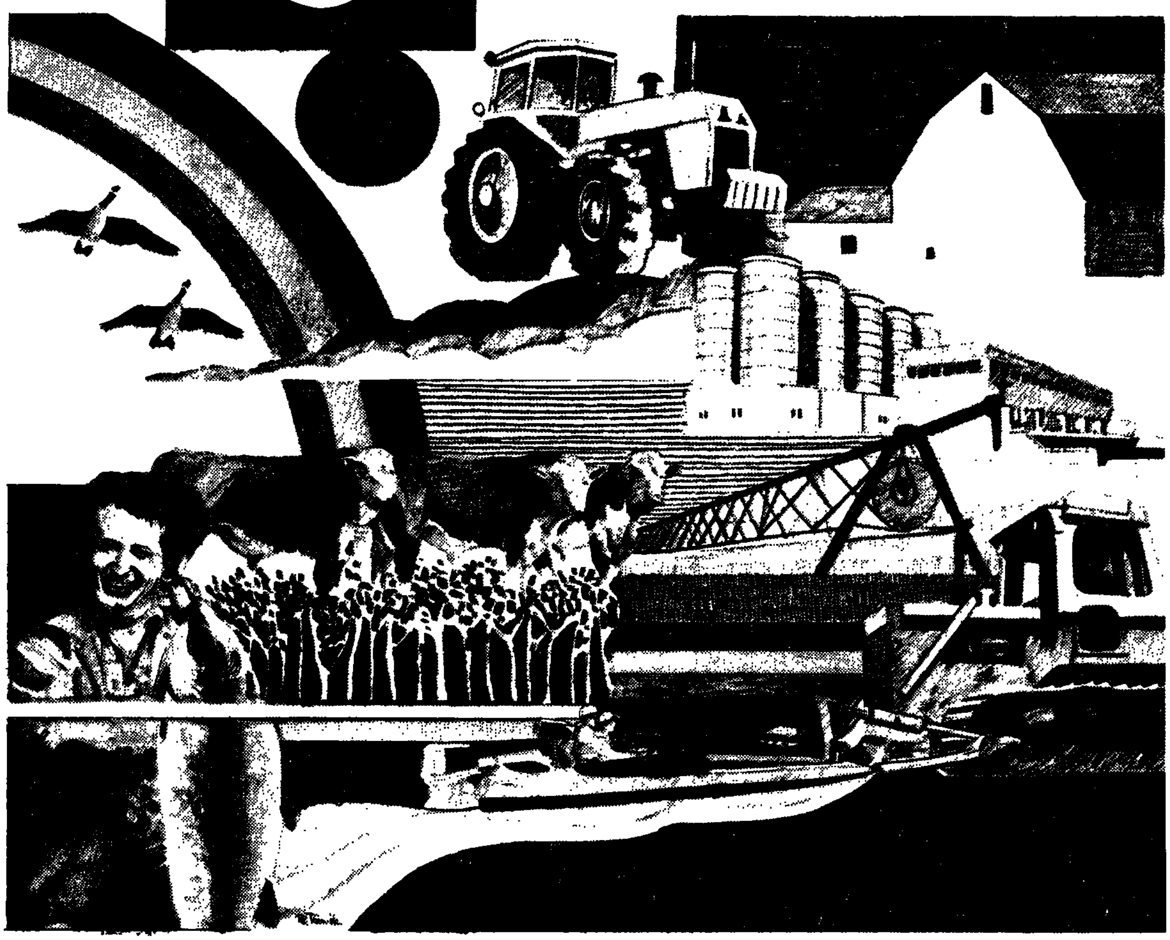
1983 STATE WATER PLAN



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CHAPTER ONE

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FOREWORD

North Dakota published its first long-range, comprehensive water and related land resources plan in 1968. Earlier State-wide water planning efforts, such as the State Planning Board's 1937 plan and the State Water Commission's 1962 plan, dealt largely with strategies for solving problems as they existed when the plans were developed. Only the 1962 plan attempted to anticipate the kinds of problems and the level of water demand North Dakota might face in the 1980's.

The 1968 Plan went a step further, projecting water use and identifying areas of potential concern in the water sector through the turn of the century. The 1968 Plan evolved during a time when pressures on the water resource were relatively insignificant in terms of the total known water supply. The State was aware of its vast lignite reserves and a mine-mouth power production industry was developing. However, interest in utilizing the coal for gasification and/or liquefaction had not yet materialized; nor was there any serious discussion of slurry pipelines. Irrigation development was growing, but slowly. Wetland drainage to enhance agricultural production was taking place with minimum consideration being given to the value of wetlands destroyed or the impact of drainage on downstream interests. The environmental movement was in its infancy, and the attitude of most of the public regarding the water resource was one of indifference.

Significant changes have occurred since the 1968 plan was published and the new plan must accommodate these changes. Some of the projections and assumptions used in 1968 do not reflect what has happened in North Dakota in recent years. In some instances, the 1968 projections have been exceeded. Irrigation, for example, has increased dramatically as has the level of energy development. In other areas, such as population growth, the 1968 projections tend to be high. Moreover, factors not considered in the 1968 projections now must be. In 1968, the possibility of mass diversion of Missouri River water to states outside the Basin was largely a matter of conjecture. Today, serious attention is being given to the idea with several formal studies being conducted by governmental agencies and private interests to determine the feasibility of using Missouri River water for a variety of purposes outside the Basin. In addition, a growing barge transportation industry, functioning on both the Mississippi and Lower Missouri Rivers, is causing downstream states to closely scrutinize water development in upper reaches of the River for potential negative impacts.

PURPOSE

The primary purpose of the study is to reassess North Dakota's long-term water requirements in a context of rapidly changing times and values, and to begin a decision-making process regarding alternative courses of action. The responsibility for decisions regarding the implementation of programs and projects contained in the plan is in the political-legislative-private domain and rests ultimately with the people. Decision-makers must agree upon the timing and extent of implementation deemed appropriate; they must ascertain the State's ability and willingness to proceed; and they must weigh the relative worth of investing the taxpayer's, stockholder's or their own dollars in the water sector as opposed to investments in other sectors.

The completion of this plan report is but one step in a continuing planning process. The report can be altered and undoubtedly will be because, while it is possible to project future water requirements on the basis of known trends, such projections do not anticipate the future influence of forces which can drastically alter those trends. Moreover, the timing of project and program implementation may be revised as a result of changing needs and values.

The 1983 State Water Plan should be viewed as a framework within which development can occur rather than a blueprint which must be followed. It should also be viewed as one part of an overall water management program which involves: (1) a permit system, (2) project investigation and design, (3) project construction, (4) program administration, (5) operation and maintenance, (6) regulation and enforcement, (7) coordination, (8) data collection and (9) research.

AUTHORITY

The North Dakota Century Code grants the State Water Commission broad powers and primary responsibility for managing the State's water resources. The Legislature has clearly expressed a need for "comprehensive, coordinated, and well-balanced short- and long-term plans and programs" for water resources. Responsibility for the "optimum protection, management, and wise utilization of all the water resources of the state" has been given to the State Water Commission and the State Engineer by virtue of the charge contained in Sections 61-01-26, Declaration of State Water Resource Policy, and 61-02-14, Powers and Duties of the Commission.

Section 61-02-14 further states that "The (State Water) Commission shall have full and complete power, authority, and general jurisdiction

"7. To cooperate with the United States and any department, agency or officer thereof in the planning, establishment, operation, and maintenance of dams, reservoirs, diversion and distributing systems, for the utilization of the waters of the state for domestic, municipal and industrial needs, irrigation, flood control, water conservation, generation of electric power and for mining, agricultural and manufacturing purposes...".

GOALS AND OBJECTIVES

The Overall Goal

The overall goal of the 1983 State Water Plan is to provide a framework for meeting, through the conservation, development and management of its water resources, the State's need to have a strong and viable social, cultural and economic structure. Inherent in this goal is a recognition of the need to provide for the well-being of the State's citizens at or near the national level and to protect the State's environment, particularly those elements that are of unique importance.

In pursuit of this overall goal, the planning process placed special emphasis on identifying water and related land resources management measures which tended to:

(a) broaden the economic base;
(b) increase employment opportunities;
(c) maintain and enhance the health, well-being and security of the people by reducing hazards from water pollution and floods;
(d) maintain a strong agricultural economy by emphasizing watershed management, soil conservation practices, irrigation, research and education; and
(e) improve the quality of life by preserving and enhancing the environmental and aesthetic values of lakes, parks, recreation facilities, fish and wildlife habitat and the most significant scenic and historic sites.

Although this goal is very broad, it served to guide the planning process and provided a basis for comparing the end product with that envisioned at the outset of the study.

Still, it was recognized that a more definitive statement of goals was needed if the results of the plan were to attain the support of those affected. It was also recognized that a goal which could be applied generally on a statewide basis would likely have significantly less applicability when applied to specific sections of the State.

Historically, the impetus for water resources development in North Dakota has come from the people. By statute, the State Water Commission and State Engineer have certain over-riding responsibilities for protecting the water resources, not the least of which is the resolution of conflicts arising between regions and watersheds where questions occur as to the manner in which water is used and managed. But, the State does not impose water projects on the citizens of the State. There are no such State-owned water projects in North Dakota. On the contrary, project development begins at the request of the local residents, and can eventually involve not only the State government but Federal government as well.

In light of this, it was difficult to conceive of a "bottoms-up" plan, one resulting from local involvement and support, that could be implemented so long as the goals were set exclusively through a "top down" (State) process. Consequently, the decision was made to foster the development of a set of goals and objectives for each of the State's major hydrologic subdivisions.

The mechanism used to bring this about was the Citizens Advisory Boards created by the Governor as Chairman of the State Water Commission. Seventeen Boards were created and functioned throughout the study (discussed in detail later in this report). One of the very first tasks of each Board was to put into motion a process for developing a set of goals and objectives that would be meaningful for the area in which they lived. The goals and objectives adopted by the Citizens Advisory Boards are summarized in Part One, Chapter 4.

THREE-ACCOUNT ANALYSIS SYSTEM

In order to develop a balanced long-term plan - one which can be embraced by the people it affects - it was necessary to build an analytical system capable of accounting for the various kinds of impacts triggered by projects and programs being considered for inclusion in that plan. The procedure developed and used throughout the planning process is called the Three-Account Analysis System. Essentially, this involved the evaluation of every project or program which was thought to have the potential for meeting needs or solving problems from three perspectives:

(1) its quantifiable, beneficial and adverse economic impacts;

(2) its beneficial and adverse environmental impacts; some of which, such as land use changes, are quantifiable; others of which, such as aesthetic damage, must be handled qualitatively;

(3) its other social effects impacts; those which are neither clearly economic nor environmental, but which, nonetheless, influence life-styles, quality of life, etc. Typically non-quantifiable.

The results of the Three-Account Analysis are presented in this report. It should be noted, however, that no information is displayed for those projects and programs which were considered, but for one reason or another, were rejected.

STUDY SCOPE

Level of Investigation

The Plan recommended in this report is the result of a preliminary or reconnaissance level study intended to provide broad analyses of water and related land resource problems and development opportunities and to furnish general appraisals of the probable nature, extent and timing of measures for their resolution or implementation. In a few instances, such as in the case of the Devils Lake Basin where a substantial amount of detailed planning had already been accomplished prior to beginning this effort, the study scope is more accurately described as modified reconnaissance. Because less time is required to update the data base of such a study, it is possible to place greater emphasis on the evaluation of impacts, and on clarifying perceptions regarding public preferences.

Study results should be viewed as comprehensive and long-range. All uses of water in North Dakota were considered in identifying problems, calculating need (the difference between developed supply and demand) and formulating measures to solve a problem, satisfy a need, or take advantage of desirable growth opportunities. Moreover, each major hydrologic subdivision is treated as a whole with emphasis given to reviewing a project's contribution toward solving regional problems.

Timeframe

The study, keyed to the period of 40 years between 1980 and 2020, uses 1990, 2000 and 2020 as benchmark years for measuring water requirements and the degree to which plan features will meet those needs. The level of detail for benchmark year 1990 is far greater than for 2000 and 2020. Specific plan elements (storage reservoirs, diversion systems, etc.) for 1990 are identified by location, size, and cost. Plan elements for 2000 and 2020 indicate only an estimate of water requirements to be met by surface-water control, level of ground-water development, modification of existing projects and various other water management programs.

Early Action Program

The timeframe ending with benchmark year 1990 deserves special mention. As indicated in the previous paragraph, it details those projects and programs with the highest priority for implementation. Throughout this report, it is referred to as the Early Action Program.

Planning Divisions

For purposes of planning, the State is divided into five major hydrologic subdivisions (Figure I-1-1): Missouri River, James River, Red River, Devils Lake, and Souris River Basins. A separate plan was developed for each major subdivision. Combined, they constitute the 1983 State Water Plan.

Most economic and demographic data are collected and compiled on the basis of political (county, township, municipal) boundaries rather than hydrologic (watershed) boundaries. In view of this, and in order to make the socio-economic data as compatible as possible with the hydrologic data, it was necessary to divide the State into Statistical Planning Areas (Figure I-1-2) which roughly approximate the hydrologic boundaries.

FIGURE I-1-1 MAJOR HYDROLOGIC SUBDIVISIONS - NORTH DAKOTA

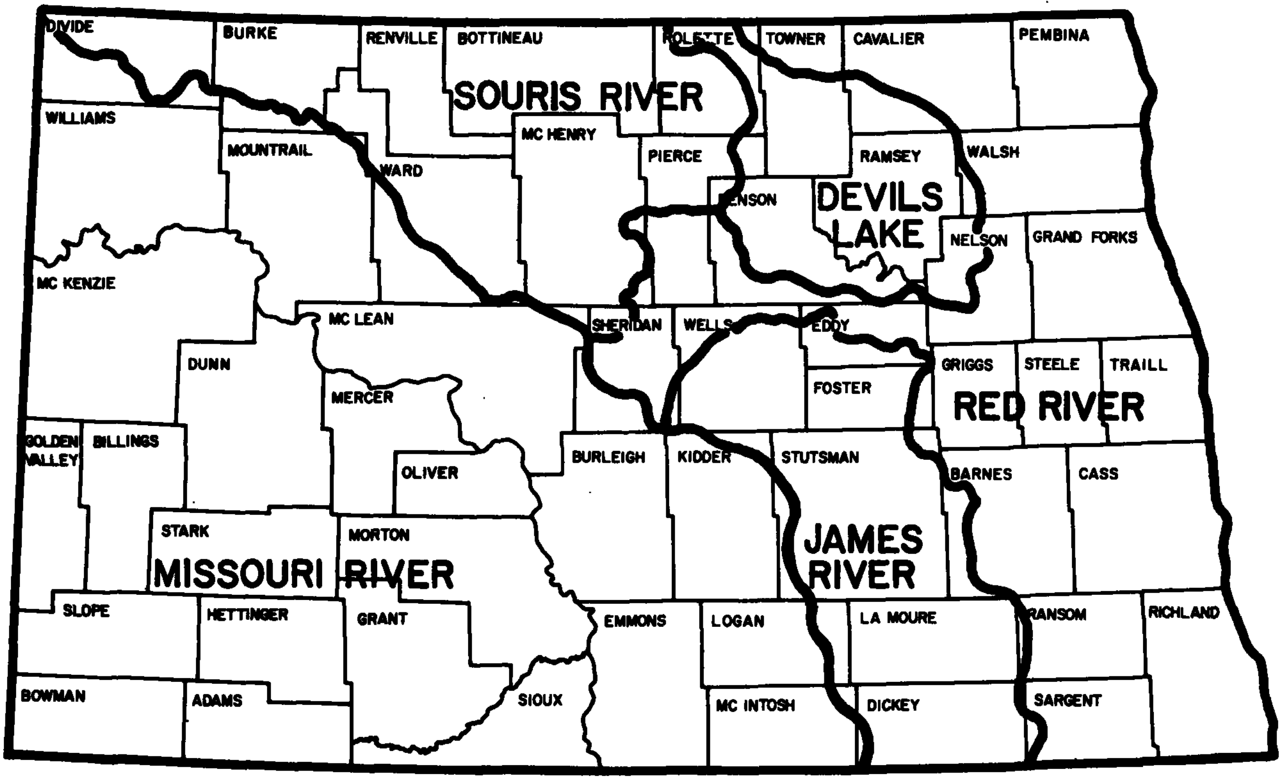
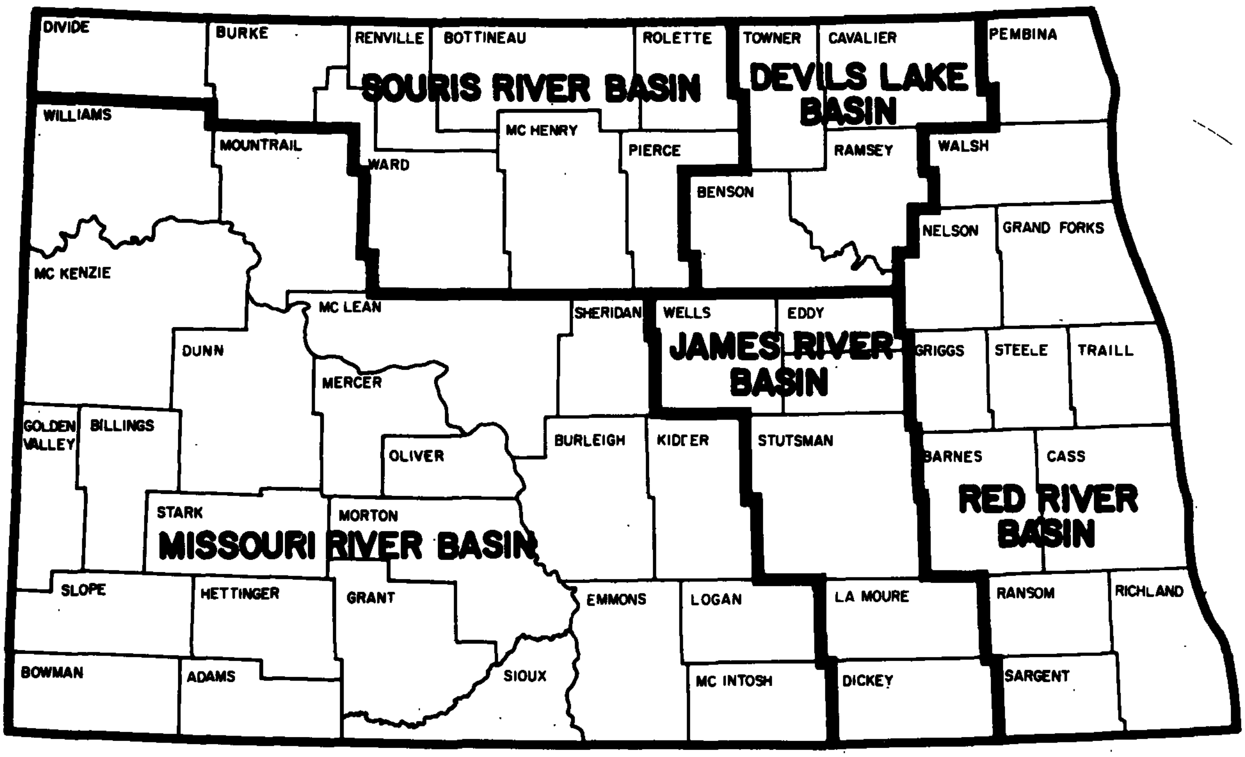


FIGURE I-1-2 STATISTICAL PLANNING AREAS - NORTH DAKOTA



PARTICIPATING AGENCIES

The following entities participated in the State Water Planning Process:

Local
- Water Resources Districts

State of North Dakota
- Department of Agriculture
- Department of Health
- Forest Service
- Industrial Commission
- Parks and Recreation Department
- Soil Conservation Committee
- Game and Fish Department
- Public Service Commission
- North Dakota State University

Federal Agencies
- Department of Agriculture
  - Soil Conservation Service
- Department of the Army
  - Corps of Engineers, St. Paul District
  - Corps of Engineers, Omaha District
- Department of the Interior
  - Bureau of Reclamation
  - Geological Survey
  - Fish and Wildlife Service

Other Organizations
- North Dakota Water Users Association
- North Dakota Association of Irrigation Districts
- North Dakota Water Resource Districts Association
- North Dakota Rural Water Systems Association

SOURCES OF AVAILABLE DATA

Data collected by Federal, State, local, and private interests were utilized in developing this report. A partial list of the more important sources includes:

Interim North Dakota State Water Resources Development Plan; Appendixes A-E, 1968. Contains valuable data and information applicable on a State-wide basis.

Souris-Red-Rainy River Basins Comprehensive Study; Volumes 1-8, 1972. Published by the Souris-Red-Rainy River Basins Commission, the B-Volume report provides invaluable information regarding the Souris, Devils Lake, and Red River Basins in North Dakota.

Missouri River Basin Comprehensive Study, Volumes 1-7, 1971. Published by the Missouri Basin Inter-Agency Committee, this report is a valuable source of information about the Missouri and James River Basins.

Yellowstone River Basin and Adjacent Coal Area Level B Study, Volume 1, Volume 6, 1978. Published by the Missouri River Basin Commission, this study involved 14 counties in southwestern North Dakota. Contains valuable information pertaining to energy development and the potential effects of such development on the area's water and related land resources.

The West River Study: An Analysis of Alternatives for Developing and Managing the West River Area's Water and Related Land Resources. Contains valuable data and information on the area south and west of the Missouri River.

The Devils Lake Study, Volumes 1-3, 1976. Devils Lake Basin Advisory Committee. A plan for implementation of long-term water and related land resources programs in the Devils Lake Basin.

James River Basin Subregional Analysis, 1980. Missouri River Basin Commission. Identifies numerous projects and programs for addressing problems and meeting planning objectives.

Red River of the North Reconnaissance Report, 1980. U.S. Army Corps of Engineers, St. Paul District (Prepared under contract with Gulf South Research Institute, Baton Route, LA.) The source of updated information regarding flooding and other problems in the Red and Devils Lake Basins.

Statistical Abstract of North Dakota, 1979. Bureau of Business and Economic Research, University of North Dakota.

