesota. The major water problems of the basin are an inadequate water supply for Sioux Falls, South Dakota; highly mineralized ground waters which result in a number of communities and much of the rural area being without an appropriate source of water supply; protracted periods of low streamflows which cause water quality problems in the Big Sioux River; frequent flooding of many cities, communities, and agricultural areas which results in frequent damage to property and loss of crops; poor ground-water quality and a lack of reservoir storage which severely limit irrigation; low streamflows which frequently cause water quality problems and reduce stream fisheries; a lack of adequate fishing waters and, particularly, a lack of water-oriented recreation areas near the communities; a lack of adequate recreational facilities at some of the natural lakes; and high water development costs and inadequate support concerning institutional arrangements and cost-sharing for needed project developments.

Problem Area 4: Middle North Platte River Basin

The Middle North Platte River Basin problem area consists of the drainage of the North Platte River and its tributaries from the Seminoe Reservoir in Wyoming downstream to the Nebraska State line. Major problems identified, but not considered by Wyoming to be critical at present, include: unsatisfactory water quality at several communities; potential water uses for steam electric powerplant cooling, coal gasification, and uranium milling in areas that already utilize most available water supplies; and irrigation return flows and municipal discharges at Casper, Wyoming. There are additional problems: several communities experience occasional flooding; about 156,000 acres of rural lands are subject to flooding; stream sediments adversely affect stream fisheries and storage capacities of reservoirs; about 23,000 acres are subject to erosion damage; about 7,000 acres have drainage problems; many of the irrigated areas suffer from late season water shortages; and many irrigation facilities need rehabilitation and improvement. Reservoir fluctuations, dewatering of tributaries during the irrigation season, low tributary streamflows, and the rapid drawdown at Guernsey Reservoir to flush sediment into irrigation canals and laterals are detrimental to local fisheries, and increasing stream depletions are causing concern downstream in Nebraska. Accelerated development and expansion of industrial activities could cause the foregoing problems to become critical unless appropriate actions to prevent future deterioration are properly planned and adequate measures applied to mitigate any adverse impacts.

Problem Area 5: Nebraska Panhandle

The Nebraska Panhandle problem area consists of the North Platte River drainage above Lake McConaughy and the drainage of Lodgepole Creek in Nebraska. Major problems include: poor water quality caused by nonpoint agricultural runoff, feedlot runoff, and chemical sediment content of irrigation return flows; periodic flooding, suffered by several communities, about 236,000 acres of agricultural land, and many irrigation structures; soil losses from cultivated lands which exceed eight tons per acre per year; drainage problems which occur on 70,000 acres of land; problems related to irrigated areas including systems rehabilitation and betterment, water-use conflicts and shortages, surface- and ground-water complexities, and institutional contraints; increasing surface- and ground-water depletions and manmade pollution which threaten the future of Nebraska's major trout fishery; and pending energy developments and associated water use in Wyoming which pose potential conflicts with agricultural and other water uses.

Problem Area 6: Upper Republican River Basin

The Upper Republican River Basin problem area includes all the drainage of the Republican River and White Rock Creek above their confluence. Major problems identified include: several communities susceptible to flooding; over 37,000 acres identified by the Department of Agriculture as subject to flood-water and sediment damages; stream sediments; nonpoint runoff stream pollution; ground-water pumping for irrigation which reduces surface-water supplies and adversely affects several large Federal reclamation projects as well as private irrigation; replacement or rehabilitation of some irrigation facilities; and the Harlan County Reservoir recreation use problems caused largely by reservoir fluctuations, sediment deposition, and upstream depletions.

Problem Area 7: Big and Little Blue River Basins

This problem area consists of the Big and Little Blue River Basins above the Tuttle Creek Reservoir. The major problems cited include excessive amounts of iron, dissolved solids, and nitrates in numerous community ground-water supplies; improperly treated community waste-water discharges which cause surface-water pollution; concentrations of septic tanks at cabin agglomerations which cause some pollution of both ground- and surface-water supplies; livestock wastes, runoff, and leaching from irrigated lands and solid waste disposal sites; and leaching of pesticides from agricultural areas. In addition, many communities suffer from frequent flooding; nearly 480,000 acres of agricultural land are subject to periodic flooding; logs and other debris cause log jams at bridges resulting in frequent damage and raising of flood crests; land surface and gully erosion affects 914,000 acres of agricultural land; improved drainage is needed on about 160,000 acres of flat uplands, shallow depressions, and bottomland areas; irrigation pumping of ground water is causing serious declines in ground-water levels; and the entire area has a serious deficiency of water-oriented recreation areas.