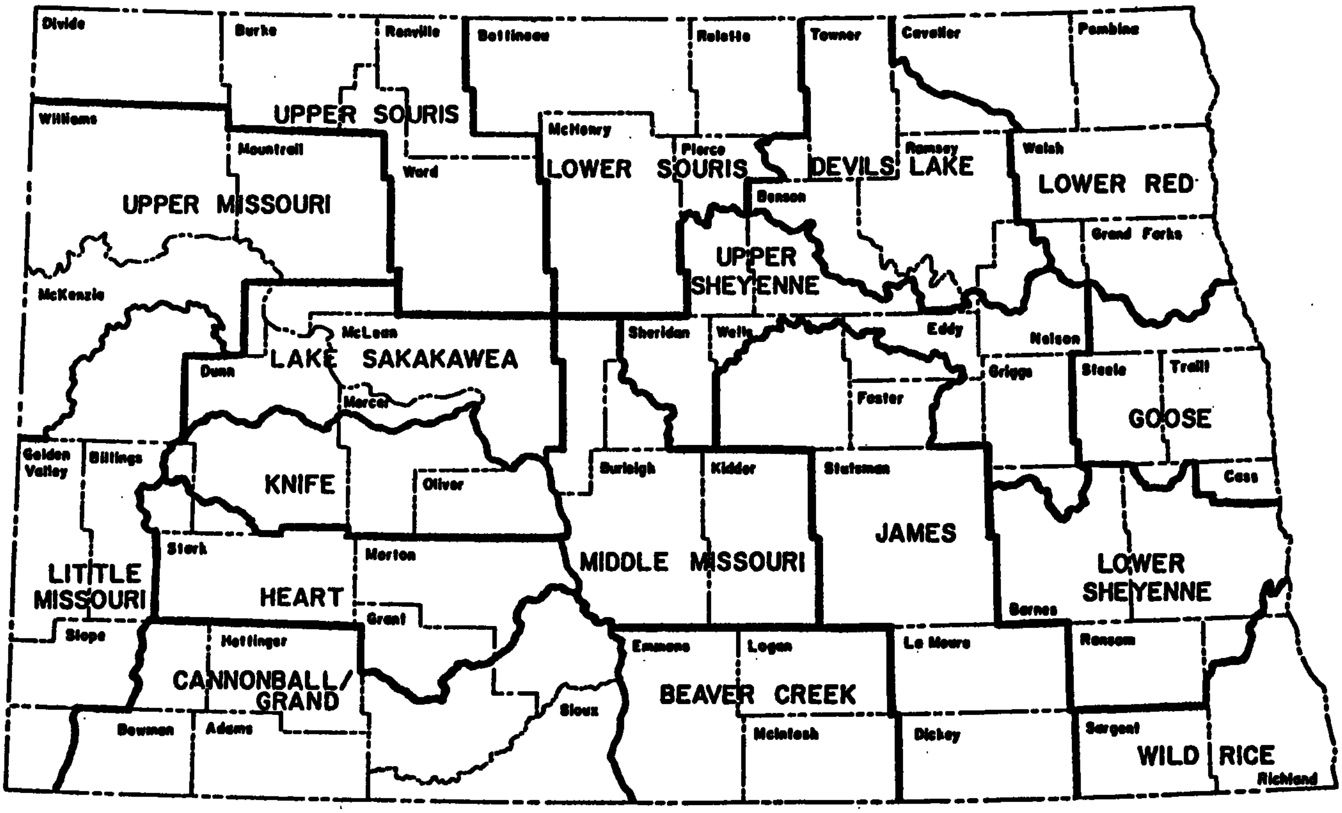
County Ground Water Studies. North Dakota State Water Commission, and Bulletin Series, North Dakota Geological Survey, and U.S. Geological Survey. These studies contain valuable data on the quantity, quality and availability of ground water resources in North Dakota.

U.S. Geological Survey Water Supply Paper and Annual Surface Water Records. These serve as valuable reference materials on the quantity, quality and availability of the State's surface water supplies.

PUBLIC INVOLVEMENT PROGRAM

In order to obtain the maximum level of participation in the State Water Planning process, the State was divided into 17 Public Involvement Regions (Figure I-1-3). The boundaries of these regions approximate watershed boundaries for the most part, but, in some instances, they were drawn on county lines to reduce travel distances for Citizens Advisory Board members and other interested citizens.

FIGURE I-1-3 PUBLIC INVOLVEMENT REGIONS,
NORTH DAKOTA STATE WATER PLANNING PROCESS



A Citizens Advisory Board was named for each Public Involvement Region. Boards ranged in size from five members in the Wild Rice Region to 14 members in the Lower Souris. Membership consisted of one representative from each of the Water Resources Districts having jurisdiction in the Region and an approximately equal number of citizens-at-large.

Each Board chose a chairman to conduct the public meetings. In the Missouri basin the chairmen were: Dale Karlgaard of Tioga for the Upper Missouri Region; Keith Farstveet of Beach for the Little Missouri Region; Harry Zacher of Elgin for the Cannonball/Grand Region; Alfred Underdahl of Hebron for the Heart Region; Fred Galloway of Beulah for the Knife Region; Wayne Johnson of Garrison for the Lake Sakakawea Region; Roger Martin of Napoleon for the Beaver Creek Region; and Fred Larson of Bismarck for the Middle Missouri Region.

George Kaftan of LaMoure served as chairman of the James River Citizens Advisory Board.

In the Souris basin the chairmen were: C.E. "Cap" Haugeberg of Max for the Upper Souris Region; and Stephen Ashley of Velva for the Lower Souris Region.

In the Red basin the chairmen were: Leon Dubourt of Walhalla for the Lower Red Region; L.C. Loerch of Harvey for the Upper Sheyenne Region, Robert Woods of Hillsboro for the Goose Region; Joe "Skip" Milton, Jr. of McLeod for the Lower Sheyenne Region; and Elroy Stein of Wahpeton for the Wild Rice Region.

In the Devils Lake basin the chairman was Russ Dushinske of Devils Lake.

Between July, 1981, when the Boards met for the first time, and November, 1982, when the Boards held their last meeting to review a draft report, 85 public meetings were held throughout the State. All meetings were open to the public, and a variety of techniques were employed to encourage attendance. Public service announcements, paid advertisements in local papers, spot announcements on local radio stations, press releases and publication of the WATER WAYS newsletter all contributed to building public awareness of the State Water Planning Process.

In addition to developing Goals and Objectives for their particular region, each Board devoted considerable time to identifying and defining water related problems and opportunities. At some point in the planning process, each Board designated which problems and opportunities should be evaluated.

Ultimately, each Board adopted a set of recommendations to the State Water Commission which reflected their collective judgments regarding the types of structural and/or non-structural measures and management practices best suited to meeting the needs of their area.

CHAPTER TWO

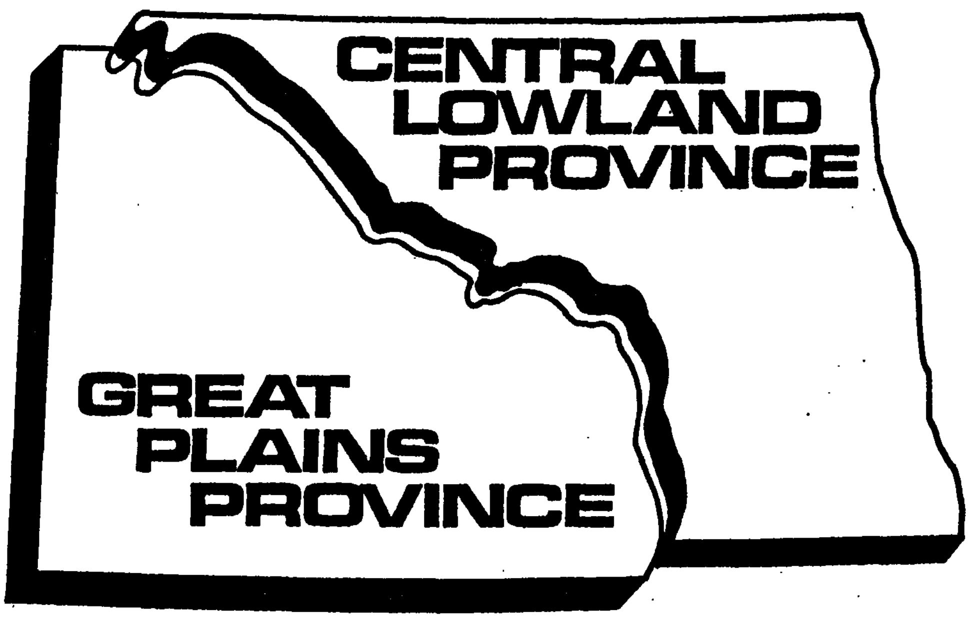
STUDY AREA DELINEATION
STATEWIDE SUMMARY

GEOGRAPHY

North Dakota is located at the center of the North American Continent bounded on the north by the Canadian provinces of Manitoba and Saskatchewan, on the east by Minnesota, on the south by South Dakota, and on the west by Montana. North Dakota is the 17th largest state in the United States with an area of 70,665 square miles, 1,208 of which are covered with water. It is rectangular in shape: 210 miles from north to south, 310 miles wide at the northern boundary, and 370 miles at the southern boundary.

North Dakota lies in two major physiographic areas (Figure I-2-1). The northeastern half of the state falls within the Central Lowland Province. It is an area of glacial deposits (drift) and former lake (lacustrine) plains formed by continental ice sheets. The southwestern half falls in the Glaciated and Unglaciated Missouri Plateau sections of the Great Plains Province. The distinguishing features of the Central Lowland are those of glacial drift. The Great Plains Province is distinguished by a landscape formed by geomorphic processes operating on a bedrock terrain or one thinly covered by drift.

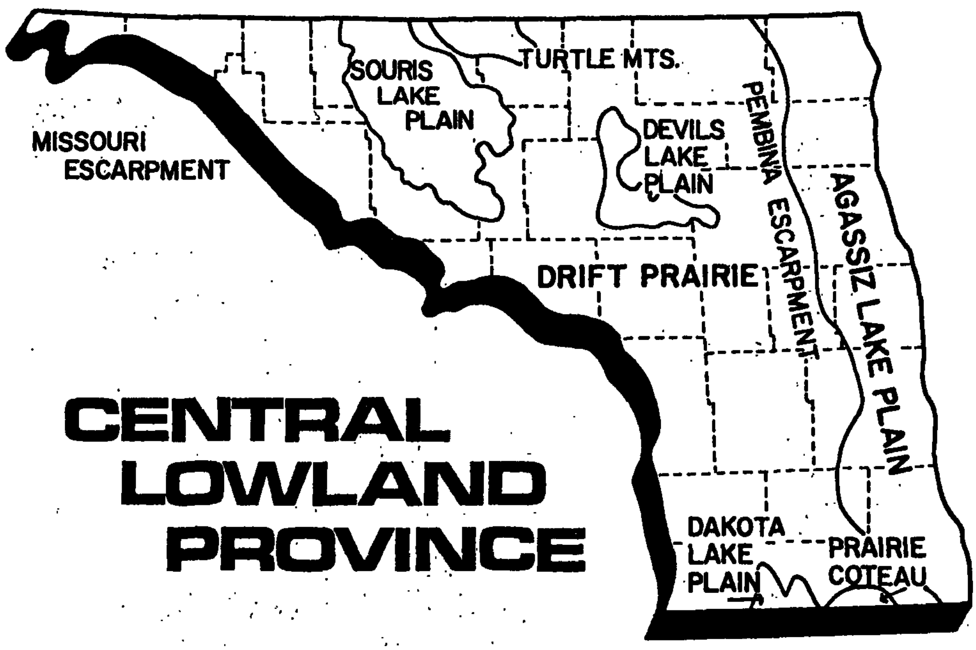
FIGURE I-2-1 PHYSIOGRAPHIC PROVINCES OF NORTH DAKOTA



The Central Lowland (Figure I-2-2) encompasses two distinct districts in North Dakota: the Agassiz Lake Plain on the eastern boundary of the State and the Drift Prairie to the west. The Agassiz Lake Plain, often referred to as the Red River Valley, is found on the 210-mile long eastern border of the State. The Red River Valley is not really a river valley, but rather a lacustrine plain that was once the bed of glacial Lake Agassiz. Here, the Red River of the North flows northward in a meandering 397-mile long channel 20 to 50 feet deep which also forms the state line with Minnesota. The major tributaries to the Red River from the west are the Wild Rice, Goose, Turtle, Forest, Park, and Pembina Rivers. The Pembina Escarpment, a steep slope formed by glacial processes, defines the western edge of the Agassiz Lake Plain.

The Drift Prairie is bordered on the east by the Pembina Escarpment and on the west by the eastern edge of the Missouri Escarpment, a northeast-facing slope. This rolling, fertile plain receives its name from the glacial deposits of sand and gravel, till, and lake sediments. Stream systems are poorly developed in the Drift Prairie. Most of the runoff drains into numerous, closed depressions. The major streams include the James, Sheyenne, Souris, and Des Lacs Rivers. Chief features of the Drift Prairie include: the Prairie Coteau - a small area of a widespread highland found in South Dakota, Minnesota, and Iowa, the Dakota Lake Plain - a glacial lake plain found in the broad James River lowland, the Souris Lake Plain - a lacustrine plain formed by glacial Lake Souris, the Devils Lake Plain - an area of lacustrine deposits from glacial Devils Lake, and the Turtle Mountains - a rolling, glaciated plateau which covers some 800 square miles in Bottineau and Rolette Counties.

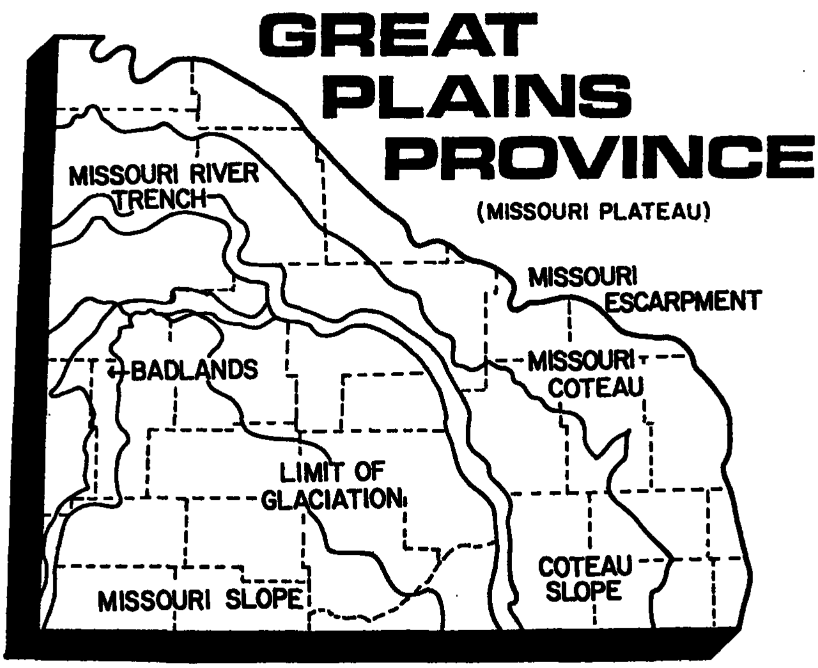
FIGURE I-2-2 CENTRAL LOWLAND PROVINCE



All of North Dakota which lies in the Great Plains Province (Figure I-2-3) is part of the Missouri Plateau Section. Its eastern boundary is the Missouri Escarpment found along the eastern edge of the Missouri Coteau. The Missouri Plateau is drained by the Missouri River and its tributaries (Figure I-1-1): the Cannonball, Grand, Heart, and Knife Rivers which rise at the eastern edge of the Badlands of the Little Missouri River and flow east to the Missouri; the Little Missouri River which drains the Badlands and the uplands to the west; and the Yellowstone River which drains the western edge of McKenzie County.

The Missouri Plateau Section includes: the Missouri Coteau District - an area dotted with prairie potholes; the Coteau Slope District - a rolling, hilly plain west of the Missouri Coteau formed by a complex of glacial land forms where drainage is poorly defined; the Missouri River Trench District - an area encompassing the flood plain, terraces, and dissected valley walls of the Missouri River; and the Glaciated and Unglaciated Missouri Slope Districts - the area south and west of the Missouri River where wide, gentle slopes prevail except near the main streams where the land is usually steep and rugged. The general drainage pattern of the Missouri Slope is to the east into the Missouri River. One of the most interesting topographic features of the Missouri Slope is the Badlands - a rough, severely dissected area formed primarily by stream erosion of the soft shales and sandstones directly underlying the land surface.

FIGURE I-2-3 GREAT PLAINS PROVINCE (MISSOURI PLATEAU SECTION)



North Dakota is drained through the Missouri River and the Hudson Bay drainage areas (Figure I-1-1). The continental divide separating these two major drainage systems runs from the northwest through the central and southeastern parts of the State. For planning purposes, the State has been divided into five major hydrologic basins. The Missouri River system includes the Missouri River and the James River Basins. The Hudson Bay system includes the Red River, the Devils Lake, and the Souris River Basins. All areas of each drainage system may not contribute runoff to the system. For instance, the Devils Lake Basin is a non-contributing, closed basin within the Hudson Bay Drainage area.

CLIMATE

North Dakota's geographic location results in a sub-humid, continental climate characterized principally by marked fluctuations in daily and seasonal maximum and minimum temperatures, and light to moderate precipitation. The precipitation tends to be irregular in occurrence, amount, and area of coverage. The inconstancy of the State's weather arises from the interaction of three major air masses that typically move rapidly across the State. The three primary air masses originate in distinct global regions: cold, dry air from the polar region; warm, moist air from the Gulf of Mexico; and cool, moist air from the northern Pacific. Both the temperature and moisture characteristics of a northern Pacific air mass change as the air moves across the Rocky Mountains. The resulting air, which is usually mild and dry, reinforces the continental nature of North Dakota's climate. The polar air mass tends to dominate the other two, but its influence is considerably lessened during the summer. Although it is common practice to use averages calculated from weather data to characterize short- and long-term climatic conditions, it must be remembered that the averages themselves only represent the highly variable weather elements of North Dakota's climate.

Warm summers and cold winters typify the State's continental climate. July is the warmest month with daily temperatures often exceeding 90°F. January is the coldest month with sub-zero temperatures a common occurrence. Within this broader climatic pattern of warm summers and cold winters occurs a wide range of daily, seasonal, and annual highest and lowest temperatures which contrast markedly with the average temperatures. For example, the annual average temperature varies from about 37°F to over 43°F (Figure I-2-4), but the range between the maximum and minimum temperatures in any one year often exceeds 120°F. The short-term variability of temperatures comes from the flow of the three major air masses across North Dakota. Record temperature extremes are -60° F and 121°F.

The freeze-free period is the number of days between the average last occurrence of freezing temperatures in the spring and the average first occurrence of 32°F or lower in the fall. The length of the freeze-free period approximates the length of the growing season which ranges from less than 110 days to over 130 days (Figure I-2-5). The freeze-free period and the growing season do not necessarily coincide. Topography and local weather conditions can produce sub-freezing temperatures at the ground surface while the air temperature a few feet above the ground remains above 32°F. The reverse can also occur.

FIGURE I-2-4 AVERAGE ANNUAL TEMPERATURE IN °F

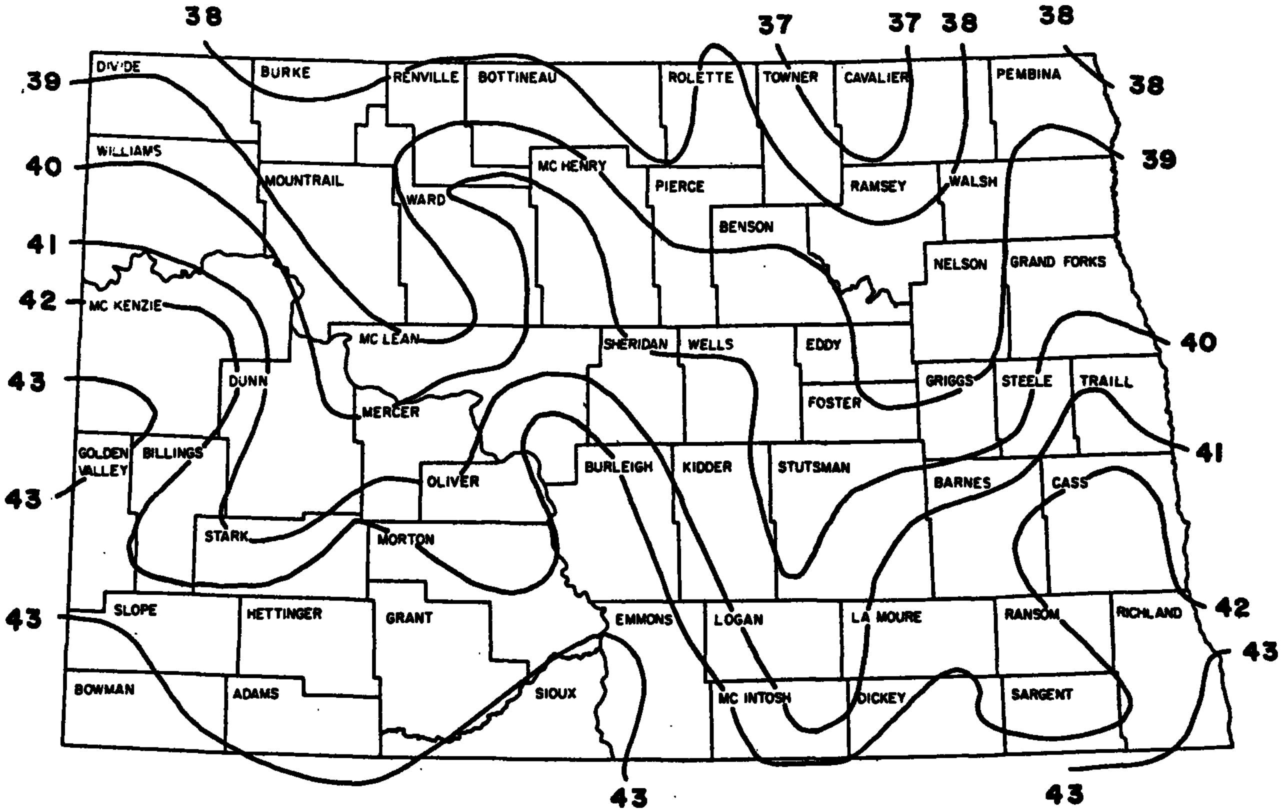
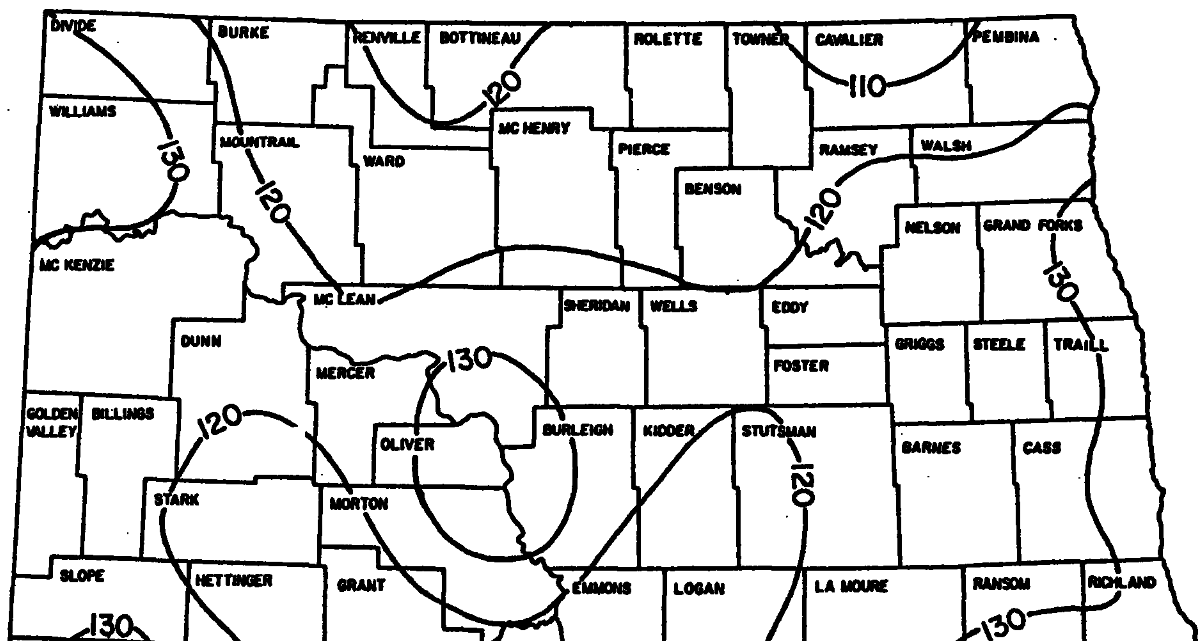
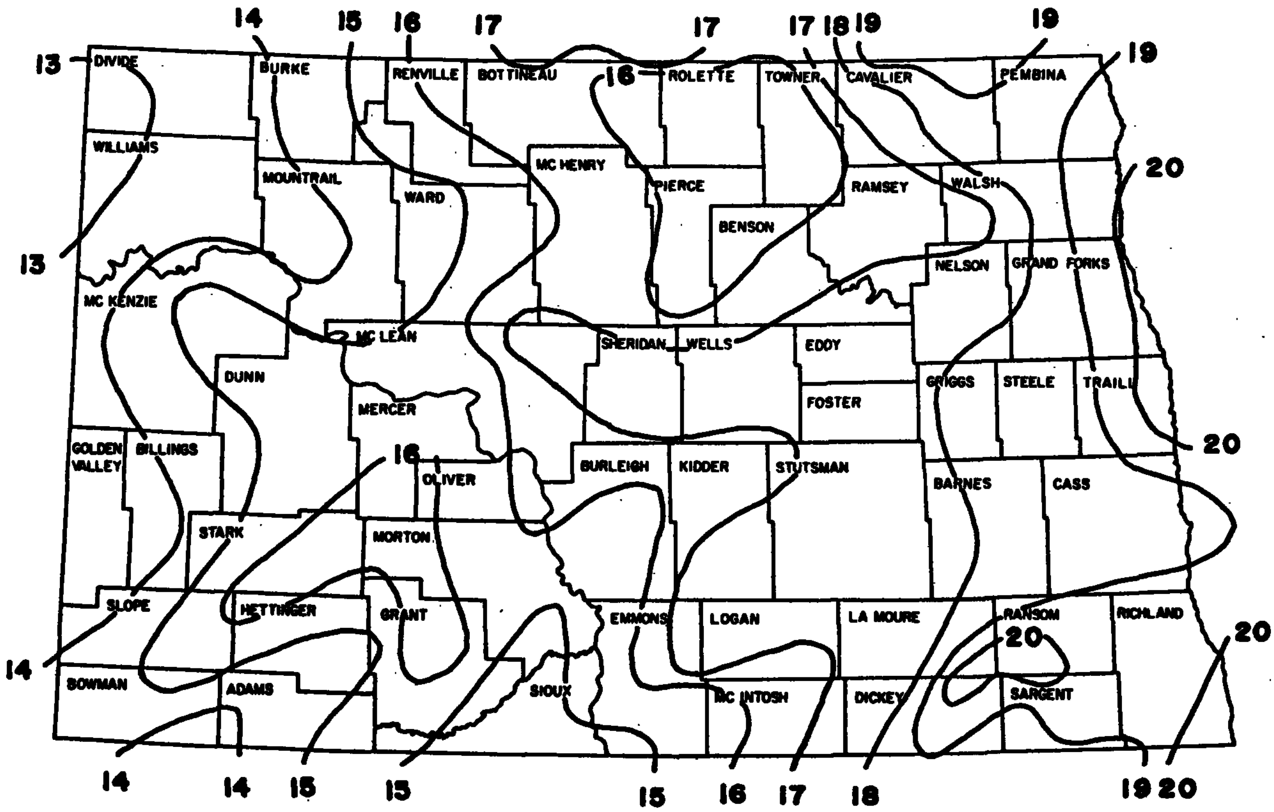


FIGURE I-2-5 AVERAGE LENGTH OF GROWING SEASON IN DAYS



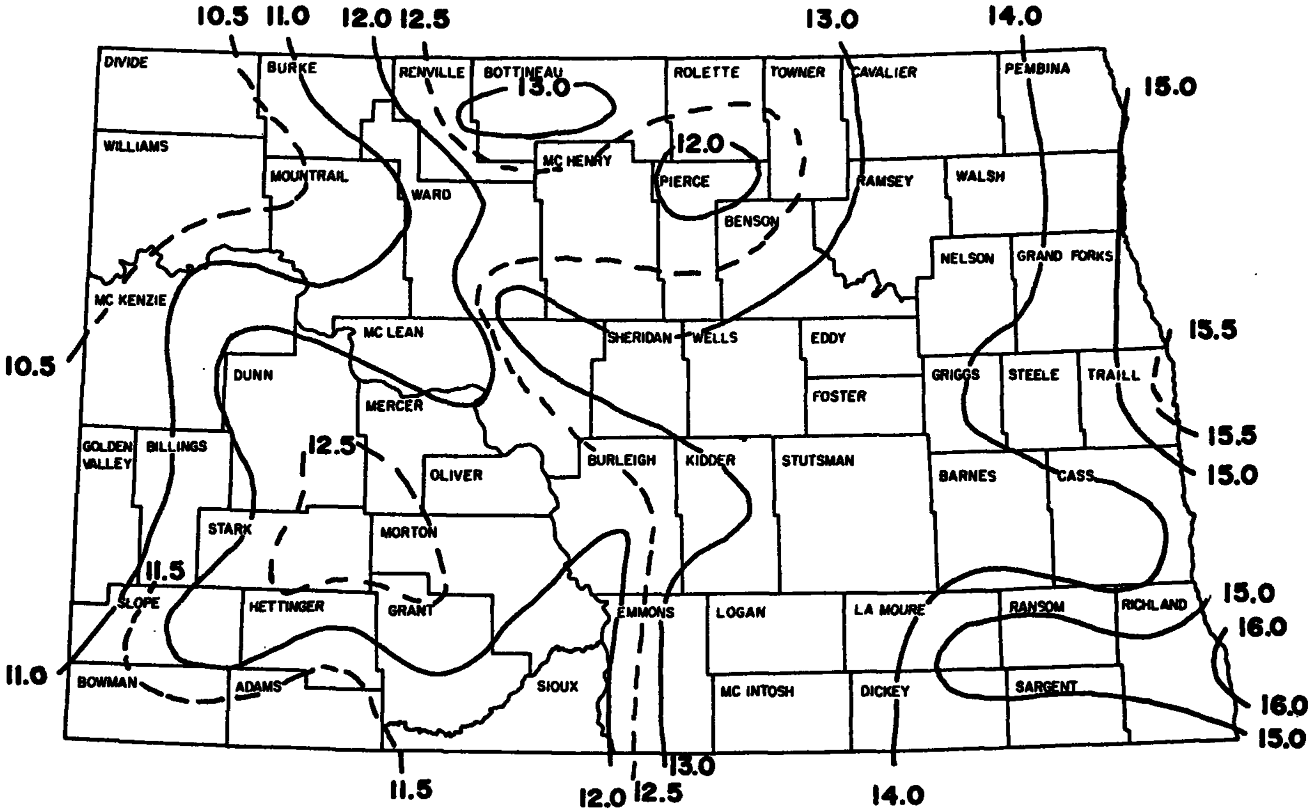
The pattern and occurrence of precipitation across North Dakota is often quite irregular during a year and from year-to-year due to the interaction of the three air masses that dominate the State's weather. The distances to the sources of atmospheric moisture for the upper Midwest and the intervening topography between those sources and North Dakota also contribute to the variability of precipitation. Average annual precipitation ranges from less than 13 inches in the northwest corner of the State to over 20 inches along parts of the eastern boundary (Figure I-2-6).

FIGURE I-2-6 AVERAGE ANNUAL PRECIPITATION IN INCHES



Although precipitation occurs throughout the year, the pattern is seasonally different. On the average, though, about 75 percent of the yearly precipitation arrives between April and September (Figure I-2-7) as rainfall from isolated thunderstorms or storm cells associated with frontal systems.

FIGURE I-2-7 AVERAGE PRECIPITATION APRIL THROUGH SEPTEMBER IN INCHES



Characteristic summer rainfall patterns in terms of quantity and area of distribution result in the wide range of total yearly precipitation amounts measured in any given area of North Dakota. Of the precipitation that falls between April and September, about 60 to 70 percent occurs during the critical months of the growing season. This rainfall is crucial for maintaining adequate moisture in the soil profile. Even slight variations in amounts or areal distribution can significantly affect an agriculturally based economy.

Evaporation returns water vapor from the earth's surface to the atmosphere. Plant transpiration augments the volume of water vapor available for evaporation. The evaporation rate is seasonally and annually variable, responding to a variety of climatic and biologic factors. Average annual evaporation exceeds average annual precipitation across the State with the greatest difference in western North Dakota. Although annual precipitation may locally exceed annual evaporation in eastern North Dakota in years of above normal precipitation, an appreciable disparity usually remain between the two in the western part of the State. The evaporation rate, which peaks during the growing season, together with the characteristic pattern of rainfall in the summer strongly influence the availability of moisture in the State. Areas deficient in moisture can be adjacent to areas of plentiful moisture. The evaporation rate intensifies the effects of below normal precipitation.

The circulation of water between the earth's surface and the atmosphere is driven by the sun's energy with precipitation and evapotranspiration the major climatic processes controlling the circulation. Water resides temporarily on the earth's surface in diverse forms where it is affected by various processes controlling its movement across the land or its residence time before being returned to the atmosphere. Some surface water becomes ground water, that is it moves below the land surface where other processes control its movement, residence time, and eventual discharge to the land surface and return to the atmosphere.

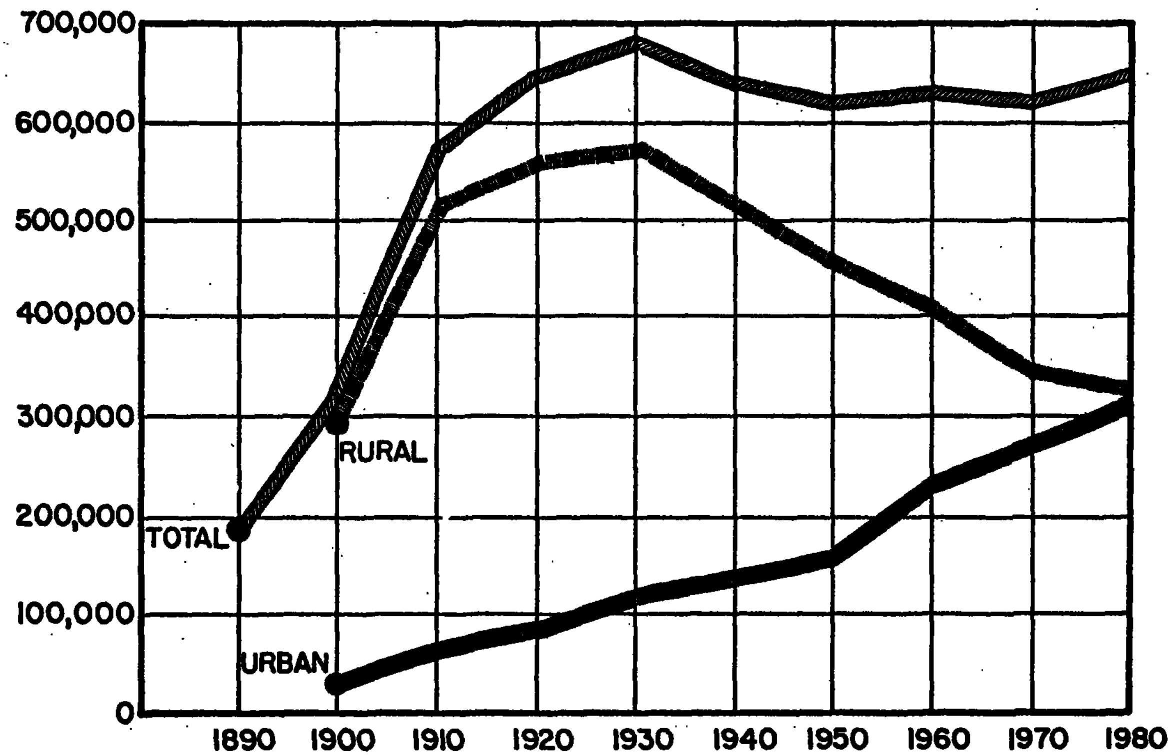
Weather records and tree ring studies indicate the State experiences cyclical periods of below and above average precipitation. Climatic, geomorphic, and pedalogic factors may combine to reinforce periods of drought or flooding either of which are potentially catastrophic economically. Recurrence intervals for these periods of extremes and what influences them needs further study.

DEMOGRAPHY

Population

North Dakota had a 1980 population of 652,437 persons, based on estimates by the U.S. Bureau of the Census. This total is up 34,676 persons from the 1970 estimate of 617,761 for an increase of 5.6 percent (Figure I-2-8). Vacant and occupied housing units in the State have increased 26.6 percent from 204,235 units in 1970 to 258,479 units in 1980.

FIGURE I-2-8 NORTH DAKOTA POPULATION, 1890-1990



North Dakota has or is part of three Standard Metropolitan Statistical Areas (SMSA). An SMSA is a county or group of contiguous counties that contains at least one city of 50,000 inhabitants or more, or "twin cities" with a combined population of at least 50,000. The Bismarck, North Dakota SMSA has a 1980 population estimate of 79,908 and includes the cities of Bismarck and Mandan plus the areas outside these central cities. The part of the Fargo, North Dakota-Moorhead, Minnesota SMSA within the State has a population estimate of 88,243 persons. That population includes the population of Fargo and persons outside the central city. The part of the Grand Forks, North Dakota, Minnesota SMSA within the State has a 1980 population of 66,088.

Major cities with 2,500 inhabitants or more and their 1980 population estimates are: Beulah - 2,878; Bismarck - 44,502; Bottineau - 2,828; Carrington - 2,636; Devils Lake - 7,441; Dickinson - 15,893; Fargo - 61,281; Grafton - 5,302; Grand Forks - 43,760; Harvey - 2,529; Jamestown - 16,281; Mandan - 15,496; Minot - 32,886; Rugby - 3,343; Valley City - 7,771; Wahpeton - 9,065; West Fargo - 10,080; and Williston - 13,354. The State has a population density of slightly over nine persons per square mile.

The general increase in the State's population between 1970 and 1980 occurred primarily in the western half of the State. Much of this increase is due to the influx of people associated with the development of the State's coal and oil reserves. Other areas of the State show marked increases in population due to activity in the manufacturing, trade, and financial sectors of the economy. The population projections for each Statistical Planning Area (Table I-2-1) reflect those trends along with the effects of migration and birth rates.

TABLE I-2-1 NORTH DAKOTA POPULATION PROJECTIONS

Statistical Planning Area	1980	1990	2000	2020
Missouri River	215,050	239,624	271,718	281,308
James River	52,994	54,572	55,026	54,840
Red River	247,148	263,351	273,702	278,593
Devils Lake	32,644	34,112	36,014	38,961
Souris River	104,601	114,529	122,755	132,144
NORTH DAKOTA	652,437	706,188	759,215	785,846

North Dakota has three Indian reservations within its borders and shares two with South Dakota. Along with the American Indian population, there are many nationalities represented in the heritage of North Dakota. They are almost totally European in origin and are primarily from Norway, Russia, and Germany. In general terms, the northern and eastern counties are primarily Scandinavian in origin with the rest of the State being primarily of German-Russian descent.

Transportation

North Dakota is served by several airlines, railroads, and by an extensive State and interstate highway system. Several airlines operate out of the State and provide national as well as international passenger and air freight service. In recent years, there has been a growing need for commuter airline service. This has been brought about largely by the increased cost of highway travel and the increased need for rapid transportation by the business and industrial sectors. Several commuter airlines have been established and have seen varying degrees of success.

There are four railroads operating in the State. In 1978, they ran on 5,117 miles of track and carried 15,869,432 tons of commodities out of, and 4,459,674 tons into the State. The major commodities shipped and their percentages of the total are: coal - 39.3; farm products - 39.1; and food and kindred products - 5.9.

The State's motor carriers transport almost 4 million tons of freight annually. The major commodities shipped and their approximate percentages of the total are: petroleum products - 50; uncategorized - 25; merchandise - 8; livestock - 8; and grain - 6.

Because of its rural nature, the State is highly dependent on its network of interstate, State, and county roads and highways. In 1977, there were 106,482 miles of roads and streets. In that year there were 7,070 miles of State roads, 9,360 miles of county roads, 85,712 miles of township roads, 3,044 miles of city streets, and 1,296 miles of other roads.

Commercial navigation is non-existent today in North Dakota, and future prospects for the development of an economically feasible navigation system are dim.

ECONOMY

Agriculture is the major industry in North Dakota. Of the 70,665 square miles of land area, about 66,000 square miles or 93 percent of the State is devoted to agricultural production. Of that total, 61 percent is cropland, 33 percent is pasture and rangeland, and one percent is forest.

In 1980, North Dakota lead the United States in the production of spring wheat - 105.5 million bushels; durum wheat - 73.2 million bushels; and sunflowers - 2.2 billion pounds. The State was second highest in the production of barley - 48.0 million bushels and flax - 3.1 million bushels. Hay is also a major crop with 2.5 million tons cut in 1980.

Production of cattle and calves is the major livestock enterprise with a 1980 inventory of about 2.0 million head. Historically, the sale of crop products has been about 70 to 80 percent of total agricultural production; livestock and livestock products 20 to 30 percent.

Total wage and salary income in 1980 increased to $3.14 billion which is a slight increase over 1979. Cass County led with income of $626.9 million followed by Burleigh County with $357.3 million and Ward County with $324.2 million. The Services sector of the economy led all sectors with $634.9 million of income. This was followed by the State and Local Government sector with $460.0 million. Farm income was below several other sectors with $228.0 million, due largely to low commodity prices.

Employment in the State totaled 336,553 persons with 44,143 of them being farm proprietors and 25,868 non-farm proprietors. The two leading sectors, retail trade and State and Local Government, employed 14 and 13 percent of the total work force, respectively. The average annual unemployment rate was 5.0 percent for 1980.

Exploration for energy sources, primarily coal, oil and gas, has resulted in a substantial boost to North Dakota's economy. This is apparent when employment in the mining sector of the economy is considered. For example, about 1,600 persons were employed in that sector during 1970 while in 1980 over 7,700 were employed. This results in an increase of 381 percent during that ten-year period. Even though the numerical increase is small when compared to total employment, the growth percentage is significant in that many support industries also benefit because of the additional business volume generated.

GEOLOGY

Bedrock Geology

The bedrock of North Dakota includes crystalline rocks older than 570 million years through Tertiary sedimentary rocks about two million years old. The Precambrian rocks form a basement complex underlying the younger sedimentary strata which have been divided into fifty formations (Figure I-2-9). Overlying the bedrock throughout much of the State are unconsolidated sediments, mostly glacial in origin.

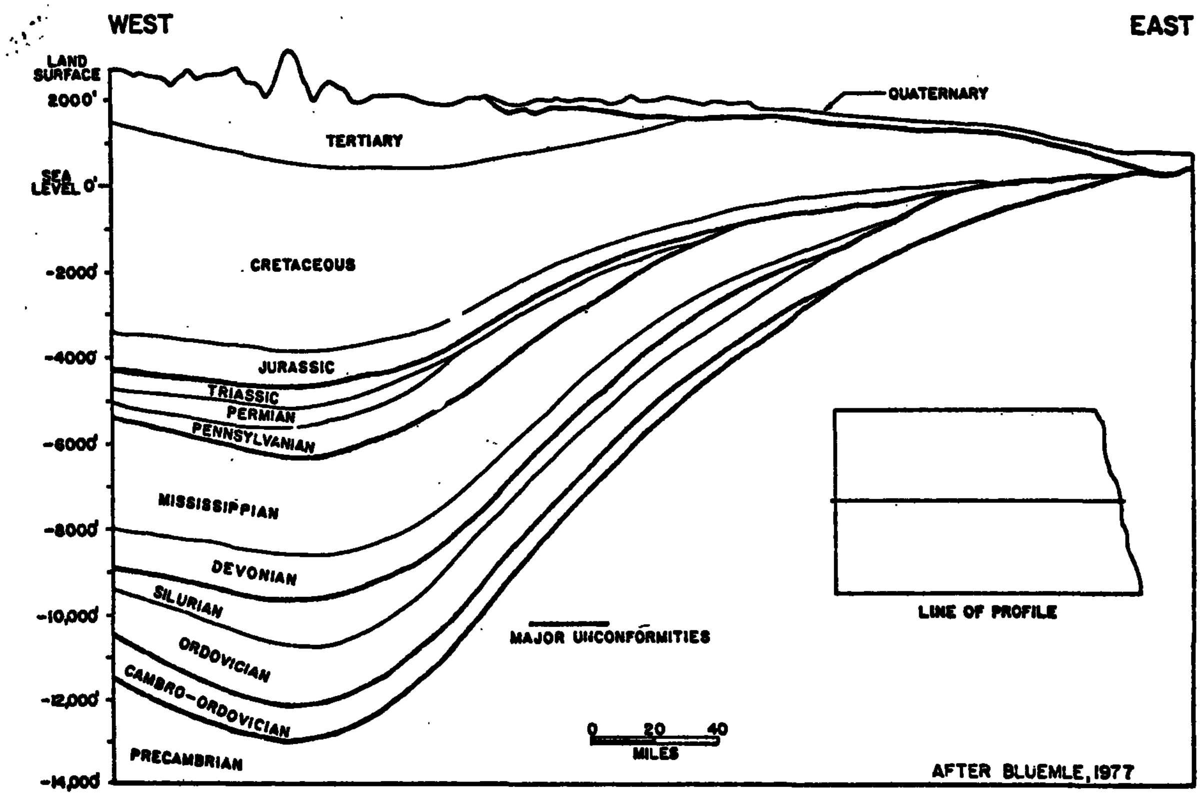
FIGURE I-2-9 NORTH DAKOTA STRATIGRAPHIC COLUMN

ERA	PERIOD	GROUP OR FORMATION		LITHOLOGY
CENOZOIC	QUATERNARY	OAHE		Clay, silt, sand, gravel
		COLEHARBOR GROUP		Glacial Drift
	TERTIARY	Undifferentiated		Gravel, sand, clay, silt
		"ARIKAREE" or "KILLDEER"		Sandstone & limestone
		WHITE RIVER GROUP	BRULE	Siltstone, clay, & sand
			CHADRON	Sand
		GOLDEN VALLEY		Clay, sand, & silt
		FORT UNION GROUP	SENTINEL BUTTE	Silt, sand, clay, sandstone, & lignite
			BULLION CREEK	
			SLOPE	
			CANNONBALL	Claystone, sand, & sandstone
			LUDLOW	Silt, sand, clay, & sandstone
MESOZOIC	CRETACEOUS	HELL CREEK		Sand, sandstone, & shale
		MONTANA GROUP	FOX HILLS	Sand, sandstone, & shale (marine)
			PIERRE	Shale
		COLORADO GROUP	NIOBRARA	Calcareous shale
			CARLILE	Shale
			GREENHORN	Calcareous shale
			BELLE FOURCHE	Shale
		DAKOTA GROUP	MOWRY	Shale
			NEWCASTLE	Sandstone
			SKULL CREEK	Shale
			INYAN KARA	Sandstone & shale
	JURASSIC	MORRISON		Shale & siltstone
		SWIFT		Shale
		RIERDON		Shale
		PIPER		Limestone, shale, evaporites
	TRIASSIC	SPEARFISH		Siltstone, sandstone, & salt
PALEOZOIC	PERMIAN			
		MINNEKAHTA		Limestone
		OPECHE		Shale & siltstone
		MINNELUSA GROUP	BROOM CREEK	Sandstone w/limestone
	PENNSYLVANIAN		AMSDEN	Dolomite, limestone, sandstone
			TYLER	Shale, sandstone, limestone
	MISSISSIPPIAN	BIG SNOWY GROUP	OTTER	Shale
			KIBBEY	Sandstone, limestone, shale
		MADISON GROUP	CHARLES	Evaporites, shale, limestone
			MISSION CANYON	Limestone, dolomite, evaporites
			LODGEPOLE	Limestone & dolomite
		BAKKEN		Black shale
	DEVONIAN	THREE FORKS		Siltstone & shale
		JEFFERSON GROUP	BIRDBEAR	Limestone
			DUPEROW	Dolomite & limestone
		MANITOBA GROUP	SOURIS RIVER	
			DAWSON BAY	
		ELK POINT GROUP	PRAIRIE	Evaporites
			WINNIPEGOSIS	Limestone & dolomite
	SILURIAN	INTERLAKE		Dolomite
	ORDOVICIAN	BIG HORN GROUP	STONE WALL	Limestone & dolomite
			STONY MOUNTAIN	
			RED RIVER	
		WINNIPEG GROUP	ROUGHLOCK	Siltstone & calcareous shale
			ICEBOX	Shale
			BLACK ISLAND	Sandstone
	CAMBRIAN	DEADWOOD		Limestone, sandstone, shale
PRECAMBRIAN				Metamorphic & igneous rocks

After Bluemle, et al., 1980

The Williston Basin is the principal geologic feature of North Dakota (Figure I-2-10). It is a structural depression underlying about 130,000 square miles of North and South Dakota, Montana, and Canada. Approximately 51,600 square miles of the Basin are in North Dakota and it is this portion that contains the Basin's deepest part. The Williston Basin is the result of progressive but intermittent subsidence occurring over the last 500 million years. This downwarping preserved more than 15,000 feet of sedimentary rock in the deepest part of the Basin near the Killdeer Mountains. The sedimentary section thins to less than 200 feet at the margins of the Basin, the result of nondeposition of sediment or erosion of previously deposited material. The sedimentary rocks are generally flat-lying with slight regional dips toward the Basin's center. Smaller tectonic features, such as the Nesson and Cedar Creek Anticlines, interrupt the overall regional attitude of the rocks.