Problem Area 8: Tri-Cities, Missouri

The Tri-Cities problem area is made up of the three central Missouri counties of Boone, Callaway, and Cole. Major problems identified include urban flooding; acid mine drainage from orphaned coal mines; poor ground-water quality in deep aquifers due to high salinity; shallow aquifers experiencing increasing pollution from surface drainage; septic tank wastes that are primarily responsible for water pollution in the Devil's Icebox Cave in Rock Bridge Memorial State Park; and acid mine drainage and other water pollution which cause frequent fish kills.

Problem Area 9: Lake of the Ozarks, Missouri

The Lake of the Ozarks problem area is located in south-central Missouri. Among the major problems identified are both point-source and nonpoint source pollutants; recent increases in clearing forest and woodland areas for agricultural uses; effects on recreational use of the lake because of pollutants; need to upgrade resort and community waste treatment; need to control or prevent resort and residential septic tank leachates from reaching the lake and causing ground-water quality problems; unplanned and uncontrolled intensive development surrounding the lake; and the lack of laws and policies to govern development and local operations to correct the cited problems.

Problem Area 10: Ogallala Ground-water Area

The Ogallala ground-water problem area within the Missouri Region covers all or parts of 52 counties in western Nebraska, five counties in northeastern Colorado, and nine counties in northwestern Kansas. Major problems identified include: a projected increase in irrigated acreage from the present 4.1 million acres to 6.2 million acres by the year 2000; increasing municipal, industrial, and other water uses; inability of the available ground-water resource to support the increasing irrigation and other demands; severe ground-water declines that already affect several parts of the area; tremendous economic and social effects on the region with projected ultimate loss of irrigated areas; and widespread resistance to legal and instititional needs to manage the ground-water resource.

Summary

The Missouri Region is often referred to as the "Breadbasket of the Nation." Most of the area is classified as Interior Plains and extends from the Rocky Mountains in the west to the Ozark Plateau in the southeast. Most of the Interior Plains area is located in the semiarid to dry subhumid climatic zones, with average annual rainfall of about 12 inches in the western plains, gradually increasing to about 30 inches in eastern Nebraska and Kansas and to about 40 inches at the confluence of the Missouri and Mississippi Rivers. The winters are cold and the summers hot. Prevalent prairie winds often cause severe blizzards in the winter and tend to cause rapid drying of the soils in the hot summers. Precipitation is often erratic, fluctuating widely from the average. The region suffers from periodic droughts and, at times, too much precipitation and runoff.

The natural resources of the area are dominated by the vast areas of pasture, range, and cropland. Forestlands are located in the Rocky Mountains, the Black Hills in western South Dakota, and the Ozarks in the southeast. There are relatively few natural lakes. Most of the available water areas are found at the manmade reservoirs constructed primarily for irrigation, hydroelectric power, flood control, navigation, and municipal and industrial water supply. Almost all of the western streams are fed by the spring snowmelt and runoff from the erratic rainfall. Therefore, streamflow fluctuates widely in the west, usually diminishing greatly in the late summer, fall, and winter, when many streams have little or no flow. At times, the only streamflow results from reservoir releases or irrigation return flows. The Northern Great Plains contain huge deposits of low-sulfur coal, much of which is easily surface mined. The western States provide oil and natural gas, and Wyoming supplies much of the Nation's uranium.

The region contains about 17 percent of the land area of the 48 contiguous States, but only 4 percent of the Nation's people. The rural population has been declining, largely due to farm mechanization, which has also caused farm sizes to increase. Most of the people live in the southern part of the region, where the metropolitan centers of Kansas City, Denver, and Omaha-Council Bluffs are located. There are only nine other SMSA's in the region. The many other smaller cities and communities serve largely as trading centers and seats of local government. The metropolitan centers and many of the larger communities provide diverse manufacturing, much of which relates to agribusiness. The population, employment, and economy are expected to grow but at a lesser rate than that of the Nation.

The principal industry of the region is agriculture and related agribusiness. Agricultural production is dominated by the growing of small grains and the raising and fattening of livestock for market. Agriculture is expected to continue to dominate the region's economy. Mining of the northern Great Plains coal has been increasing at a steady rate and probably will provide a large share of the Nation's future energy. Improved technology, increasing oil and natural gas prices, and indicated future scarcities of oil and gas may lead to production of large quantities of synthetic oil and gas from coal.