FIGURE I-2-10 WEST-EAST CROSS-SECTION OF NORTH DAKOTA



The age, stratigraphic position, and lithology of the sedimentary rocks trace the past 570 million years of North Dakota's geologic history. The bedrock is predominantly of marine origin, but is overlain by bedrock of continental origin in the western half of the State and in the Turtle Mountains. The bedrock of marine origin was deposited in relatively shallow seas or in the nearshore environments of those seas. Included are the limestones and dolomites, shales, sandstones, and evaporites from the Deadwood to the Fox Hills Formations (Figure I-2-9). Four major unconformities occcur within this stratigraphic section, each of which marks an extended time of nondeposition of sediment or of erosion. Overlying the Fox Hills are those rocks predominantly terrestrial in origin. These rocks were formed from sediments transported from source areas in the ancestral Rocky Mountains and laid down in river, lake, or swamp environments. The lignite beds in these rocks formed from the remains of plants growing in the extensive swamps. Of the formations overlying the Fox Hills, only the Cannonball Formation is marine in origin. It represents the only invasion of Tertiary seas into the Williston Basin. Rocks of late Tertiary age are found only in the western part of the State, mostly as erosional remnants such as buttes.

Glacial Geology

Continental glaciation refers to the movement of very thick, massive sheets of ice across a region. The slowly moving ice sheets alter the existing landscape by erosion, disrupt established drainage patterns, and deposit great quantities of material collectively called glacial drift.

Along a stationary ice front, a moraine is built up of the material brought to the melting edge of the glacier by the continually flowing ice. During glacial retreat, huge blocks of ice separate from the main ice sheet and stagnate. Complete melting of these glacier remnants produces a characteristic topography. The melting glacier produces great quantities of meltwater carrying sand, gravel, boulders, silt, and clay from the ice margin in large meltwater channels. These outwash materials are deposited immediately in front of the glacier, in valleys leading away from the ice front, under the ice front itself, and surrounding blocks of stagnant ice. Lakes are created by the meltwater where the drainageways are blocked. Such glacial lakes can exist long enough to form well-defined beaches along the lakeshore and accumulate appreciable thicknesses of lake-bottom sediments.

Continental glaciation has significantly altered North Dakota's landscape within the last two million years. Although glacial erosion was part of the transformation, most of the change came through disruption of drainage patterns and deposition of drift. At least four major advances of continental glaciers are recognized in the glaciated midwest. All four advances may have invaded North Dakota with each advance altering the existing landscape and depositing various glacial landforms. The results of the most recent advance conceals or obscures, for the most part, that of the older advances.

Prior to glaciation, the trend of North Dakota's river systems was northeast. For example, the preglacial Missouri River flowed northeast through Divide County and into Canada, the preglacial Yellowstone flowed northward through the present valley of Little Muddy Creek, and the preglacial Little Missouri continued northward through what is now White Earth River. This drainage was blocked both by the sheets of ice and deposits of glacial drift and diverted the water to new outlets. The effects of glaciation on existing drainage systems is most apparent south and west of the Missouri River where meltwater channels are deeply incised into bedrock. Within the glaciated part of the State, only the effects of meltwater drainage from the last ice retreat are visible on the land surface. Glacial lakes existed where meltwater was dammed by surrounding uplands and the ice front, and with an outlet at sufficient elevation to form a basin. The areal extent, depth of water, and longevity of such lakes were affected by movement of the ice front uncovering or blocking outlets of different elevations, or by the rate at which an active outlet was incised into the underlying material. Some glacial lakes were relatively short-lived lasting for only a few hundred years. Others were significant landscape features, but have since disappeared completely or only remnants exist today.

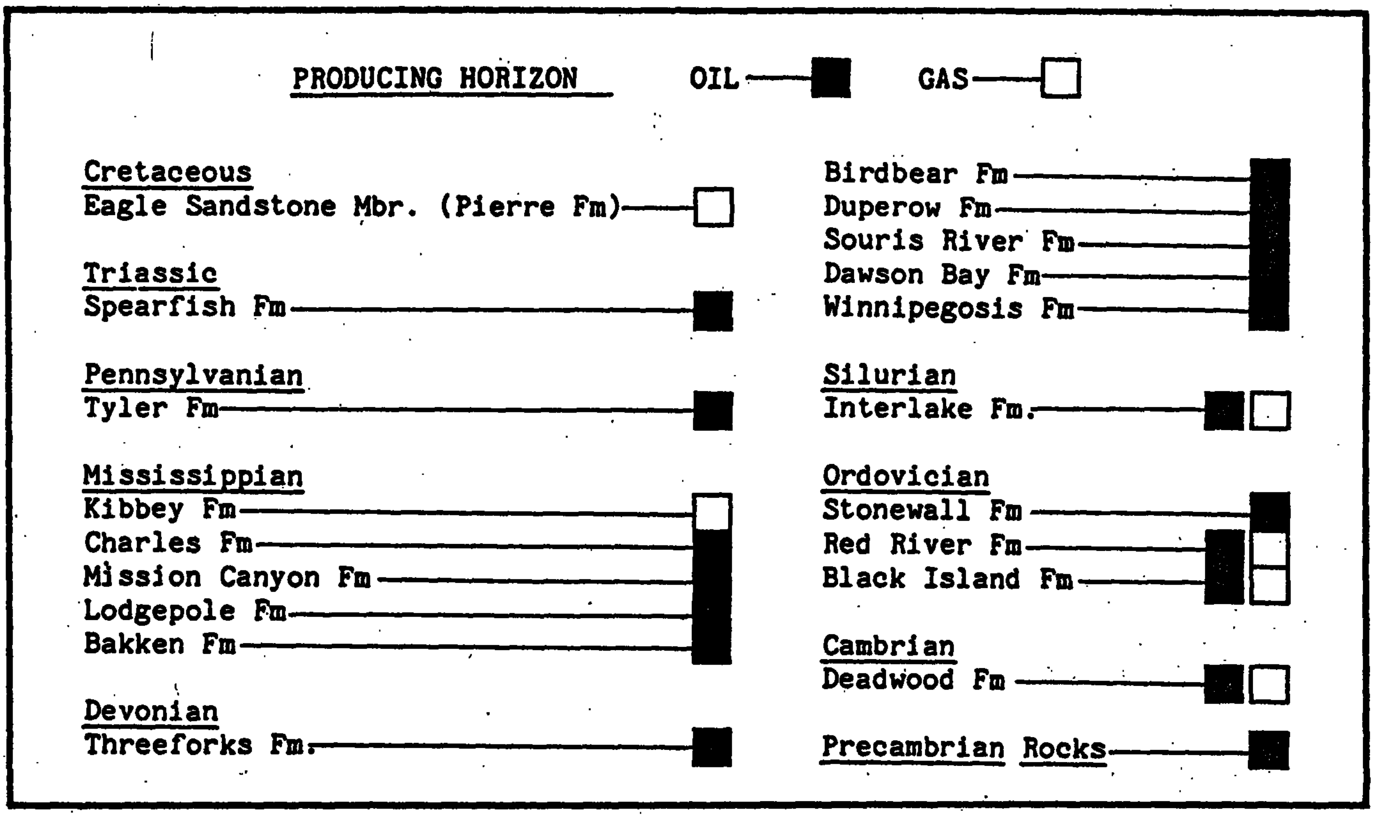
Continental glaciation moved great quantities of material into North Dakota from Canada and from one part of the State to another. This glacial drift originated from the bedrock, unconsolidated sediment, and soil over which the ice was moving. The drift was deposited as outwash, lake sediments, various types of moraines, and other glacial land forms such as eskers and kames. Thickness of the drift is quite variable, but ranges from less than 50 feet to about 800 feet. In some areas of southwest North Dakota, glacial erratics are the only evidence for glaciation. The linear and arced hills of end and recessional moraines mark stillstands in the slow oscillations of ice fronts across North Dakota. The hummocky, dead-ice moraine of the Missouri Coteau delineates a broad band where the last ice advance stagnated on the general rise of the land surface to the southwest and a gentle escarpment formed by the Fox Hills and Hell Creek Formations. Within the stagnant-ice area closed depressions formed in the drift when isolated buried blocks of ice melted. Minor advances of the ice front overrode previously deposited drift, altering the drift and its landforms. The result is a complex system of the various types of drift deposits. Contained in the glacial drift are bodies of sand and gravel which range from thin, lenticular beds to very thick deposits filling valleys incised into bedrock or till. The effects of ice overriding such sand and gravel units extend from little apparent change to such marked changes as completely removing most of the deposit. Because such sand and gravel deposits form the most prolific aquifers in the State, deciphering their depositional history is an important step in managing this water resource.

Mineral Resources

Mineral resources can be categorized as major or minor based on the extent of the resource, its geological nature and occurrence, and extent of commercial development. Only a few of the mineral resources of North Dakota can be classified as major. These are oil and natural gas, lignite, and sand and gravel.

Commercial development of natural gas preceded that of oil (Folsom, 1973) with the discovery in 1929 of the State's only natural gas field, located in western Bowman County. North Dakota's oil industry began to develop in 1951 with the discovery of oil in Williams County. By the end of 1980, total production included over 596 million barrels of oil and almost 880 million cubic feet of natural gas (Gerhard & Anderson, 1981) from 20 producing horizons (Figure I-2-11). Recoverable reserves are estimated to be greater than 1 billion barrels of oil and more than 1 trillion cubic feet of natural gas.

FIGURE I-2-11 PRODUCING HORIZONS OF NORTH DAKOTA, 1951-1981



The lignite beds of western North Dakota are part of a larger Great Plains coal region that extends into Canada, Montana, Wyoming, and South Dakota. The North Dakota portion of this region encompasses some 28,000 square miles of 23 counties and includes a resource estimated at nearly 351 billion tons (Carlson, 1981). Only part of this resource can be recovered economically with current strip-mining technology. Estimates of recoverable reserves total about 16 billion tons (Carlson, 1981). The amount of the total resource that could be utilized may increase with development of new processes using lignite as a raw material.

North Dakota's sand and gravel resources occur as two main types of deposits (Moran, 1973). The first type consists of linear ridges formed as beaches and offshore bars of glacial lakes and is most coon along the western edge of the Red River valley. The second type is found throughout the State as sand and gravel deposits of outwash plains, deltas, point bars, and terraces. Recoverable reserves of sand and gravel have not been quantified on a statewide basis because of the nature and widespread occurrence of this resource. Most of the sand and gravel produced is used for concrete aggregate, road construction and maintenance, and fill material.

North Dakota has 15 minor mineral resources classified as such because of the occurrence of the resource or because recovery is uneconomical. Of the 15, the clay and lightweight aggregate resource is probably the most important followed by production of crushed, broken, and dimension stone. Other minor mineral resources currently utilized are salt, gem stones, leonardite, and peat. Some of the minor mineral resources may be recovered in the future as economics dictate. Some of these resources have been recovered, but operations became uneconomical and ceased. Included are uranium and molybdenum, volcanic ash, lime and cement rock, potash, and possibly sodium sulfate. Gold and manganese are known to occur in the State, but they are more geologic curiosities than mineral resources. Lastly, the occurrence of zeolities has been reported (Sheppard, 1973) but none of the known deposits of these unique minerals have the potential for commercial development.

NATURE AND OCCURRENCE OF WATER RESOURCES

Surface Water

Surface water is that water found on the land surface, and includes overland flow and flow in distinct channels. The three major sources of surface water are: (1) streams and rivers flowing into the State, (2) precipitation, and (3) ground-water discharge along streambeds or as springs. Surface water leaves the State in outflowing streams and by evapotranspiration, or it percolates downward into the subsurface and may enter the ground-water flow system.

Annual precipitation averages 13 to about 20 inches west-to-east across North Dakota, and annual runoff averages 1/4 to 1 inch. The difference between average annual precipitation and runoff is due mostly to evapotranspiration. Periods of considerable runoff occur during the spring when snow meltwater moves down drainage systems, and in the summer when thunderstorms generate intense rainfall in limited areas over a short time. Flooding of the larger streams generally occurs during the spring, but the magnitude of the flooding varies from year-to-year depending on such factors as characteristics of the snow cover, soil-moisture conditions, frost depth, winter temperatures and temperatures during spring melting, spring precipitation, and the extent of ice jams. Smaller streams are more susceptible to flooding in the summer with peak flows the result of thunderstorms. North Dakota's major rivers are characterized by large, average-annual discharges (Figure I-2-12). However, variations in flow during the year can be great with periods of no flow possible on most of the larger streams and rivers. Optimum use of total, annual streamflow requires reservoirs designed to control the release of water throughout the year. Normal capacity statewide of surface-water storage in nearly 19.5 million acre-feet. Maximum capacity is about 27.0 million acre-feet.

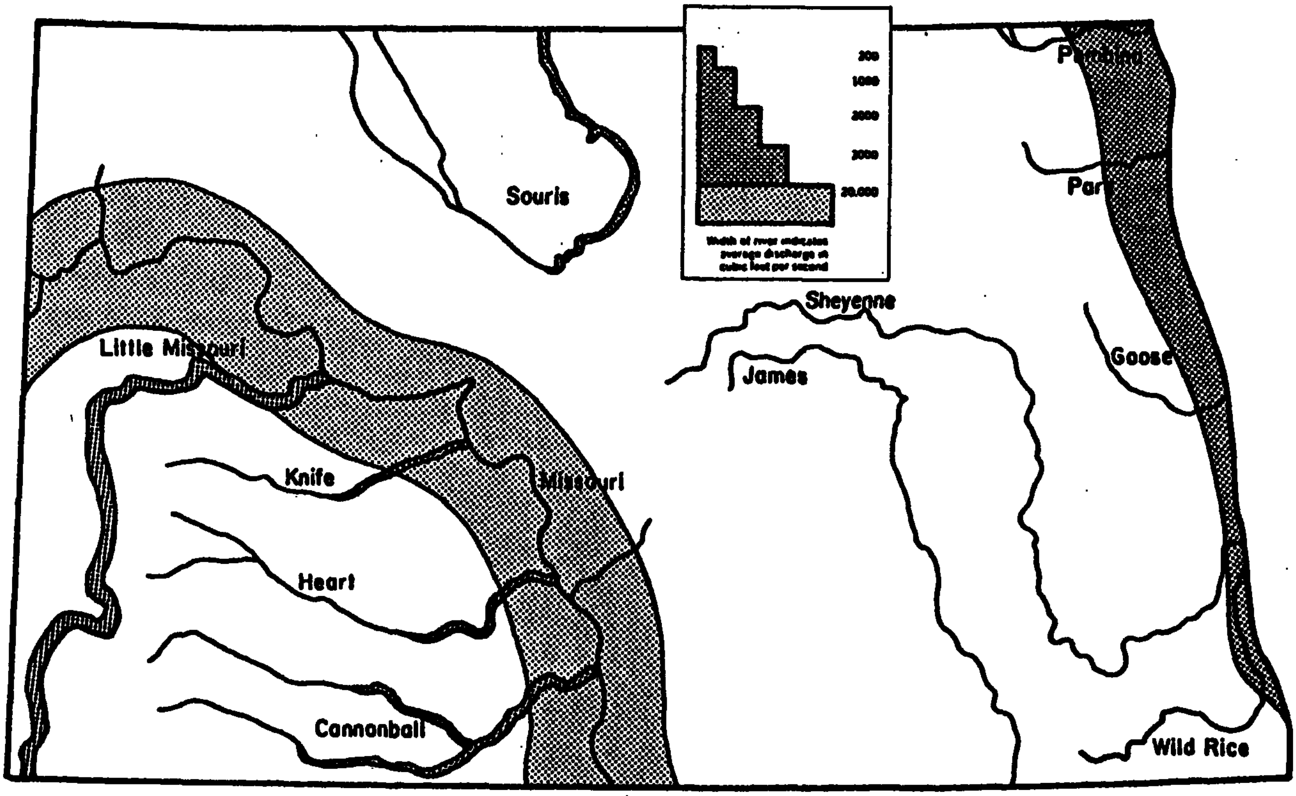
Wetlands are depressions in the land surface where sufficient water accumulates to saturate the soil or cause standing water for at least part of a year. The diversity of wetlands common to the glaciated region of the State arises from the interaction of topography, hydrology, and climate. The biological aspects of wetlands have been established, particularly those related to wildlife habitat. Efforts to determine the role of North Dakota's wetlands in ground-water/surface-water interaction, surface-water hydrology, and affects on stream sediment and pollution have been based mostly on studies of localized areas. Further research is necessary to gain a requisite, region-wide and comprehensive perspective on the relationships between wetlands and surface-water quality and quantity, and ground water.

TABLE I-2-2 WETLAND TYPES

TYPE	GENERAL DESCRIPTION	CHARACTERISTICS
Type I	Seasonally flooded	Are often farmed over on cropland or are mowed for native hay on prairie grassland. Native vegetation includes smartweed (Polygonum spp), tealgrass (Eragrostis hynoides), chafa (Cyperus escutentus), redroot cyperus (Cyperus erythrohizos), and numerous other minor species.
Type II	Inland fresh meadow	Usually grows in waterlogged soil and often in shallow standing water up to about three inches. The soil is usually without standing water during most of the growing season. Vegetation includes numerous grasses, carex (Carex spp), rushes (Juncaceae), redtop (Agrostis alba), mannagrasses (Glyceria spp), prairie cordgrass (Spartina pectinata) and mints (Labiatae).
Type III	Inland shallow fresh marshes	Usually grows in waterlogged soil and often in shallow standing water up to about six inches. Vegetation species include whitetop (Scolochloa festucacea), rice cutgrass (Leersia oryzoides), carex (Carex spp), giant burreed (Sparganium eurycarpum), and bulrushes (Scirpus spp.
Type IV	Inland deep fresh marshes	Vegetation grows in soil covered with six inches to three feet or more of water, and on open water surface. Vegetation includes cattails (Typha spp), reeds (Phragmites spp), bulrushes (Scirpus spp), spikerushes Eleocharis spp), wildrice (Lizania aquatica), pondweed (Pontamogetor spp) naiads (Najas spp), coontail Ceratophyllum demersum), watermilfoils (Myriophyllum spp), waterweeds (Anacharis spp), duckweeds (Lemna and Spirodela spp), plus numerous other minor species.
Type V	Inland open fresh water	Includes shallow ponds and reservoirs with less than ten feet of water. Vegetation includes pondweed, naiads wildcelery (Vallisneria spiralis), coontail watermilfoil muskgrasses (Chara spp), waterlilies (Nymphaea castalia and spatterdocks (Nuphar spp).
Type X	Inland saline marshes	The soil is waterlogged and often covered with two to three feet of saline water. Vegetation would include alkali bulrushes (Scirpus paludosus), hardstem bulrushes (Scirpus acutus), wigeongrass (Ruppia maritima), and sago pondweed (Polamogeton pectinatus).
Type XI	Inland open saline water	More permanent areas of shallow, saline water in which the depth is variable. Vegetation at water depth less than six feet would include sago pondweed (Polamogeton pectinatus), wigeongrass (Ruppia maritima), and muskgrass (Chara spp).

Shaw, S.P. & C.G. Fredine, 1956

FIGURE I-2-12 AVERAGE DISCHARGE OF THE PRINCIPAL RIVERS



The most recent statewide inventory of wetlands is the 1964 Inventory of the U.S. Fish and Wildlife Service and is based on a 1956 classification system of wetland types (Table I-2-2). This inventory identified about 1.7 million acres (Table I-2-3) across most of North Dakota, but these results are considered to be conservative. Eleven counties in southwestern North Dakota were not included because they have few naturally occurring wetlands. A new statewide inventory of wetlands by the U.S. Fish and Wildlife Service is in progress. This inventory uses a different and more detailed classification hierarchy than the 1964 inventory.

TABLE I-2-3 1964 WETLANDS INVENTORY STATEWIDE SUMMARY

Wetland Type	Total Number	Total Acres
I	184,741	218,693
III	264,247	622,452
IV	34,624	458,877
V	7,902	285,986
X	353	12,486
XI	778	77,958
TOTAL	492,645	1,676,452

Surface water contains suspended and dissolved organic and inorganic matter. The type and concentrations of these materials are related to such factors as the rate of stream discharge; the geological, pedologic, and topographic characteristics of the drainage basin; climate; ground-water inflow; and land- and water-management practices. Surface-water quality varies greatly with the volume of streamflow. Greater volumes of streamflow are usually associated with better quality water because of dilution, shorter contact time of water with the streambed, and proportionately less ground water entering the stream channel. The average, dissolved-solids concentrations of most North Dakota's major streams at moderate to high flows is less than 500 milligrams per liter (mg/l). The range of average, dissolved-solids concentrations is from about 100 mg/l to more than 2,000 mg/l for high and low streamflows, respectively. This relationship between concentrations of dissolved solids and volumes of water is also apparent in surface-water bodies. Devils Lake is a good example of this relationship. The water quality is markedly different when the water level is high than when the lake level is low. Another component of water quality is sediment. Stream-carried sediment derived from water and wind erosion moves through a drainage system as the suspended and bed loads. The sediment yield of a drainage basin varies as changing patterns of land use and weather interact with the basin's physiographic characteristics.

Ground Water

Ground water occurs throughout the entire geologic section of North Dakota, from the Precambrian crystalline rocks to the recent, unconsolidated deposits at the land surface (Figure I-2-9). Some of the materials within the geologic section are aquifers, that is they are sufficiently permeable to yield water to wells. Bedrock aquifers underlie the whole State, but aquifers within the unconsolidated, Quaternary deposits typically occur in the glaciated portion of the State. For the following discussion, these aquifers are grouped by age: pre-Cretaceous, Cretaceous through Tertiary, and Quaternary

The principal pre-Cretaceous bedrock aquifers occur within carbonate and clastic rock formations. Compared to the overlying aquifers, relatively little information is available on a statewide basis regarding the areal extent, thickness, degree of interconnection, or geohydrology of individual aquifers in this group. The pre-Cretaceous formations are thickest near the center of the Williston Basin, but thin eastward toward the flanks of the Basin. In some areas of the Red River valley, they are completely absent. Large well-yields can be obtained from the dolomites and limestones where formation permeability has been increased substantially by fractures, joints, or solution cavities. However, where these rocks are massive and such secondary porosity absent, even low well-yields may be impossible to achieve. Well yields from the less permeable, fine-grained sandstone formations typically are less than those possible from the carbonate rocks. However, relatively large yields are possible where the aquifer is sufficiently thick or where joints and fractures are present. Associated with the increasing depth of these pre-Cretaceous aquifers from east to west is a general increase in water temperature and concentrations of dissolved solids. In addition to the carbonate and clastic rock formations, fractured Precambrian rock forms an aquifer in localized areas of the Red River valley. Although yielding limited supplies of water, this aquifer is the only source of ground water in these areas.

The bedrock aquifers of Cretacious to Tertiary age constitute a significant water resource in terms of area extent, accessibility, and level of utilization. These aquifers are predominantly the sandstones and beds of fractured lignite found mostly in the western half of the State. The only bedrock aquifers in this second group found in eastern North Dakota are the sandstones of the lower Cretaceous Dakota Group and fracture zones of limited areal extent in the upper Pierre Formation. Yields to wells tapping these aquifers are generally on the order of tens of gallons per minute depending on thickness and permeability of the aquifer. Well yields from lignite beds and the Pierre aquifer are less. The quality of water in this group of aquifers is generally better than that of the underlying pre-Cretaceous aquifers. The water quality also improves from the oldest to youngest aquifers within this group.

The aquifers found in sediments of Quaternary age (Plate I-2-1) are most prevalent and productive in the glaciated portion of the State. In the unglaciated part of the State, the aquifers occur in thin alluvial sediment along stream valleys. The glacial-drift aquifers are glaciofluvial sand and gravel beds formed as outwash, valley fill, or deltaic deposits. The ability of these deposits to yield water depends on the thickness, extent, and permeability of the deposit and the amount of water stored in and recharged to the deposit. Large deposits of sand and gravel constitute major glacial-drift aquifers capable of supplying water to high-capacity wells. Well yields range from less than one hundred to hundreds of gallons per minute depending on the geohydrology of the aquifer. The quality of the water is usually better than that of the underlying bedrock aquifers, although it does vary from one area to another.

Geothermal Energy

Geothermal energy is heat naturally occurring in heated water or bedrock that can be extracted for useful purposes. There is good potential in North Dakota for developing low ($< 30^{o}C$) and medium (30^{o}-$150^{o}C$) temperature resources (Harris et al., 1980 and 1981; and Ritz, 1981), particularly in the western two-thirds of the state. Ground-water temperature increases with depth, so the pre-Cretaceous bedrock aquifers deep within the Williston Basin comprise the medium-temperature hydrothermal reservoirs. The shallower glacial-drift, alluvial, and bedrock aquifers constitute low-temperature reservoirs most suited to space heating. Because temperature and dissolved solids increase with depth, using the higher temperature ground water has two constraints - depth to the aquifer and very poor water quality.

LAND RESOURCES

North Dakotans have chosen many ways to develop and use the State's land resources. Each type of land use, whether it involves agriculture, the expansion of urban areas, or industrial development has a direct although usually different effect on water resources. When land-use changes occur, as in the conversion of grassland to tilled farmland or farmland to urban land, there is typically a significant change in runoff from a given amount of precipitation and in the quality components of the runoff water. Therefore, consideration of land resource management is an integral factor in planning water resource development.

One example of how land and water resources can be used together is in the use irrigation. Over six million acres of irrigable soils have been identified throughout the State (Plate I-2-2). If a substantial part of this potential is to be realized, a concerted effort must be made to efficiently manage these resources. In order to maintain the viability of those resources, the application of various land treatment techniques must be incorporated in order to adequately protect them.

Adequately treated land will reduce erosion, sedimentation, and pollution of streams and lakes and will help retain water on the land, thus improving infiltration. The need for any one of several types of treatment measures is very much dependent on soil type, slope of the land, and land cover. Measures that can be used on land to minimize negative impacts and enhance food and fiber production include, but are not limited to: conservation cropping systems, contour stripcropping, cover cropping, use of crop residue, field boarders, field stripcropping, field windbreaks, grassed waterways, grasses and legumes in rotation, stubble mulching, and terraces. Adequate treatment is considered to be obtained when management and treatment of a specific field through a production cycle holds average soil loss by wind and water to allowable limits. Adequate treatment in most cases, can be accomplished by adoption of one or more of the alternative measures, thus allowing the producer flexibility in the management of his particular operation. The status of land treatment in the State is shown in Table I-2-4.

TABLE I-2-4 NORTH DAKOTA LAND TREATMENT

STATUS	Cropland Acres (000)	%	Pasture Acres (000)	%	Range Acres (000)	%	Forest Acres (000)	%	Other Acres (000)	%	Total Acres (000)	%
Adequately Treated	16,052	60	1,826	61	6,101	53	350	66	1,627	71	25,956	59
Needing Treatment	10,769	40	1,148	39	5,330	47	184	34	657	29	18,088	41
TOTAL	26,821	61	2,974	7	11,431	26	534	1	2,284	5	44,044	100

Source: USDA, Soil Conservation Service, North Dakota Mgt. Form No. 2, 1980.

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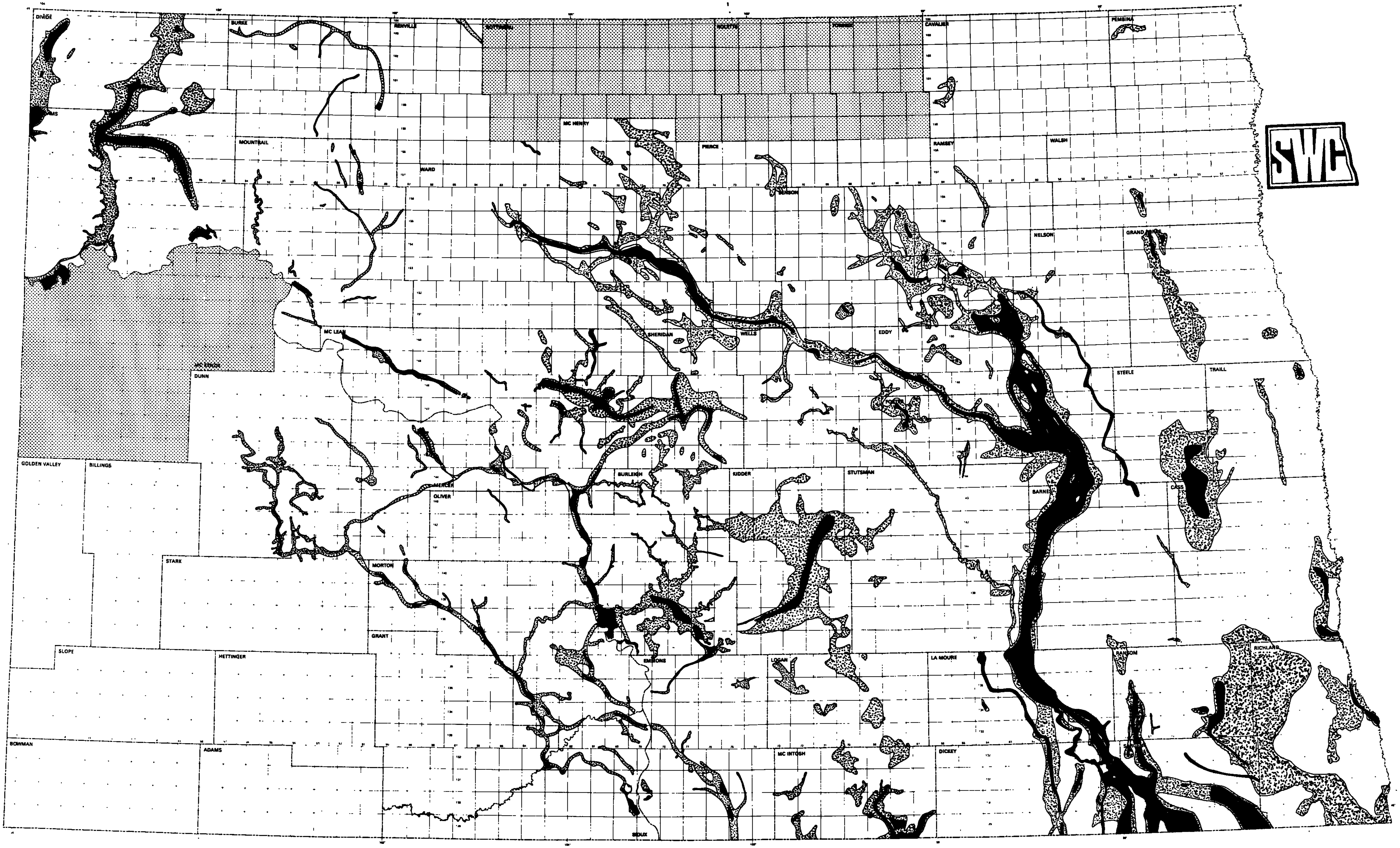
PLATE I-2-1 GLACIAL DRIFT AQUIFERS AND ESTIMATED POTENTIAL YIELDS

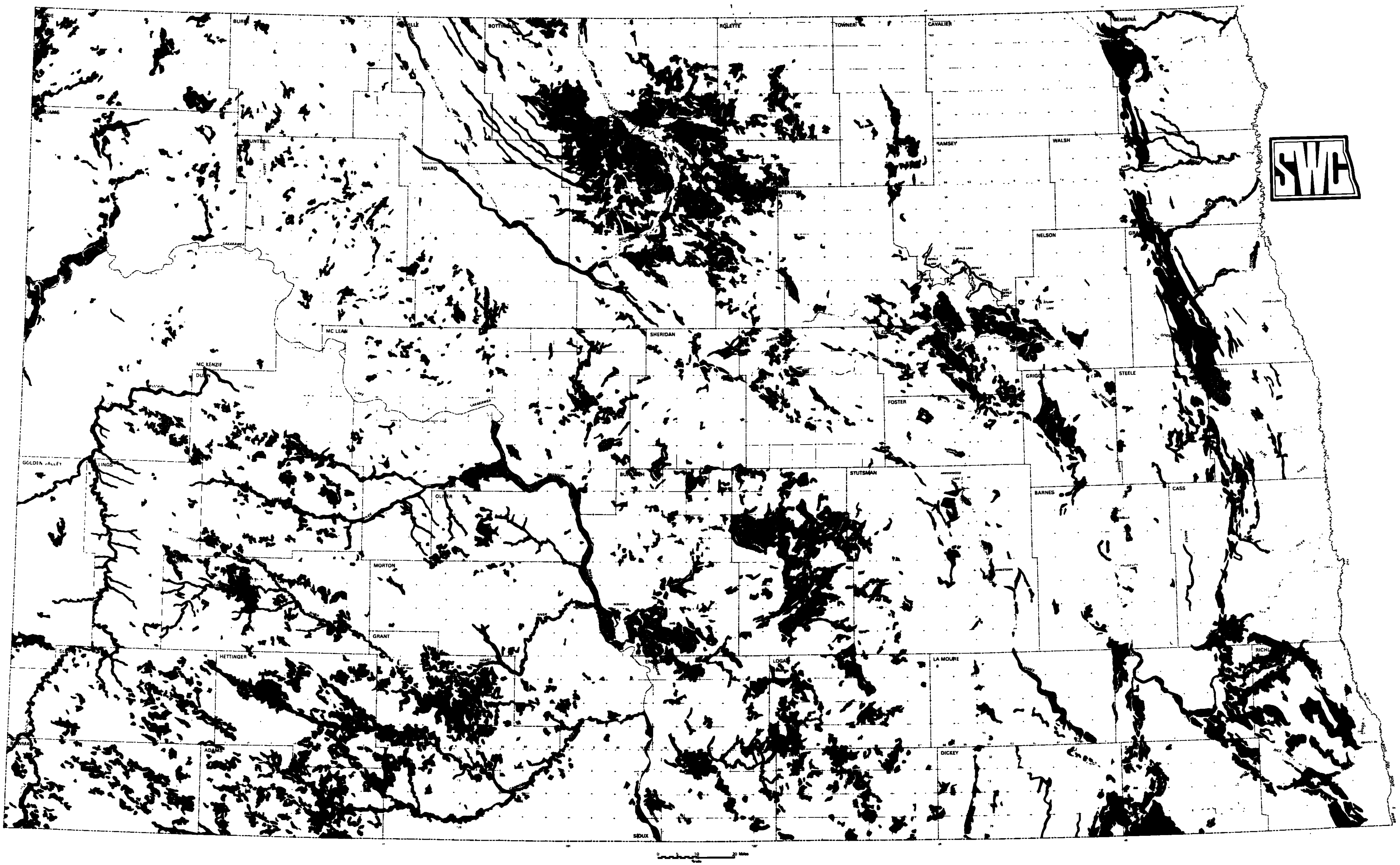


The potential yields shown are general estimates of average yields to properly constructed individual wells.

MORE THAN 500	POTENTIAL YIELD IN GALLONS PER MINUTE
50 to 500	
STUDY IN PROGRESS	

PLATE I-2-2

IRRIGABLE SOILS OF NORTH DAKOTA



IRRIGABILITY OF NORTH DAKOTA SOILS

COUNTY	IRRIGABLE	CONDITIONAL	NON-IRRIGABLE	TOTAL CO. ACRES
ADAMS	40,592	143,321	447,831	631,744
BARNES	42,003	833,094	89,963	965,060
BENSON	103,394	624,091	193,886	921,371
BILLINGS	55,325	6,760	677,878	739,963
BOTTINEAU	260,352	681,147	140,489	1,081,988
BOWMAN	147,225	22,865	576,179	746,269
BURKE	31,212	204,413	485,907	721,532
BURLEIGH	235,156	343,694	487,202	1,066,052
CASS	114,036	970,144	41,204	1,125,384
CAVALIER	13,027	817,130	134,716	964,873
DICKEY	87,658	334,572	308,330	730,560
DIVIDE	97,398	263,778	465,185	826,361
DUNN	172,385	104,805	1,058,421	1,335,611
EDDY	118,173	198,796	93,709	410,678
EMMONS	157,967	400,446	435,013	993,426
FOSTER	37,436	297,932	78,020	413,388
GOLDEN VALLEY	30,473	15,388	597,768	643,629
GRAND FORKS	176,131	571,020	169,896	917,047
GRANT	288,609	53,686	721,353	1,063,648
GRIGGS	69,988	266,857	120,685	457,530
HETTINGER	187,535	61,043	475,486	724,064
KIDDER	324,835	301,973	287,250	914,058
LaMOURE	38,334	606,480	90,538	735,352
LOGAN	136,324	167,523	343,141	646,988
McHENRY	482,817	445,756	290,195	1,218,768
McINTOSH	265,678	116,244	253,903	635,825
McKENZIE	86,179	231,621	1,514,067	1,831,867
McLEAN	146,149	590,846	755,955	1,492,950
MERCER	77,469	181,251	453,334	712,054
MORTON	83,615	46,161	1,114,845	1,244,621
MOUNTRAIL	92,016	386,169	761,442	1,239,627
NELSON	45,369	509,113	89,311	643,793
OLIVER	57,579	83,512	327,208	468,299
PEMBINA	83,174	575,275	58,433	716,882
PIERCE	187,190	325,262	178,576	691,028
RAMSEY	9,889	735,386	85,697	830,972
RANSOM	135,610	323,248	90,711	549,569
RENVILLE	41,919	483,028	44,501	569,448
RICHLAND	231,859	570,315	120,292	922,466
ROLETTE	74,927	328,983	196,625	600,535
SARGENT	117,694	390.241	49,980	557,915
SHERIDAN	48,651	345,946	247.685	642,282
SIOUX	28,081	2,508	690,084	720,673
SLOPE	121,730	52,700	606,284	780,714
STARK	146,341	10,548	699,599	856,488
STEELE	60.661	358,407	38,338	457,406
STUTSMAN	103,422	1,078,302	281,536	1,463,260
TOWNER	43,856	611,979	10,075	665,910
TRAILL	76,674	465,802	7,103	549,579
WALSH	65,254	679,663	80,984	825,901
WARD	78,092	727,081	508,004	1,313,177
WELLS	76,891	566,464	180,559	823,914
WILLIAMS	109,387	635,690	625,876	1,370,953
TOTAL	6,143,741	20,148,459	18,881,252	45,173,452

North Dakota State Water Commission

IRRIGABILITY OF NORTH DAKOTA SOILS

This compilation of irrigable, conditionally irrigable, and non-irrigable soils of North Dakota is based on the General Soils Maps prepared by North Dakota State University (NDSU) and the U.S. Soil Conservation Service (SCS). The General Soils Maps were used as they are the only consistent source for the entire State.

The NDSU Soils Department furnished two computer printouts. One listed by county, each soil that occurred in that County and its acreage; the other listed all the soils found in the State with a corresponding statewide code. By combining this information and the April, 1979 revision of the North Dakota Irrigation Guide, prepared by the SCS, the acreages of irrigable, conditionally irrigable, and non-irrigable soils for each County were computed.

The three irrigability classes, as defined in the guide, are as follows: 1. Irrigable - the soils in these irrigation groups have no restrictions to continued irrigation using the proper water application rates, amounts, timing and water quality. 2. Conditional - the soils in these irrigation groups have restrictions due to water table, low internal permeability or salinity. The restrictions can be corrected with drainage or should be monitored and carefully managed. Generally, these soils should be irrigated only as inclusions of less than 20 percent with irrigable soils. Extensive irrigation could require more economical drainage systems and complex management and monitoring. 3. Non-irrigable - the soils in these irrigation groups have severe restrictions to irrigation and should only be irrigated as minor inclusions with other irrigable soils.

It is important to note that because the maps are general in nature, the acreages for the irrigability classes will not be exact. In some cases, the areas delineated on the county maps as being of one irrigability class may also contain acreages of one or both of the other classes. Therefore, soils are presently being irrigated outside the areas delineated as irrigable.

No attempt was made to subtract the acreages of man-made features such as cities, roads, etc.

CHAPTER THREE

PROCEDURES, CONSTRAINTS, AND CRITERIA

PLAN FORMULATION PROGRAM

Study Management

One of the primary functions of the State Water Commission is that of setting policy regarding the manner in which the State manages its water and related land resources. Since one of the products of the State Water Planning Process is a body of recommendations pertaining to the need for new policy and/or the amendment of existing policy, it was decided that the Commission itself would manage the study rather than delegate that responsibility to an inter-agency task force or to the Commission's Planning Division.

Study Management Board Members:

Honorable Allen I. Olson, Governor
Kent Jones, State Department of Agriculture, Ex-Officio Member
Florenz Bjornson, West Fargo, Commissioner
Guy Larson, Bismarck, Commissioner
Henry Schank, Dickinson, Commissioner
Alvin A. Kramer, Minot, Commissioner
Garvin Jacobson, Alexander, Commissioner
Ray Hutton, Oslo, Minnesota, Commissioner
Bernie Vculek, Crete, Commissioner

In its capacity as the Study Management Board, the Commission performed the following functions:

1) Approved the study concept embodied in the work plan (Plan of Study);

2) Provided clarification of current water policy and administrative practices, as required;

3) Participated in the review of a draft of this report and authorized publication of a final report following review of participating governmental agencies and interested citizens;

4) Served as a clearing house for the resolution of conflicts emanating from the review process which could not otherwise be resolved; and

5) Determined priorities for implementation of the projects and programs contained in the Early Action Program

General Planning Procedures

The procedure followed in conducting this study involved five sequential steps:

1) Compilation of existing water and related land resources data. This was largely a matter of updating and verifying data published in other reports. In some instances, such as in the case of population growth, it was necessary to make major revisions in available projections as a result of the marked changes in growth rates and patterns which have occurred in recent years in selected areas.

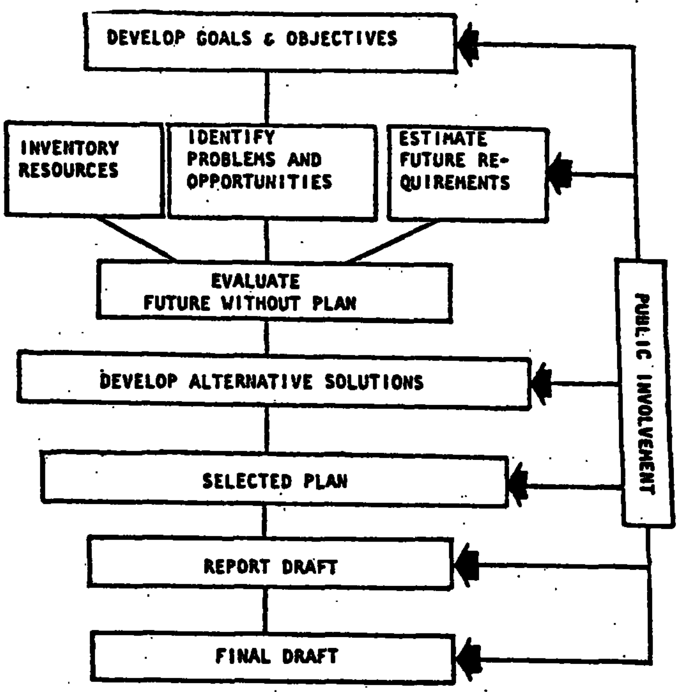
2) Analysis of supply and demand for water in order to determine current and projected requirements for each major hydrologic sub-division. A net requirement for any particular water use exists when the demand for water exceeds the developed supply.

3) Identification and evaluation of problems and the analyses of opportunities. Problems in the water resources sector tend to manifest themselves in terms of either too much or not enough water. Solutions are often difficult to find because not only must they be sound from an engineering and economic standpoint, but must also be socially acceptable.

4) Selection of development, management and problem-solving alternatives, including both initial investment and operation and maintenance costs. Alternatives are viable when they can be embraced and supported by those who will feel the impacts.

5) Agreement as to recommended implementation priorities.

FIGURE I-3-1. GENERAL PLANNING PROCESS



Problem Identification Procedure

The State of North Dakota hosts an array of water and related land resources problems. Some problems, such as flooding, erosion, loss of waterfowl habitat, and inadequate quantities of good quality rural-domestic water, are of the lingering variety. They have long been recognized as problems and much has been done to alleviate their impacts, but few have been totally resolved. Other problems, including the shortage of water-based outdoor recreation opportunities, stream pollution, lake eutrophication, and inadequate municipal/industrial water supplies, are of relatively recent vintage, but are of equal importance.

The scope and severity of a particular type of problem can vary dramatically over the State. What is perceived to be a serious problem in one hydrologic basin may be viewed as only a minor problem or no problem at all in another. Flooding, for example, is a recurring and severe problem in the Devils Lake and Red River basins; a serious but more localized problem in the Souris and James River basins; and a relatively minor problem in the Missouri River Basin.

Given the high degree of variability that exists from region-to-region regarding the nature and severity of problems, and recognizing that options and preferences differ from region-to-region as well, each Citizens Advisory Board was asked to identify those problems whose resolution was of high priority and required a cooperative approach in terms of technical assistance and/or cost sharing.

To assist Citizens Advisory Boards in their identification of problems to be addressed in the planning process, each board was furnished a list of historical problems based on the contents of Water Commission project files. This list contained information regarding (1) <u>type of problem</u>; e.g. flooding, water supply, drainage; (2) <u>location</u>; (3) <u>description</u>; (4) <u>degree of severity</u>; and (5) <u>current status</u>. Board members were asked to review the list and to supplement, revise and delete where appropriate. Following action by the Boards, the "problems lists" were discussed further during three public meetings held in each of the 17 Public Involvement Regions. The problem identification process was concluded when each of the Boards had formally approved a list of problems to be evaluated as part of the planning process.