Many of the western tributaries to the Missouri River are quite long, drain large areas, and originate in the Rocky Mountains; the eastern tributaries generally are much shorter and drain much smaller areas. Six large reservoirs on the Missouri River main stem generate most of the region's hydroelectric power, maintain adequate flows for an eight-month navigation season and for water quality and water supply needs, and would permit the diversion of water northeastward and eastward for irrigation as well as for municipal and industrial needs. In addition, there are over 100 tributary reservoirs with storage capacities in excess of 25,000 acre-feet, some 1,500 smaller reservoirs, and thousands of stock ponds scattered throughout the region. These manmade reservoirs provide most of the water surface for water-oriented recreation as well as for fish and wildlife propogation and preservation.

Over 90 percent of the water consumed in the region is used for irrigation, and its share of the total water consumed will probably continue at that rate over the next 25 years. The number of acres of land under irrigation has been increasing steadily and is expected to continue to grow. The use of center-pivot sprinkler type irrigation, which can be used on somewhat hilly terrain as well as on level lands, has been increasing most rapidly throughout the Platte and Kansas River Basins. Currently about 27 percent of the region's available surface-water supplies are being depleted, which is expected to increase to 35 percent by the year 2000. For the area upstream of Sioux City, Iowa, subregion 1006, an estimated 24 percent of surface water supplies are being depleted, and that rate will increase to 38 percent by the year 2000. In addition, considerable amounts of ground water are being depleted, particularly, the Ogallala formation in eastern Colorado, western Kansas, and western Nebraska.

Many broad, major issues involving national policies confront the Missouri Region. The resolutions are not immediately apparent. The major Indian reservations and most of the Federal land holdings are located in the upper part of the region. Because Indian and Federal reserved water rights have not been quantified, uncertainty makes it difficult and sometimes impossible to plan for using and managing the available water supplies.

Considerable disagreement has been expressed concerning the NF, SRF, and other available estimates of current water uses and availability.[1] Increased competition for available water supplies indicates the need to examine current and projected water uses to assure maximum efficiencies and an equitable distribution of available supplies. Although current estimates indicate that adequate water supplies are available for northern Great Plains coal field development, project or diversion plans are needed to assure adequate amounts of water at various points. Increasing use of ground water in many areas of the region is affecting streamflows; the interrelationships are currently under study.

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[1] The FOREWORD indicates the need to consider all relevant viewpoints and estimates in the light of conditions that exist at the time policy decision are to be made.

Interbasin water transfers may help solve the problems of some water-short areas, although such transfers currently pose legal, policy, and institutional problems. Requests for adjudication of many water problems through the Federal and State court systems are increasing. Appropriate legislation could resolve some of the legal, policy, and institutional problems. The extent of Federal participation in water resources planning and development needs clarification.

Current estimates of instream flows needed to maintain fisheries, wildlife, and aquatic ecosystems are based largely on judgment. There is a lack of uniformity in standards and procedures used by the States in developing water-related recreation uses and needs. Considerable controversy, largely over environmental, preservation, and conservation issues, has resulted recently over every proposed Federal reservoir project. This is particularly evident in the Missouri Region concerning Federal irrigation projects. The projected estimates of future water use indicate that, during extended drought periods, sufficient water may not be available to maintain navigation flows, to provide for irrigation, and to serve other purposes. An objective study needs to be made to determine allocations and priorities of water use and control under critical conditions of deficient supplies. The study should recognize applicable Federal and State laws, water rights, and statutory requirements for operation of the Missouri Basin system of projects.

Sheet, gully, and streambank erosion results in the loss of valuable soils and lands at many locations throughout the region. This soil shows up as silt in many of the streams causing additional problems. Sediment is the major stream pollutant by volume throughout the region. Many communities suffer from periodic flooding, and agricultural and other flood losses in the rural areas continue to mount.

Many communities suffer periodic water shortages because of inadequate water supply sources. Others do not have readily available sources of supply which can pass standard public health requirements. It is assumed that all municipal and industrial effluents will be adequately treated by 1983 as stipulated in Public Law 92-500; however, the region will continue to have water quality problems resulting from nonpoint sources for which there currently are no feasible remedies. Also, in some areas it is highly doubtful that periodic low streamflows can adequately assimilate even properly treated point-source waters.

Conclusions and Recommendations

The need for certain water planning activities has been clearly established through the analysis of water and related land resources data for the Missouri River Basin. Those planning activities involving a significant Federal role or awareness are summarized in the following recommendations.