Opportunity Identification Procedure

In order to deal effectively with the water and related land resource problems identified by the Citizens Advisory Boards, it was also necessary to determine what opportunities (options, choices, alternatives) existed which had the potential for either resolving a problem or reducing its severity. Once again, the Citizens Advisory Board assumed a leadership role.

Initially, they concentrated their efforts on identifying potential reservoir sites, most of which had never been subjected to any type of feasibility analysis. A preliminary analysis of these potential projects was conducted by the Water Commission's Engineering Division and the results were furnished to the appropriate Board for further consideration. In several instances, the Water Commission Planning Staff was directed to delete projects which lacked strong public support or fell far short of producing benefits commensurate with costs. On the other hand, many projects were approved and have become elements in the State Water Plan.

Citizens Advisory Boards were also furnished with a list of projects and programs proposed by various governmental agencies which, for a myriad of reasons, had not been implemented. Boards were asked to review the list and to indicate which merited further consideration in the planning process and which did not. In so doing, the Boards were initiating the plan formulation process. Part IV of this report contains a Table listing those opportunities which were reviewed by the Boards but rejected either because they failed to produce sufficient primary and secondary economic benefits to warrant anticipated costs or because support was lacking on the local level.

LEGAL CONSTRAINTS

Water is a very complex resource and the guidelines established over the years for its management are equally complex. A substantial body of laws and policies administered by a variety of governmental entities from the foundation for water development and management in North Dakota. As a consequence, the planning process must include a review of pertinent state and federal statutory provisions and administrative policies. The following is a summary of selected legal factors affecting water resources.

State Law

North Dakota law provides that all waters within the State, with limited exceptions, belong to the public and are to be available for uses consistent with the best interests of the State's citizens. In most cases, anyone wishing to appropriate water for a beneficial use must first apply to the State Engineer for a water permit. When he acquires a water permit and perfects that permit by applying the water to a prescribed beneficial use, his right to the continued use of that water is established. For nearly sixty years North Dakota followed a dual water rights doctrine involving both prior appropriation and riparian ownership. However, in 1963, the Legislature enacted statutes repealing the riparian doctrine and adopting the prior appropriation doctrine. The prior appropriation doctrine embraces the concept of "first in time is first in right".

The responsibility in administering water rights rests largely with the State Engineer. Chapter 61-04 of the North Dakota Century Code (NDCC) contains statutory provisions detailing the requirements for obtaining a water permit; the procedures followed in reviewing and perfecting a permit; and the enforcement and monitoring authorities vested in the State Engineer. Important to the planning process is the State Engineer's authority to reserve and set aside waters for beneficial use in the future as outlined in Section 61-04-31 NDCC.

In addition to his responsibilities in administering the State's water rights, the State Engineer, by statute, is involved in the planning, design, and construction of various structural water management works. The State Engineer is secretary and chief technical advisor to the State Water Commission and works closely with Water Resource District Boards across the State.

The State Water Commission was established in 1937 in reaction to the harsh drought conditions experienced at that time. The Legislature recognized that development of the State's water resources must begin if the disasterous effects of nature's capriciousness were to be reduced. Broad powers and authorities assigned to the State Water Commission center around its primary function as a "water authority", responsible for setting policy and providing for the development of water resources. Specific direction is given to the Commission through its listing of powers and duties found in Section 61-02-14 NDCC.

Sixty-one (61) Water Resource Districts have been established in North Dakota to facilitate local management of water resources. Most of these districts are county-wide, and the boards representing these districts are very often the "moving force" in initiating water development. Powers and duties granted the Water Resource District Boards by the Legislature are listed in Section 61-16.1-09 NDCC and Section 61-16.1-10 NDCC, respectively.

The State Engineer and State Water Commission share the responsibility for managing and developing water resources for the social and economic welfare of the State's citizens. Subsection 4 of the State Water Resource Policy states that: "Accruing benefits from these resources (water resources) can best be achieved for the people of the State through the development, execution, and periodic updating of comprehensive, coordinated and well balanced short- and long-term plans for the conservation and development of such resource..." Such plans provide an assessment of future water management and supply needs and can be a valuable tool to both the State Engineer and State Water Commission when considering possible water reservations as provided for in Section 61-04-31 NDCC.

Other State agencies involved in certain aspects of water management include the Department of Health; Game and Fish Department; Parks and Recreation Department; Soil Conservataion Committee; Geological Survey; and the Weather Modification Board.

Specific information concerning State water laws is provided in a document entitled <u>North Dakota Water Laws, 1981</u>, compiled by the North Dakota State Water Commission.

Compacts for the Yellowstone and Souris Rivers establish the rights and constraints of the various compact members to the surface water of the respective Basins. Members of the Yellowstone River Compact include Montana, Wyoming, and North Dakota. The Souris River Compact includes North Dakota and the Canadian Provinces of Saskatchewan and Manitoba.

Federal Law

While there is no specific expressed power over water and related land resources in the United States Constitution, a large body of Federal law has evolved through judicial interpretation of the Commerce Clause, the General Welfare Clause, and the War and Treaty Power.

The original thinking in establishing the Commerce Clause related mostly to protection and enhancement of the Nation's waterways, but new interpretations have expanded its application to flood control; water quality and pollution; watershed development; and the recovery of impoundment project costs through production and marketing of hydroelectric power.

Under the General Welfare Clause, the Congress has the authority to implement large scale reclamation, irrigation, and other internal improvement projects related to water and land resources.

The Treaty Power has been utilized by the Federal government in the protection of migratory waterfowl. Congress has enacted several statutes providing for the acquisition of National Wildlife Refuges and fee title and easements to preserve habitat for migratory waterfowl. These programs have been the focus of much controversy in the management of North Dakota's water resources.

The following is an abbreviated description of selected Federal regulatory acts affecting water resource management in North Dakota:

- The Refuse Act, Section 13 of the Rivers and Harbors Act (1899), makes it unlawful to deposit refuse matter into navigable bodies of water or into the tributaries thereof without first acquiring a permit issued by the Secretary of the Army.

- The Clean Water Act is a more extensive pollution control act which shifted much of the pollution abatement responsibility from the Army Corps of Engineers to the Environmental Protection Agency.

- Section 10 of the Rivers and Harbors Act (1899) facilitates control over construction of any feature that may impair navigation capacity.

- The Wild and Scenic Rivers Act of 1968 encourages cooperations between the Departments of Agriculture and the Interior in the evaluation of unique rivers for inclusion in the National Wild and Scenic Rivers Systems.

- The Fish and Wildlife Coordination Act directs the Fish and Wildlife Service to investigate the potential for damages to fish and wildlife resources that may result from the implementation of proposed water development projects. Mitigation measures are to be determined with related financial obligations being assessed to the overall project costs in accordance with the Federal Water Project Recreation Act of 1965.

- The National Environmental Protection Act of 1969 requires an assessment of overall environmental implications associated with any proposed Federal action.

- The first Flood Control Act was adopted in 1936 and concentrated primarily on structural relief measures. More recently, there has been a change in philosophy away from the structural approach to the non-structural. The first comprehensive program offering nationwide flood insurance protection was adopted by Congress in 1968 and was called the National Flood Insurance Act. The Flood Disaster Protection Act of 1973 moved more definitely in the direction of requiring local entities to enact land use control measures designed to reduce the growth in annual flood damages as a precondition to qualify for further direct or indirect federal assistance.

Selected Federal water development acts are summarized in the following:

- The Reclamation Act of 1902 authorizes the Secretary of the Interior to plan and construct water impoundments and distribution projects for multiple purpose water supply.

- The Watershed Protection and Flood Prevention Act of 1954 provides the authority for the Secretary of Agriculture to undertake small, multi-purposes, watershed improvement projects.

- The Flood Control Act of 1944 contains provisions encouraging development of water resources in the Missouri River basin. The O'Mahoney-Milliken amendment to the Act clearly stipulates that states lying wholly or partly west of the 98th meridian shall be entitled to Missouri River water for beneficial, consumptive uses.

Some major issues affecting water development in North Dakota center around the question of Federal reserved water rights. The following is a summary of the current situation.

The real beginning of the Federal reserved water rights doctrine came in 1908 when the U.S. Supreme Court decided the case of Winters v. United States 207 U.S. 564 (1908). In that case, the Supreme Court held that when Congress created an Indian reservation, an unspecified quantity of water had been implicitly set aside for Indian use, and that this reserved water right was superior to the rights of subsequent appropriators who had obtained water rights under the applicable state laws, even though the Indians had not made a diversion for beneficial use. The Winters Doctrine, as it became known and accepted, was held applicable to all Indian reservations, whether created by treaty, Act of Congress, or Executive Order. For many years, the Winters Doctrine was generally regarded as a special rule of Indian law. However, in 1963, in Arizona v. California, 373 U.S. 546 (1963), the U.S. Supreme Court applied the Winters Doctrine to non-Indian federal reservations, holding that "the principle underlying the reservation of water for Indian reservations is equally applicable to other Federal establishments".

The Federal reserveu water rights, or "reservation" doctrine, simply means that when public lands are withdrawn or reserved from the public domain, quantities of the then unappropriated water necessary to fulfill the primary purposes for which the land is withdrawn is also reserved and exempted from appropriation under state laws. As a result, an Indian or Federal reservation acquires reserved water rights which vest on the date the reservation was created, without the requirement that such reserved water rights be applied to beneficial use, and such Federal reserved water rights are superior in right to subsequent appropriations under state law.

Indian Water Rights

While Indian reserved water rights have the same legal basis an non-Indian Federal reserved water rights, and enjoy the same priority and other conditions, there are some differences. The actions of the United States with respect to

Indian reserved water rights are limited by its fiduciary duty as trustee to act for the benefit of the Indians. This principle derives from the recognition that the United States holds only the bare legal title as trustee while the Indians retain the equitable title to use the reserved water. Non-Indian Federal reserved rights, on the other hand, are managed in the public interest.

Policy and Implementation

Both Indian and Non-Indian reserved water rights create uncertainty for State water right systems. Most reserved water rights are not quantified, and since such rights are not required to be used to remain valid, subsequent water users who acquire water rights under State law cannot be guaranteed that their investments will not be jeopardized without compensation by the eventual utilization of reserved water rights. Thus, it is the general position of western states, where water supplies are often scarce and insufficient to satisfy demands, that Federal reserved water rights, both Indian and non-Indian, should be quantified to clarify the uncertainty that is created by such reserved water rights.

GENERAL PLANNING ASSUMPTIONS

The State Water Plan reflected in this report is based in part on projections of economic activity and population which are in turn based upon a number of assumptions. The broadest of these assumptions are: (1) that no major war will occur during the period to 2020; (2) that throughout the period covered by the study, the Government will implement the policies needed to maintain full employment; (3) that per capita food and fiber consumption will be maintained at or near current levels; and (4) that the export of the types of agricultural products grown and/or processed in North Dakota will grow at a relatively slow but steady rate.

Population Growth

The population of the United States is projected to nearly double between now and 2020. North Dakota's population is projected to increase by only 20 percent during the same period, with the rural segment of the population continuing to decline.

Economic Growth and Development

The State's economy is projected to grow at a rate below that of the Nation, though in absolute terms, its growth is projected to increase in magnitude. This lesser growth rate is attributed to the State's having a comparatively small share of the Nation's rapidly growing industries and a locational disadvantage. Agriculture has a comparative advantage for continued growth, but it is a declining industry in terms of employment.

SPECIFIC PLANNING ASSUMPTIONS

Part III of this report, FUTURE WITHOUT PLAN CONDITIONS, discusses the current status of water and related land resources management in each of the State's five major hydrologic sub-divisions and projects baseline conditions through the year 2020. In making these projections, it is necessary to do so on the basis of a reasonable set of assumptions. For a discussion of those assumptions, refer to Part III.

The information presented in Part III is organized by major resource elements: (1) Land Resources; (2) Rural Domestic Water; (3) Municipal-Industrial Water; (4) Agriculture (Irrigation); (5) Self-Supplied Industrial Water; (6) Flooding; and (7) Fish and Wildlife and Outdoor Recreation.

PLANNING CRITERIA

Flood Damage Reduction

The analysis of flood damage reduction needs and alternative corrective measures recognized the nature of the areas subject to flooding; number of people affected; present and projected annual flood damages; probabilities of flooding and the duration and depth of flooding. Both structural and non-structural approaches for reducing or preventing flood damages were evaluated.

Structural measures are considered essential to the economic and social well-being of those urban areas where existing damages are high, the floodplain has been intensively developed, and many people are affected by recurring floods. Structural measures are assumed to be designed to provide protection for urban areas against floods having a one percent chance of being exceeded during any single year (100-year flood). The regulation of floodplain land use and development in areas subject to urban growth is viewed as an integral element in any overall urban flood damage reduction program.

A variety of measures, including multi-purpose and single-purpose reservoirs, channel modification, and farmstead levees are considered as appropriate elements for reducing rural flood damages. Structural/non-structural measures for rural flood damage reduction are assumed to be designed to provide protection against floods having a ten percent chance of being equaled or exceeded during a single year. A much higher degree of protection for rural areas is usually not economically feasible.

The outputs from flood damage reduction programs are measured in monetary terms as annual flood losses prevented. It should be noted, however, that definitive information regarding reductions in average annual dollar damages is available only for those projects which have reached a fairly detailed level of analysis. Since many of the flood damage reduction elements have not been evaluated in sufficient detail to calculate precise dollar reductions in average damages, the output of such elements is frequently limited to flood storage and/or retention capacities.

Erosion Control

Wind and water erosion are the major sources of sediment on a statewide basis with streambed and bank erosion contributing only minor amounts. Options available for erosion control include grade stabilization structures, river bank stabilization, and a variety of land management practices.

Water Supply

Diversion or withdrawal requirements of surface and ground water for municipal, rural domestic, and industrial purposes; as well as for industries not connected to municipal system, thermal power cooling, livestock, irrigation and mineral processing have been projected over the long term.

Water Quality

Attainment of desirable surface water quality is achievable through meeting water quality standards established by the State. The State Health Department, which is responsible for monitoring water quality and for enforcement of applicable standards, furnished information regarding water and waste water treatment needs, and that information has been incorporated into the recommended plan for each hydrologic subdivision. The quantification of outputs is expressed in terms of population served and stream miles enhanced or preserved.

Irrigation

Determination of the availability of surface water for irrigation was based on streamflow data records, other studies and from a consideration of other uses of water. Where irrigation or other uses were imposed on ground water, a general appraisal was made of the effects on ground water supplies over the projection period.

Water requirements to supply crop needs included a consideration of on-farm losses and transit losses from the point of diversion through the delivery system.

The authorized 250,000-acre initial stage of the Garrison Diversion Project was considered in place for planning purposes. Planning for new irrigation development included continuation of the current rate of private irrigation development utilizing ground water, and additional surface water developments needed to enhance the State's economy.

It is important to note that the approach used to project irrigation development through 2020 differs markedly from that used in earlier comprehensive studies. In these earlier studies, the need for additional irrigation development was limited to that required to meet the State's historical share of projected food and fiber requirements. The State's historical share was based on a disaggregation of national (including export) demands for food and fiber. The problem with this approach was that it tended to show reduced needs (and justification) for additional irrigation development in North Dakota compared to other States in the region. It tended to perpetuate the status quo by maintaining historical relationships relative to the number of irrigated acres in each State.

From a National perspective this approach may be appropriate, even though it fails to recognize that such things as locational advantage or disadvantage are in a state of constant flux. From the point of view of most North Dakotans who participated in the planning process, it is unacceptable. Accordingly, the irrigation development recommended in this report is based on a perceived need to stabilize the State's economy, to diversify the agricultural sector, to utilize and manage the State's water and land resources in a manner that improves the overall quality of life, and to capture a larger share of current and future food and fiber markets.

Recreation

Projection of future demands for outdoor recreation activities and for fishing and hunting were based on participation rates provided by the State Parks and Recreation Department. However, a supply-demands-requirements analysis was completed only for outdoor recreation activities because of the unavailability of adequate information regarding the capacity of a variety of resource elements to satisfy hunting and fishing needs.

Fish and Wildlife

Many of the projects and programs included in the Recommended Plan have fish and wildlife benefits, but in most instances they are incidental to major project purposes. The State Water Plan does not, however, contain a specific fish and wildlife component in the sense that it spells out amounts, numbers or types of habitat requiring preservation nor the number and kinds of new and/or improved fisheries required to meet current and projected needs. In order to determine how much and what types of habitat are required to meet the demand for hunting and fishing, it is necessary to know (1) the existing resource base; (2) the capacity of that base to meet both current and projected demands; (3) projected demands, including latent demands; and (4) the capacity and mix of habitat to be acquired to meet demands.

The lack of adequate information regarding resource capacity precluded the completion of a supply-demand-needs analysis. Wetlands values are extremely complex and often misunderstood. Recognizing this, an attempt was made to better inform Board members and interested citizens about values other than hunting through the publication and dissemination of a paper entitled "General Functions and Values of Wetlands in North Dakota" (June, 1982). Similarily, papers entitled, "Water Quality As It Relates to the Future of North Dakota's Fisheries" were prepared and disseminated for each of the State's major hydrologic subdivisions. Additionally, a paper was published regarding minimum instream flow requirements for maintaining limited survival (10%), good (30%), excellent (60%), and fishing (200%) flows for all streams included in the "1978 Stream Evaluation Map" prepared by the U.S. Fish and Wildlife Service in cooperation with the North Dakota Game and Fish Department.

COST ESTIMATING CRITERIA

The costs presented for elements included in the State Water Plan reflect the first costs developed (in 1980 dollars) and no attempt was made to determine investment costs requiring estimates of construction periods and interest rates.

Most of the costs (and benefits) associated with program elements are updated to 1980, from earlier studies, using indexes. In a majority of cases, the updating was accomplished by the Governmental agency which had undertaken the original studies. Costs for potential new projects -- those surfacing as part of the opportunities identification process -- were calculated by the Water Commission's Engineering Division.

In some instances, it was not possible to develop cost estimates, because of severe time constraints. More detailed study is required to fully develop cost/benefit data in such cases, and recommendations regarding priorities and agency responsibility are included in this report.

It should be noted that while cost information is incomplete, the cost totals found in the Program Summary Tables do reflect an order of magnitude of investment requirements needed to implement the State Water Plan.

COST SHARING

To provide some indication of the general sharing of costs for implementing the State Water Plan, a broad analysis of cost-sharing practices was made. It was assumed that existing institutional and legal arrangements would apply for this analysis, though it was recognized that over the projection period these could be modified.

Each Citizens Advisory Board was advised that the Federal Administration is currently reviewing project cost-sharing and financing for water resource development functions. New policies for Federal involvement concerning cost recovery and financing for projects with vendible outputs are currently being reviewed on the Federal level. The basic principle governing the development of specific cost sharing and financing policies is that, whenever possible, the cost of services produced by water projects should be paid for by their direct beneficiaries. While not all cost-sharing and financing policies for projects have been established yet, under the Administration's policies and principles, the level of non-Federal participation will be significantly greater than in the past. Adoption of the new policies being contemplated would dramatically alter current policy and drive local, State, and private costs upward. However, because policy change regarding cost-sharing and financing practices have not been formally adopted, for purposes of the State Water Planning Process, the following ratios based on historical averages were used, except in instances where agencies were in a position to provide definitive estimates for a specific project:

Category	Soil Conservation Service	Corps of Engineers	Bureau of Reclamation
		(percent)	
Urban Flood Damage Reduction	*	83	*
Rural Flood Damage Reduction	73	93	90
Drainage	42	65	--
Agricultural Water Supply (Irrigation)	47	81	82
M & I Water Supply	0	46	29
Recreation - General	37	83	82
Navigation	--	93	93
Hydro-Power	--	39	35
Land Treatment Practices	75	*	*

*Not Available

Projects included in the State Water Plan, when implemented, must be operated, maintained, and repaired (OM&R). Almost without exception, the costs associated with OM&R are borne by local entities. Except in cases where an agency was able to provide OM&R costs for a specific project, the following rates were used:

Practice	Percent of Initial Project Costs
Multi-Purpose Reservoir	1
Single-Purpose Reservoir	1
Channel Improvements	2
Snagging & Clearing	5
Levees, Dikes, Floodways	2
Water Supply Treatment Facilities	5
Waste Treatment Facilities	Population served x $18
Streambank Stabilization	2
Drainage	1.5

CHAPTER 4

GOALS AND OBJECTIVES

INTRODUCTION

Developing a comprehensive list of goals and objectives early in a planning process is necessary in order to establish a common direction and purpose for those who participate. This increases the efficiency of the overall process by bringing the most important issues into focus.

In developing the 1983 State Water Plan, each of the 17 Citizen Advisory Boards was encouraged to develop its own goals and objectives to better represent unique physical conditions and social attitudes of their region. Accomplishing this task began with an initial statewide listing gleaned from earlier study reports. The initial draft organized these goals and objectives by function, addressing water supply, irrigation, water quality, flooding, fish and wildlife, outdoor recreation, transportation, weather modification and energy. The draft was reviewed first by the Citizen Advisory Boards who made corrections, deletions and numerous additions. The general public responsed to draft goal and objective statements during the third round of meetings. Comments obtained at these meetings aided the Citizen Advisory Boards in completing this initial step of the planning process. Table I-4-1 presents goal and objective statements approved by each of the seventeen citizens advisory boards.

TABLE I-4-1

APPROVED GOALS AND OBJECTIVES

WATER SUPPLY GOALS & OBJECTIVES

GOAL: Meet projected water supply demands for all purposes for the years 1990, 2000, 2020 and beyond.