Historically, many valuable services have been provided in the development, conservation, and preservation of water and related land resources by Federal agencies, especially the Departments of the Interior, Army, Agriculture, and Housing and Urban Development. Federal agencies have developed capabilities and talents which would be impractical, if not impossible, to develop at a State or local level. The activities of the Federal agencies should be continued, and in the Missouri River Basin, the Missouri River Basin Commission should continue to provide member States and Federal agencies with coordination and comprehensive planning services to facilitate continued effective performance by the Federal water agencies.

Federal funding to States under Title III of the Water Resources Planning Act of 1965 should be increased to assist States in completing and maintaining current State water plans and in participating with Federal agencies in water resources planning activities.

A study to determine (1) historical and current ground- and surface-water uses and availability in the Missouri River Basin and (2) implications of alternative assumed future water utilization schemes should be funded beginning in fiscal year 1980. The study should be undertaken by the MRBC with the participation of Federal and State agencies and with full cognizance of work already performed. This study would require establishment of a regional information system for water-use and availability data and related land resources information.

An MRBC to define the issues associated with water and related land resources on Indian and Federal lands should be undertaken as soon as current studies (scheduled for completion by June 6, 1979) by Federal agencies under Presidential mandate are completed. The study should provide a basis for ultimately resolving those issues and lead to the eventual quantification of Indian and Federal reserved water rights.

A study program should be initiated to evaluate alternative water allocation methods and their implications with the objective of establishing priorities and an up-to-date institutional framework for allocating flows of the Missouri River. This study program should begin as soon as practicable.

Studies should be conducted to determine the severity, extent, and effects of continued ground-water pumpage and to formulate measures for resolving the problem in areas where the use of ground water is significantly affecting ground-water levels and streamflow. This is an especially serious problem in Nebraska and Kansas.

Improved data are needed on instream flow requirements for maintaining and enhancing fisheries, wildlife habitat, aquatic ecosystems, recreation, and esthetics. The Fish and Wildlife Service should lead and coordinate efforts to develop these data.

Uniform criteria are needed by State and Federal agencies in defining recreation opportunities and needs, evaluating recreation benefits, and presenting recreation data and information. The Bureau of Outdoor Recreation should coordinate the development of those criteria.

Funding should be accelerated for the land conservation and management programs and watershed projects of the Soil Conservation Service and the States.

Flood damage abatement programs of the Soil Conservation Service, the Corps of Engineers, Federal Insurance Administration, and National Weather Service have been effective in controlling flood losses in both urban and rural areas and should be accelerated.

The rural water supply programs of the Farmers Home Administration and other Federal and State agencies are providing a very important service in many parts of the Missouri River Basin and should receive increased funding.

MRBC's comprehensive, coordinated, joint plan (CCJP), together with the commission's priorities program, should be used as a guide for programming and funding basic data collection, planning-related research, special studies, regional and river basin studies, implementation studies, and program and project implementation in the Missouri River Basin. The commission's current CCJP recommends that comprehensive studies on a multiobjective, multidisciplinary basis be conducted by 1985 in the following areas: Missouri-Bad Rivers subregion (1014); Missouri-Big Sioux subregion (1017); Niobrara subregion (1015); South Platte subregion (1019); North Platte subregion (1018); Middle Missouri Basin subregions (1023 and 1024); Kansas River Basin subregions (1025, 1026, and 1027); and Missouri-Kansas City subregion (1030). Special Studies, in addition to those cited above, are recommended for the Upper Platte River Basin and the Missouri River below Gavins Point Dam. The latter study should focus on channel degradation and aggradation.

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Warren Viessman, Jr., Library of Congress
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Harry A. Steele, Consultant
Pat Waldo, Consultant
Francis M. Warnick, Consultant
Bernard J. Witzig, Consultant
Leo R. Beard, University of Texas

[1] The Washington staff of the Federal agencies was augmented by field office staff who participated with Washington offices or through the Regional Study Teams.
[2] Several States had representatives on more than one Regional Study Team. Contributions of those not named were greatly appreciated.

THE NATION'S WATER RESOURCES — 1975-2000

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Authorization

The United States Water Resources Council was established by the Water Resources Planning Act of 1965 (Public Law 89-80).
The purpose of the Council is to encourage the conservation, development, and utilization of water and related land resources on a comprehensive and coordinated basis by the Federal government, States, localities, and private enterprises with the cooperation of all affected Federal agencies, States, local government, individual corporations, business enterprises, and others concerned.