	MISSOURI RIVER DRAINAGE Public Involvement Regions									HUDSON BAY DRAINAGE Public Involvement Regions							
OBJECTIVES:	Beaver Creek	Cannonball Grand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
Provide technical, administrative, and financial assistance to local governments to assure a safe, reliable supply of drinking water. Research methods to deal with troublesome minerals in "raw water supplies.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Develop self supporting rural water systems in areas where increasing demand exceeds available supplies and where the quality of existing supplies is poor. Many smaller communities across the State could benefit from rural water systems. Subsidies should be considered to systems serving isolated farms.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Develop energy resources only after exhaustive evaluation of the trade-offs and only when such developments will not significantly reduce streamflow, lake levels, and/or ground water storage.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Encourage reuse and reclamation of water in order to minimize water losses in consumptive use.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

WATER SUPPLY CONTINUED

	MISSOURI RIVER DRAINAGE Public Involvement Regions									HUDSON BAY DRAINAGE Public Involvement Regions							
	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
Continue to evaluate quality and quantity of surface and ground water resources and provide up-to-date inventories on water availability to prospective water users and to local government decision makers.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Provide assistance in developing water supplies for new industries in the State, particularly those that will process North Dakota's agricultural products.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Quantify Indian and Federal Non-Indian water rights to resolve the question of water availability thus aiding water development planning.	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X
Reserve sufficient quantities of water from the Missouri River system to provide a viable supply for all foreseeable municipal, industrial, agricultural, and domestic needs.		X	X	X	X		X		X	X	X	X	X	X	X	X	X
Complete the Garrison Diversion Project.			X				X		X	X	X	X	X		X	X	X
Determine the need for additional water distribution systems across the State. The southwest area of North Dakota urgently needs a more reliable supply of good quality domestic water via the Southwest Area Pipeline Project and has the potential for a project similar to the West River diversion Plan.		X	X	X	X		X					X					
Develop water distribution systems in ways which are environmentally sound and which minimize disruptions to agriculture and other land uses by expanding available technologies.	X	X	X		X		X		X	X	X	X	X	X	X	X	
Initiate a public education program designed to aid citizens in their understanding of water resource management including conservation of water in homes, industry, and in agriculture and maintenance of water quality.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Develop small dams where appropriate on some of North Dakota's streams to retain a larger supply of water for use in late summer and fall months.	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
Encourage communities that could feasibly use surface waters as an improved source for their municipal supplies to convert to such a system.	X		X		X		X		X	X	X	X	X		X		

WATER SUPPLY CONTINUED

	MISSOURI RIVER DRAINAGE Public Involvement Regions									HUDSON BAY DRAINAGE Public Involvement Regions							
	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
Study potential for and the impacts that may result in utilizing shallow "sand point" wells for in-city irrigation and industrial uses.							X		X	X							
Monitor closely ground-water levels in areas adjacent to water development works such as canals and dams to detect changes that may adversely affect area landowners. Areas along the Oahe Reservoir, Lake Audubon and McClusky Canal are examples. Landowners should be notified of potential problems.					X		X										
Continue to study modifications to the Garrison Diversion Project that would eliminate Canadian concerns.							X		X								
IRRIGATION GOALS & OBJECTIVES																	
GOAL Encourage irrigation development where feasible in the public and private sectors to help stabilize and diversify the State's agricultural production.																	
OBJECTIVES:																	
Assist irrigators in publicly and privately developed projects to achieve optimum efficiency in their water use through rehabilitation of older systems and improved irrigation techniques.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Complete phase two ground-water studies to increase practical knowledge of the State's aquifer systems thereby improving the ability to manage the resource. Ground water should be managed so as to assure its availability for domestic use.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Satisfy the water supply needs for new irrigation development by developing water supply facilities that demonstrate the potential for maximum net economic, social, and environmental benefits to the public.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Analyze all alternatives for distribution of Missouri River water for irrigation in conjunction with other beneficial uses. Southwestern North Dakota has considerable potential for such a diversion.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Utilize treated waste water where the characteristics of the water and the soil are compatible.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

IRRIGATION CONTINUED

	MISSOURI RIVER DRAINAGE Public Involvement Regions									HUDSON BAY DRAINAGE Public Involvement Regions							
	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
Establish flow models on highly appropriated rivers to determine whether additional irrigation withdrawals can be made and the best timing for such withdrawals.	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
Conduct research to determine how, when, and at what rates water can be applied to various soils to arrive at long-term cost effective, efficient use of water. The State Water Commission and State Department of Agriculture should work together utilizing available soils and water information to assure long-term soil productivity and preservation of water quality.		X	X	X	X	X	X			X		X	X		X	X	X
Soil analysis should be completed statewide to determine areas of irrigable soils; maps should then be made available outlining these areas. Potential irrigators should be deterred through the water permitting process from applying water that is not compatible with the land involved.	X	X	X	X	X	X	X		X	X	X	X	X		X		
Modify the Bureau of Reclamation's criteria used to establish the irrigability of soils to make them more applicable to the glacial-till soils of North Dakota.				X			X		X								
Continue and improve public information/education programs concerning development of irrigation depicting both pro and con factors. Information should include availability and use of water resource data and background on the State Water Commission's policies regarding the granting of new irrigation permits.	X	X	X	X	X	X	X	X		X			X	X	X	X	X
Complete development of the Garrison Diversion Project features. Develop early-on irrigation along the McClusky Canal which would have secondary benefits of moving water through Lake Audubon and potentially improve that lake's water quality.			X		X		X		X	X			X		X	X	X
Complete sufficient soil analysis to determine the potential for irrigation near Lake Sakakawea and Lake Oahe. Develop a pilot project, possibly on the Fort Berthold Reservation, to establish feasibility.					X		X										
Revise laws governing the organization of irrigation districts to shorten the time required for their establishment.	X	X	X	X		X	X										
Consider legislation to limit the acreage an individual can irrigate when the water supply in a given aquifer is limited thus making water available to more landowners.															X		

WATER QUALITY GOALS & OBJECTIVES

GOAL Maintain and enhance the quality of all waters of the State.

OBJECTIVES:

	MISSOURI RIVER DRAINAGE Public Involvement Regions									HUDSON BAY DRAINAGE Public Involvement Regions							
Objective	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
Increase the level of financial support to local government to facilitate training programs for waste-water treatment plant operators.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Increase the level of financial support to local governments to facilitate maintenance and up-grading of waste-water treatment plants. Aid local governments in monitoring quality of municipal water discharges.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Improve land management practices to aid in the control of nonpoint source pollution including effective control of erosion. Research should continue to find additional ways to cut nonpoint source pollution.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Increase monitoring of water quality where needed to aid in detection and elimination of sources of pollutants that may affect water users and the natural environment.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Counties having zoning ordinances should include ordinances concerning water quality controls. This may apply to land use regulations in areas determined to be ground-water recharge areas.	X	X	X		X	X	X		X	X		X	X	X	X		X
Restore, where practical, natural and manmade lakes to a condition that will enable continued usefulness. New manman lakes should incorporate features to aid in extending their useful life.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Enforce regulations pertaining to seismic exploration and energy exploration. Failure to properly seal-off drilled holes in certain areas has resulted in suspected co-mingling of waters from different water-bearing strata.	X		X	X	X	X	X	X	X	X			X		X	X	X
Take advantage of Federal Clean Water Act provisions for implementation of lagoons for animal waste.		X			X	X	X		X	X		X	X	X	X		X
Achieve strict adherence to water quality laws particularly with regard to point-source pollution permit holders.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Recognize the value that wetlands may have for their contribution of filtering runoff waters. Additional research is needed to better establish the significance of the benefits derived from maintaining wetlands for this purpose.	X	X			X				X	X	X	X	X		X		X

WATER QUALITY CONTINUED

	MISSOURI RIVER DRAINAGE Public Involvement Regions									HUDSON BAY DRAINAGE Public Involvement Regions							
	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
Develop a solid information base on ground water for the principal aquifers on the Fort Berthold Reservation.					X												
Recognize and maintain the usefulness of the sandhills region of the Sheyenne River Basin to water quality and flow.												X					
Limit, through better management practices, the amount of commercial fertilizers and pesticides that can be applied to the land.												X	X				
Provide financial support to farmers to encourage incorporation of minimum till and no-till farming practices. Recognize multiple benefits including water quality improvement, erosion control, and wildlife habitat enhancement.															X		

FLOODING GOALS & OBJECTIVES

GOAL Reduce and/or eliminate flood damages to lives and property in floodplains and other flood prone areas.

OBJECTIVES:

	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
Develop structural, nonstructural, or a combination of measures to reduce flood damages as determined on a case by case basis. Structural measures would include small tributary dams designed with permanent reservoirs or as "dry" dams which hold runoff for short periods. Consider use of stored flood waters for irrigation, recreation, storage for domestic use and other uses. Levee systems is another structural measure.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Negotiations should continue with Canadian government on the construction of flood retention structures in the Souris River Basin in Canada.																	X
Implement land treatment measures to control runoff flows during spring snowmelt and summer storms.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Develop and maintain a data base and data management system to contain information related to floodplain management. Maps of rural flood prone areas is an example.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Develop and maintain a public information/ education program concerning floodplain management.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

FLOODING CONTINUED

	MISSOURI RIVER DRAINAGE Public Involvement Regions									HUDSON BAY DRAINAGE Public Involvement Regions							
	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
Achieve active participation by all flood prone communities in North Dakota in the regular phase of the National Flood Insurance Program.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Adopt and implement a comprehensive flood hazard mitigation plan in all flood prone communities.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Avoid direct or indirect governmental support of hazardous or nuisance floodplain use.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Actively administer North Dakota's Floodplain Management Act which would limit development in the floodplain.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Develop a State funded program similar in function to the U.S. Department of Agriculture's Watershed Protection and Flood Prevention Act of 1954 (P.L. 566). This would, among other things, identify and treat the source or reservoir sedimentation.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Continue research to determine measures for control of high water erosion on Lake Sakakawea.			X		X		X										
Continue research and implementation of erosion control and bank stabilization especially along the Missouri River between Garrison Dam and Lake Oahe.							X										
Maintain and improve where necessary the existing rain gaging network. Data collection methods should be such that reflect both rainfall amounts and rates.					X	X	X		X	X	X	X	X		X		
Continue and/or enlarge where needed the existing stream gaging system, particularly on smaller streams. State and local coop stations could augment U.S. Geological Survey stations.		X			X		X		X	X	X	X	X		X	X	X
Maintain channel capacity of coulees and streams across the State. Remove obstructions where necessary.									X						X		
Improve coordination between State agencies and between local government units such as Water Resource Boards, Township Board, and County Commissions concerning modifications to natural drainage patterns and drainage improvements.		X		X	X	X	X		X	X	X	X	X	X	X		X

FLOODING CONTINUED

	MISSOURI RIVER DRAINAGE Public Involvement Regions									HUDSON BAY DRAINAGE Public Involvement Regions							
	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
Recognize wetlands as a land management practice to reduce downstream movement of eroded soils.	X	X	X		X				X	X	X	X	X				X
Identify wetlands as specific surface water formations which should be protected. Discourage the practice of drainage permanent wetlands where such activity would contribute to excess runoff.		X				X				X	X	X	X				
Encourage upstream watershed landowners who have drained their land to hold water on their land for the short period of time necessary to prevent major downstream flooding. Financial compensation to these landowners should be considered.	X	X		X			X		X	X	X	X	X	X	X	X	X
Manage discharges from drained wetlands through the use of gated culverts where possible to retain water so the timing of these flows does not contribute to flooding. Develop agreeable, coordinated plans for orderly drainage and stop excess water from entering problem watersheds via legal and illegal drainage.	X	X			X		X		X	X	X	X	X	X	X	X	X
Study the potential for taxing property owners throughout a watershed to generate revenue to pay for flood damages, particularly damages to public property.		X									X						
The importance of preserving and developing "arable lands" as a valuable resource should be given greater recognition when determining the benefit-cost ratio for water projects.	X	X	X		X		X		X	X	X	X	X	X	X	X	X

FISH & WILDLIFE GOALS & OBJECTIVES

GOAL Perpetuate, and enhance where possible, fish and wildlife resources for continued recreational, aesthetic, educational, and scientific use.

OBJECTIVES:

	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
Maintain habitat which is necessary for wildlife populations at levels which will support populations adequate to meet growing recreational demands.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Provide incentives through voluntary programs like the Federal and State Water Bank Programs to encourage private landowners and farm operators to maintain and/or improve wildlife habitat. This method of providing wildlife habitat is perferable to permanent easement and fee title purchases typical of wetland preservation.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

FISH & WILDLIFE CONTINUED

	MISSOURI RIVER DRAINAGE Public Involvement Regions									HUDSON BAY DRAINAGE Public Involvement Regions							
	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
Undertake a joint Federal/State effort to identify and secure "essential" habitat areas for rare and endangered species of plants, wildlife, and fish.	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
Encourage private initiative to identify and maintain natural areas.									X								
Improve cooperation/coordination between fish and wildlife interests and landowners.	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X
Alleviate problems of point and nonpoint source pollution which adversely impacts on aquatic and related ecosystems.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Initiate a cooperative effort between State and Federal entities to define and quantify benefits derived from maintaining fish and wildlife habitat to facilitate fair appraisals in water resource management plans.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Develop a more equitable method for mitigating habitat affected by water development projects.	X	X	X		X		X	X	X	X	X	X	X		X	X	X
Use a common sense approach to fish and wildlife management which considers all involved interests.	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Consider development of wetlands habitat in conjunction with flood control projects, particularly small impoundments.	X	X			X		X		X	X	X	X	X	X	X	X	X
Adopt intensive management of Federal and State easement and fee title lands to encourage more efficient production.	X	X					X		X	X	X		X	X	X	X	X
Improve dispersal of fish plantings across the State.		X	X			X	X		X	X							
Provide protection from wildlife depredation on farmlands adjacent to Federal and State refuges and production areas. Blackbirds have been a particular problem in sunflower and small-grain crops.	X	X			X	X	X		X		X	X	X	X	X	X	X
Expand wildlife habitat within the Lake Sakakawea Reservoir taking area and in the Fort Berthold Reservation.					X												

OUTDOOR RECREATION GOALS & OBJECTIVES

GOAL Develop sufficient water-based outdoor recreation facilities to meet the needs projected for 1990, 2000, and 2020.

OBJECTIVES:	MISSOURI RIVER DRAINAGE Public Involvement Regions									HUDSON BAY DRAINAGE Public Involvement Regions							
	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
Identify and evaluate opportunities to develop new sites and/or improve upon existing facilities along the State's streams and lakes. Developments should be suitable for all age groups and should not seriously effect natural ecosystems.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Maintain water quality in streams and existing lakes at a level compatible with swimming, boating, game-fish reproduction and aesthetic appeal. Care should be exercised in creating new recreation lakes to maintain good water quality.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Increase the level of funding assistance to expedite implementation of practical outdoor recreation facilities which are either independent developments or included in multi-purpose projects.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Promote riverbank parks and trails.	X	X				X	X		X	X	X	X					
Develop more public access areas on lakes across North Dakota placing more emphasis on recreational activities such as swimming, boating, and fishing.	X	X			X		X		X	X	X	X	X		X	X	X
Participate with the U.S. Army Corps of Engineers in development of cabin areas and a marina on Lake Sakakawea.					X		X	X									
Expand wildlife habitat within the Lake Sakakawea Reservoir taking area and in the Fort Berthold Reservation.					X												
Provide historical markers in appropriate locations, particularly along riverbanks.	X	X	X				X		X	X					X		
Groom riverbank vegetation at recreation sites to encourage desirable growth.		X	X							X							
Investigate the possibility of an impoundment on Beaver Creek in Emmons County for recreation, flood control, and water for irrigation.	X																
Provide a good source of water for recreation dams and in streams through diversion where practical to enhance recreational opportunities.	X	X				X	X		X				X				
Promote wetlands as a significant tourist attraction.		X								X							
Improve recreational facilities at Homme Dam in Walsh County.											X						

	MISSOURI RIVER DRAINAGE Public Involvement Regions									HUDSON BAY DRAINAGE Public Involvement Regions							
TRANSPORTATION GOALS & OBJECTIVES	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
GOAL Provide sufficient water and navigable area to allow use of Missouri River for barge transportation in North Dakota.																	
OBJECTIVES:																	
Determine navigable areas of river and minimum water depths to maintain navigability.	X	X	X				X									X	X
Map navigable portion of Missouri River channel at all locations within the State.							X										X
Study location and formation of sandbars on the Missouri River that would be detrimental to river barge traffic.							X										X
The above objectives should be coordinated with downstream states.							X										

	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
WEATHER MODIFICATION GOALS & OBJECTIVES																	
GOAL To develop a scientifically credible and socially acceptable statewide program of precipitation management to be administered under existing State authority and local control.																	
OBJECTIVES:																	
Establish public awareness concerning the existing program's ability in precipitation management.	X	X	X			X	X	X	X			X	X			X	X
Maintain an adequate raingauge network for climate analysis and provide a climate data base to potential users.		X	X			X	X	X	X			X	X				X
Improve and maintain hail occurrence records across North Dakota and near its borders.		X	X			X	X	X				X	X				X
Recognize weather modification as a water management tool and coordinate activities with water resource needs as depicted by local, state, and federal agencies.		X	X			X	X	X				X	X				X
Provide opportunity for public review and assessment of operational weather modification programs.		X				X	X	X				X	X				X
Set and administer standards for operational programs to protect the public health and environmental welfare.		X				X	X	X				X	X				X

	MISSOURI RIVER DRAINAGE Public Involvement Regions									HUDSON BAY DRAINAGE Public Involvement Regions							
	Beaver Creek	CannonballGrand	Heart River	Knife River	Lake Sakakawea	Little Missouri	Middle Missouri	Upper Missouri	James River	Goose River	Lower Red	Lower Sheyenne	Upper Sheyenne	Wild Rice	Devils Lake	Lower Souris	Upper Souris
WEATHER MODIFICATION CONTINUED																	
Coordinate all weather modification and climate research activities within North Dakota.		X				X	X	X			X	X	X			X	X
Determine the economic impact on the State's economy resulting from precipitation management operations.		X				X	X	X			X	X	X				X
ENERGY GOALS & OBJECTIVES																	
GOAL Manage water resources for optimal use in energy production while minimizing potential negative impacts.																	
OBJECTIVES:																	
Determine the need for and capacity of hydroelectric generation in North Dakota. Reserve sufficient water for future hydroelectric plants.	X	X	X				X		X			X	X	X	X	X	
Assess the potential for pumpback or off-stream hydropower development in North Dakota along the Missouri mainstem.					X		X										
Pursue controlled energy industry development on the Fort Berthold Reservation.					X												

PART TWO

THE SETTING

CHAPTER ONE

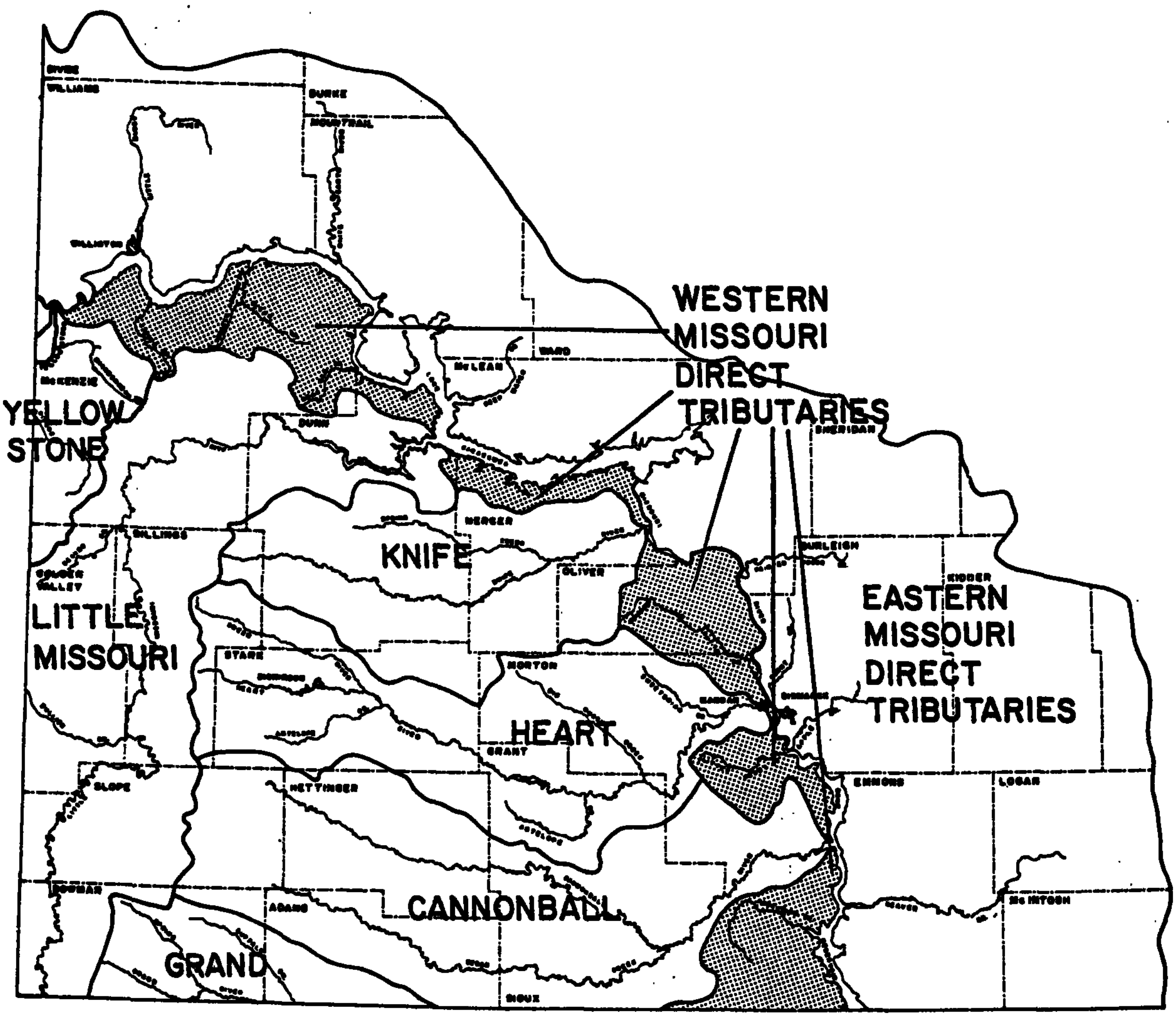
THE MISSOURI RIVER BASIN

PHYSICAL DESCRIPTION

Geography

The Missouri River Basin, largest in the State, drains 33,902 square miles in western and central North Dakota, or approximately 48 percent of the State's total area. The Basin is made up of seven subbasins and a rather extensive area north and east of the river which is normally noncontributing. Two major reservoirs, Lake Oahe and Lake Sakakawea, occupy major portions of the mainstem Missouri River in North Dakota. The seven subbasins included in the Missouri River Basin are those of the Grand, Cannonball, Heart, Knife, Little Missouri, and Yellowstone Rivers and the direct minor tributaries (Figure II-1-1).

FIGURE II-1-1 SUBBASIN DELINEATION - MISSOURI RIVER BASIN



Grand River Subbasin

Approximately 890 square miles of the Grand River Subbasin lie within the State. The North Fork of the Grand River rises near the North Dakota-South Dakota boundary in Bowman County and flows within 1 to 3 miles of the state line for more than 40 river miles before it leaves the State in the southwestern corner of Adams County. Channel length is 44 miles with an average drop of about 4 feet per mile. The Grand River subbasin lies entirely outside the glaciated region. Uplands consist largely of flat to gently rolling terrain in which the water courses have quite thoroughly dissected the plateau surface. The Grand River flows in a meandering course through a valley averaging 1.5 miles in width. Important tributaries located in North Dakota include South Fork, Spring, Lightning, Buffalo, and Hidden Wood Creeks.

Cannonball River Subbasin

The Cannonball River rises in the northeastern corner of Slope County near Amidon and flows in a southeasterly direction through Hettinger and Grant Counties to its confluence with Cedar Creek, its major tributary, on the Grant-Sioux County border. From this point the Cannonball River flows northeasterly, forming the north boundary of Sioux County, until it enters the Missouri River (Oahe Reservoir) at a point approximately 30 miles above the North Dakota-South Dakota state line. The total area drained by the Cannonball River is approximately 4,310 square miles. The Cannonball River meanders through an irregular valley 0.25 to 1.5 miles wide and about half as long as the river channel itself. Channel length is 204 miles with an average drop of 3.6 feet per mile. Important tributaries, in addition to Cedar Creek, include Thirty Mile Creek in Hettinger County, and Dog Tooth and Louse Creeks in Grant and Morton Counties.

Heart River Subbasin

The Heart River rises in Billings County near the northwestern corner of Stark County and follows an erratic course eastward to its confluence with the Missouri River near Mandan. The Subbasin is approximately 120 miles long, and has an average width of approximately 28 miles. The river gradient averages 3.6 feet per mile along its 190 miles of channel, as the river meanders side to side through a valley about 1.5 miles wide. The total area drained by the Heart River, all of which is in North Dakota, is approximately 3,340 square miles and includes most of Stark County and parts of Billings, Dunn, Hettinger, Grant, Morton, and Oliver Counties. Important north-side tributaries of the Heart River are Green River, Heart Butte Creek, Big Muddy Creek, and Sweetbriar Creek. Antelope Creek of Stark County and Antelope Creek of Grant County are important south-side tributaries.

Knife River Subbasin

The Knife River heads in the northeastern corner of Billings County and the southeastern corner of McKenzie County. From this area it flows eastward and slightly southward to the Dunn-Mercer County line, crossing it about 15 miles north of the southeastern corner of Dunn County. From here, the Knife turns and flows eastward and slightly northward to its confluence with the Missouri River at Stanton in Mercer County, about 65 miles above Bismarck. The total area of 2,507 square miles drained by the Knife River lies in North Dakota and includes major portions of Oliver, Billings, Morton, and Stark

Counties. A low divide on the west separates the Knife River Basin from the Little Missouri River drainage basin. The Knife River Basin is roughly oval in shape with the greater axis of about 88 miles lying approximately east and west. The greatest width, north and south, is about 40 miles. The river has one important tributary, Spring Creek, which drains about 660 square miles in the northern portion of the Subbasin. The Knife River Valley is 0.25 to 2 miles wide with a narrow stream channel which varies in depth from 20 to 35 feet. Channel length of the Knife River is 124 miles with an average drop of 2.8 feet per mile.

Little Missouri River Subbasin

Rising in northeastern Wyoming, the Little Missouri River flows in a northerly direction, draining portions of northwestern South Dakota, southeastern Montana, and southwestern North Dakota. It enters North Dakota in the extreme southwest corner of the State and meanders northward to a point in northwestern Dunn County where it turns eastward and discharges into the Little Missouri Bay of Lake Sakakawea. The average drop along the 220 miles of the Little Missouri channel in North Dakota is about 3.2 feet per mile. The Little Missouri drains about 4,750 square miles in North Dakota, including major parts of Slope, Golden Valley, and Billings Counties and lesser parts of Bowman, McKenzie, and Dunn Counties. Two major tributaries, Little Beaver Creek and Beaver Creek, originate in Montana and join the river in North Dakota.

A major portion of the area drained by the Little Missouri River in North Dakota is of the "Badlands" type. The headwaters of the tributary creeks rise in and flow through a largely prairie region, creating numerous, deep, steep-walled gullies or ravines in their rapid fall to the main stream. Except in the spring when most runoff occurs and during short periods immediately following violent storms during the summer months, most streams directly tributary to the mainstem of the Little Missouri are dry.

Yellowstone River Subbasin

The Yellowstone River originates in Wyoming and flows in a generally northeastward direction for 871 miles to its confluence with the Missouri River near Buford, North Dakota. Only 16 miles of river lie within the State. The average channel slope for these 16 miles is less than 1 foot per mile compared to a river average of 13.3 feet per channel mile. About 750 square miles are drained by the Yellowstone River in western McKenzie County and the northwestern corner of Golden Valley County. North Dakota tributaries to the Yellowstone River are Bennie Pierre Creek, Horse Creek, and Charbonneau Creek.

Direct Minor Missouri River Tributaries

The Yellowstone, Little Missouri, Knife, Heart, Cannonball, and Grand River Subbasins collectively drain about 16,550 square miles west of the Missouri River in North Dakota. The remaining drainage area has been divided into two distinctive areas for planning purposes: the Eastern Missouri Direct Tributaries Subbasin, and the Western Missouri Direct Tributaries Subbasin, a large portion of which is noncontributing.

Eastern Missouri Direct Tributaries

The Subbasin consists of the land area north and east of the Missouri River and drained by mainstem tributaries. The Subbasin's total area of about 14,550 square miles is made up of Burleigh and Emmons Counties; major portions of Williams, Mountrail, McLean, Sheridan, Kidder, Logan, and McIntosh Counties; and lesser portions of Stutsman, Wells, Ward, Burke, and Divide Counties. The northern portion of the Subbasin abuts the southern boundary of the Souris River Basin while the eastern boundary of the Subbasin adjoins the western border of the James River Basin. Approximately 5,000 square miles of the Subbasin are normally noncontributing. Under normal conditions, runoff does not reach the Missouri River; rather it is trapped in the many small lakes and potholes which are characteristic of the noncontributing portion of the Subbasin. Principal tributaries in the Eastern Missouri Direct Tributaries Subbasin include the following: Little Muddy River, Williams County; White Earth River, Mountrail, Williams, and Burke Counties; Little Knife River, Mountrail County; Deepwater Creek, Mountrail and McLean Counties; Painted Woods Creek, McLean and Burleigh Counties; Burnt and Apple Creeks, Burleigh County; and Beaver Creek, Emmons, Logan, and McIntosh Counties. A small area in North Dakota drains via Spring Creek to the Missouri River in South Dakota.

Western Missouri Direct Tributaries

The Subbasin includes approximately 2,800 square miles of land drained by Missouri River tributaries flowing directly into the mainstem of the River from the west. This area consists of four hydrologically separate but topographically similar sections (Figure II-1-1).

The first of these sections begins immediately downstream from the confluence of the Yellowstone and Missouri Rivers southwest of Williston in McKenzie County near the North Dakota-Montana border and ends at a point north of Stanton in eastern Mercer County near the confluence of the Knife and Missouri Rivers. The area is bounded on the north by Lake Sakakawea and on the south by the northern boundaries of the Yellowstone, Little Missouri, and Knife River Subbasins. Steep bluffs, 200 to 600 feet high, are common in the upper reaches of the Missouri River Valley. These bluffs are frequently dissected by numerous small streams and coulees and comprise the Missouri River "breaks". Principal tributaries from west to east in the area include Timber, Tobacco Garden, Clear, and Bear Den Creeks, all of which are located in northern McKenzie County.

A second section of the Western Missouri Mainstem Tributaries begins near Stanton, just south of the confluence of the Knife and Missouri Rivers in Mercer County and ends at a point southeast of Mandan in Morton County immediately above the Heart River's confluence with the Missouri River. Area topography is similar to that found in upstream reaches of the river except that bluffs overlooking the river are not as steep or as severely dissected by small stream valleys and coulees as those found in the western-most portion of the State.

A third section of the Missouri River Mainstem Tributaries is the drainage area of the Little Heart River, located south of Mandan in Morton County, and of several nearby smaller streams directly tributary to the Missouri. This area's topography is similar to the area described in the previous paragraph.

An extensive portion of Sioux County, drained by Battle Creek, Porcupine Creek, and Four Mile Creek, constitutes a fourth division of the Western Missouri Mainstem Tributaries. Oahe Reservoir serves as the eastern boundary of this area. It is bounded on the west and north by the southeastern boundary of the Cannonball River Subbasin. The entire area is a part of the Standing Rock Indian Reservation. Its topography is also similar to other direct tributary areas.

Geology

The bedrock exposed in the Missouri River Basin ranges from the Cretaceous Pierre Formation to the Tertiary White River Group (Figure I-2-9). The Pierre crops out in western Bowman County and along Beaver Creek and Lake Oahe in Emmons County. The White River Group caps some of the larger buttes in the western part of the Basin. The intervening Fox Hills to Golden Valley Formations crop out in a pattern typical of sedimentary basins, that is the older formations have a larger areal extent than the overlying younger ones. Within the intervening formations and in the Fort Union Group mostly, occur the lignite resources of North Dakota. Bedrock older than the Pierre underlies the entire Missouri River Basin and consists mostly of limestones, dolomites, and sandstones. These rocks comprise the oil and gas reservoirs of the Williston Basin in western North Dakota.

Unconsolidated sediments of Quaternary age are predominantly glacial drift and Recent alluvial deposits. Approximately the southwest third of the Missouri River Basin escaped glaciation during the Pleistocene Epoch. The unconsolidated sediments in this unglaciated part of the Basin are mainly alluvial deposits along stream valleys. The Missouri River divides the glaciated part of the Basin roughly in half. Although the unconsolidated sediments are mostly glacially derived, they are more prevalent on the northeastward side of the river. South and west of the Missouri River the glacial deposits typically are sparse consisting of scattered boulders and thin patches of till. Several systems of broadly anastomosing meltwater channels incised into the underlying bedrock are present in this part of the Basin. Glaciofluvial sediments interbedded with till in some areas fill these channels to depths ranging from less than 50 feet to more than 200 feet. The glaciofluvial sediments are mostly sand, but also present are beds and lenses of gravel. The area of the Basin north and east of the Missouri River is dominated by the Missouri Coteau. The Coteau is an amalgamation of terminal and dead-ice moraine sufficiently thick to mask the preglacial topography in most of the area. The influence of preglacial topography is evident, however, in a band of mostly ground moraine parallel to the Missouri River. Glaciofluvial sands and gravels, together with lesser amounts of silts and clays, fill both buried and surficial meltwater channels that once carried glacial meltwater away from the ice sheets. Present in the subsurface are the buried valleys of the preglacial and possibly interglacial drainage system. These valleys are commonly filled with thick deposits of sands and gravels intercalated with till or lacustrine deposits. Two noteable examples of this type of valley are the courses of the ancestral Yellowstone and Missouri Rivers in Divide and Williams Counties.

SOCIO-ECONOMIC CHARACTERISTICS

The Missouri River Statistical Planning Area (SPA) contains the fourteen counties west of the Missouri River plus Burleigh, Emmons, Kidder, Logan, McIntosh, McLean, Mountrail, Sheridan, and Williams Counties on the east. The Missouri River SPA is 32,581 square miles with a 1980 population estimate of 215,132 or about 33 percent of North Dakota's population (Table II-1-1).

TABLE II-1-1 POPULATION ESTIMATES OF MISSOURI RIVER STATISTICAL PLANNING AREA

County	1960[1/]	1970[2/]	1980[3/]	%Change 1960-1970	% Change 1970-1980
Adams	4,449	3,832	3,584	-13.9	- 6.5
Billings	1,513	1,198	1,138	-20.8	- 5.0
Bowman	4,154	3,901	4,229	- 6.1	+ 8.4
Burleigh	34,016	40,714	54,811	+19.7	+34.6
Dunn	6,350	4,895	4,627	-22.9	- 5.5
Emmons	8,462	7,200	5,877	-14.9	-18.4
Golden Valley	3,100	2,611	2,391	-15.8	- 8.4
Grant	6,248	5,009	4,274	-19.8	-14.5
Hettinger	6,317	5,075	4,275	-19.7	-15.8
Kidder	5,386	4,362	3,833	-19.0	-12.1
Logan	5,369	4,245	3,493	-20.9	-17.7
McIntosh	6,702	5,545	4,800	-17.3	-13.4
McKenzie	7,296	6,127	7,132	-16.0	+16.4
McLean	14,030	11,251	12,383	-19.8	+10.1
Mercer	6,805	6,175	9,404	- 9.3	+52.3
Morton	20,992	20,310	25,177	- 3.2	+24.0
Mountrail	10,077	8,437	7,679	-16.3	- 9.0
Oliver	2,610	2,322	2,495	-11.0	+ 7.5
Sheridan	4,350	3,232	2,819	-25.7	-12.8
Sioux	3,662	3,632	3,620	- 0.8	- 0.3
Slope	1,893	1,484	1,157	-21.6	-22.0
Stark	18,451	19,613	23,697	+ 6.3	+20.8
Williams	22,051	19,301	22,237	-12.5	+15.2
Missouri River SPA	204,283	190,471	215,132	- 6.8	+12.9
North Dakota	632,446	617,761	652,437	- 2.3	+ 5.6
Percent of State	32.3	30.8	33.0	N/A	N/A

1/U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1960.
2/U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1970.
3/U.S. Bureau of the Census, Preliminary Population and Housing Unit Counts, PHC80-P-36, November, 1980.

Bismarck, the largest city in the region, with a 1980 population estimate of 44,502 and Mandan, with 15,496 inhabitants, combine to form the largest urban area in the region. This urban area accounts for almost 28 percent of the total population of the Missouri River SPA. Other major cities in the SPA and their 1980 population estimates are: Dickinson, 15,893; Williston, 13,354; Beulah, 2,878; Hazen, 2,376; Watford City, 2,114; Washburn, 1,766; Hettinger, 1,738; and Tioga, 1,595. These cities combine to form another 41,714 inhabitants, or about 19 percent of the total Missouri River SPA population.

The urban population has increased due mainly to the increase in the mining of fossil fuels. There has been a steady decline in the rural population attributable to increased mechanization of farms and increased farm size. The rural population of the Missouri River SPA has dropped by 22,446 persons, from 144,305 in 1960, to 121,859 in 1980 (Table II-1-2).

TABLE II-1-2 RURAL AND URBAN POPULATION
FOR MISSOURI RIVER STATISTICAL PLANNING AREA [1/]

	1960		1970		1980	
	Number	Percent	Number	Percent	Number	Percent
Urban[2/]	59,978	29.4	69,481	36.5	93,273	43.4
Rural	144,305	70.6	120,990	63.5	121,859	56.6
Farm[3/]	73,079	35.8	54,781	28.8	NA	NA
Nonfarm[4/]	71,226	34.9	65,836	34.6	NA	NA
Total Population	204,283	100.0	190,471	100.0	215,132	100.0

[1/]Source: U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1960 and 1970; Part 36, PC 80-1-A36, 1980.

[2/]Urban inhabitants are persons living in all incorporated places and unincorporated places of 2,500 persons or more.

[3/]Farm inhabitants are persons defined as actively farming 10 or more acres with sales of $50 or more per year and farms of less than 10 acres with sales of $250 or more per year.

[4/]Nonfarm inhabitants are rural residents not actively farming.

In 1929, the population of the area totaled about 229,000. The population then began a decline to a low of about 190,000 in 1970, when it again began increasing, reaching the present population of about 215,000. This decline is attributable to a high outmigration preceding 1970. The increase is due to the high inmigration associated with increased business activity, development of the SPA's fossil fuel reserves, and a high birth-to-death ratio. The area has a 1980 population density of 6.6 persons per square mile compared to 8.7 persons per square mile for the whole State.

Employment Characteristics

Employment in the Missouri River SPA increased from 81,096 in 1970 to 111,856 in 1980, 33.2 percent of the State total. The farm sector of the economy has almost twice as many individual proprietors as the non-farm sector, but has a very small portion of the total wage and salary employment. The reason for this is that most of the farms and ranches are owned and managed by the operator and his family with very little outside employment; whereas non-farm proprietors hire most of the labor force in the area.

Total employment and number of persons employed in each sector is shown in Table II-1-3.

TABLE II-1-3 EMPLOYMENT BY TYPE AND BROAD INDUSTRIAL SOURCES
FULL AND PART-TIME WAGE AND SALARY EMPLOYMENT PLUS NUMBER
OF PROPRIETORS FOR THE MISSOURI RIVER STATISTICAL PLANNING AREA

	1970	1975	1976	1977	1978	1979	1980
TOTAL EMPLOYMENT	81,096	90,283	93,366	96,738	104,062	108,423	111,856
Number of Proprietors	27,084	23,842	23,717	23,890	24,621	25,118	25,385
Farm Proprietors	18,482	17,117	16,929	16,743	16,813	16,797	16,378
Non-Farm Proprietors	8,602	6,725	6,788	7,147	7,808	8,321	9,007
Wage and Salary Employment	54,012	66,441	69,649	72,848	79,431	83,303	86,471
Farm	2,744	2,206	2,453	2,058	2,254	2,282	2,301
Non-Farm	51,268	64,235	67,196	70,790	77,177	81,021	84,170
Private Non-Farm	35,183	44,112	47,616	51,291	57,719	63,038	67,142
Mining	775	1,457	1,746	2,100	2,418	4,254	7,448
Construction	2,378	4,573	5,205	6,043	7,792	8,141	7,922
Manufacturing	2,488	3,454	3,504	3,566	3,791	4,021	3,695
Trans., Comm., and Pub. Util.	3,450	3,633	3,964	4,097	4,444	4,911	5,976
Wholesale and Retail Trade	12,618	15,079	16,279	17,395	17,287	19,034	20,294
Finance, Ins. and Real Estate	1,432	2,028	2,187	2,415	2,611	2,874	3,126
Services	9,880	13,043	13,738	14,451	15,742	16,846	17,489
Other	82	239	227	234	319	311	184
Government	16,085	20,115	19,565	19,492	19,458	18,083	17,028
Federal Civilian	2,558	2,651	2,605	2,683	2,586	2,467	2,622
Federal Military	101	1,474	1,356	1,275	1,411	1,612	1,370
State and Local	13,426	15,990	15,604	15,534	15,454	13,987	13,020

Source: U.S. Department of Commerce, Bureau of the Census, Regional Economics Information System, April 1982.

Burleigh County has the highest employment in the SPA by virtue of its county seat of Bismarck being the trade center for a large area of central North Dakota.

Annual unemployment for the area has typically been between four and six percent (Table II-1-4).

TABLE II-1-4 AVERAGE ANNUAL UNEMPLOYMENT RATE
COUNTIES OF MISSOURI RIVER STATISTICAL PLANNING AREA

County	1972	1973	1974	1975	Percent 1976	1977	1978	1979	1980
Adams	2.8	2.7	2.9	3.9	2.4	2.2	2.0	1.7	2.1
Billings	4.2	4.6	4.4	7.3	5.9	7.7	4.5	3.5	2.3
Bowman	4.1	3.7	4.4	3.2	2.6	3.1	2.4	2.3	2.3
Burleigh	5.1	5.3	4.9	5.1	5.0	5.2	4.0	3.8	5.2
Dunn	8.5	8.5	6.4	9.5	8.6	7.8	5.6	5.5	5.2
Emmons	7.6	7.6	6.6	9.8	8.1	8.0	5.9	5.1	6.8
Golden Valley	2.5	3.4	3.0	4.7	3.7	4.0	3.4	3.7	3.1
Grant	6.6	7.0	5.8	5.9	6.3	5.7	5.1	4.2	5.0
Hettinger	5.7	5.9	5.4	5.0	5.0	4.1	4.1	3.7	3.3
Kidder	7.6	8.9	6.1	6.9	8.2	9.4	8.2	5.6	7.9
Logan	7.5	7.0	6.5	6.9	6.6	5.8	4.9	4.4	5.0
McIntosh	5.1	5.5	3.9	6.2	6.2	4.6	3.3	3.7	4.3
McKenzie	4.1	3.6	3.1	4.1	4.8	4.7	3.4	3.1	3.1
McLean	8.7	9.1	7.5	6.9	7.7	7.2	5.2	4.8	6.4
Mercer	6.1	5.8	4.5	5.6	5.5	5.5	3.6	4.5	5.6
Morton	8.4	8.5	7.5	7.1	6.8	6.9	5.5	5.0	8.0
Mountrail	7.2	7.1	6.5	5.7	6.1	6.6	5.0	4.9	4.1
Oliver	8.6	10.3	6.1	5.6	5.3	4.0	4.1	5.1	7.5
Sheridan	5.4	5.5	4.5	6.4	6.3	7.2	7.3	4.9	5.8
Sioux	7.9	8.7	6.9	8.5	7.2	7.6	7.5	8.3	10.4
Slope	4.5	4.8	4.5	5.5	6.0	5.7	5.3	3.7	3.1
Stark	5.1	5.4	4.9	4.7	4.7	5.5	4.2	4.2	4.3
Williams	4.8	5.4	4.6	4.6	4.2	4.5	2.8	2.5	2.4
Missouri River SPA	6.0	6.3	5.3	6.0	5.8	5.8	4.7	4.3	4.9
North Dakota	4.9	5.1	4.6	5.2	5.1	5.5	4.3	4.2	5.0
United States	5.6	4.9	5.6	8.5	7.7	7.0	6.0	5.8	7.1

Source: North Dakota Employment Security Bureau, Unadjusted Annual Averages.

Income Characteristics

Total labor and proprietors income for the Missouri River SPA increased from $409 million in 1970 to $1,463 million in 1980. With few exceptions, each sector's income increased steadily from 1970 to 1980. The agricultural sector is one of those exceptions. Farm income fluctuated substantially from year to year, with highs and lows being directly correlated to the price movements of agricultural commodities (table II-1-5).

TABLE II-1-5 PERSONAL INCOME BY MAJOR SOURCES
FOR THE MISSOURI RIVER STATISTICAL PLANNING AREA

	1970	1975	1976	1977	1978	1979	1980
Total Labor and Proprietors Income (1000's)	408,927	781,890	796,752	835,806	1,152,062	1,279,130	1,463,087
Per Capita Personal Income	2,863	5,401	5,547	5,714	7,258	7,974	9,272
Labor Income by Industry (1000's)							
Farm	88,733	211,380	152,183	83,356	241,139	171,736	166,999
Manufacturing	19,436	37,706	42,556	46,984	53,387	61,840	65,284
Mining	7,814	24,411	30,717	42,973	54,191	104,475	144,963
Contract Construction	23,823	66,592	76,809	103,485	152,671	163,533	175,530
Wholesale & Retail Trade	79,126	131,749	154,310	163,130	168,841	203,981	244,638
Finance Insurance & Real Estate	12,048	22,311	25,580	34,511	40,629	47,159	60,853
Transportation, Comm., and Pub. Util.	30,603	54,986	61,715	68,224	80,759	109,282	143,260
Services	52,781	94,952	107,985	128,251	145,198	175,260	206,812
Other	120	2,180	2,092	2,888	3,832	4,438	3,518
Federal Civilian	21,390	42,014	36,385	38,920	41,964	42,117	45,400
Federal Military	3,960	3,916	3,990	4,288	4,583	5,208	4,401
State and Local	55,031	83,812	94,031	105,780	117,633	146,137	149,111

Source: U.S. Department of Commerce, Bureau of the Census, Regional Economics Information System, April 1982.

Farm income in the Missouri River SPA and for the State of North Dakota varies greatly from year to year. The major cause is commodity price instability, but weather, government farm programs, and other factors also contribute.

The percent of families in specified income brackets in the Missouri River SPA for 1969 are: 14.0 percent earned less than $3,000; 14.6 percent earned $3,000 or more but less than $5,000; 16.4 percent earned $5,000 but less than $7,000; and 55.1 percent earned $7,000 or more. By using the same specified income brackets, the percentages for North Dakota are: 12.1, 14.3, 16.9, and 56.7, respectively.

ECONOMIC BASE

Description of Study Area

One way to gain a perspective of the economic activity in the Missouri River SPA is to trace each sector's contribution to the area's total economy. It is normal for a sector's contribution to the area's economy to fluctuate significantly in respect to the other sectors. However, the major contributors remain the same; only their ranking varies with time and various stimuli (Table II-1-6).

TABLE II-1-6 PERCENT OF TOTAL EARNINGS BY SECTOR FOR THE MISSOURI RIVER STATISTICAL PLANNING AREA[1]

Sector	Percent of Total Earnings[2]						
	1970	1975	1976	1977	1978	1979	1980
Farm	21.7	27.0	19.1	10.0	20.9	13.4	11.4
Manufacturing	4.8	4.8	5.3	5.6	4.6	4.8	4.5
Mining	1.9	3.1	3.9	5.1	4.7	8.2	9.9
Construction	5.8	8.5	9.6	12.4	13.3	12.8	12.0
Wholesale and Retail Trade	19.3	16.9	19.4	19.5	14.7	15.9	16.7
Finance, Ins. and Real Estate	2.9	2.9	3.2	4.1	3.5	3.7	4.2
Transportation, Comm., and Pub. Util.	7.5	7.0	7.7	8.1	7.0	8.5	9.8
Services	12.9	12.1	13.6	15.3	12.6	13.7	14.1
Other	0.0	0.3	0.3	0.3	0.3	0.3	0.3
Federal, Civilian	5.2	5.4	4.6	4.7	3.6	3.3	3.1
Federal, Military	1.0	0.5	0.5	0.5	0.4	0.4	0.3
State and Local	13.5	10.7	11.8	12.7	10.2	11.4	10.2

[1]Computed from Regional Economics Information System data compiled in table II-1-5.
[2]Total percentages will not add to 100 because of non-disclosure policies of U.S. Department of Commerce.

Agriculture

The Missouri River SPA, like the rest of North Dakota, is highly dependent on agriculture for its livelihood. The health of North Dakota's economy is directly related to the farm economy situation.

Farms have gradually increased in size and become fewer in number.

In 1970, approximately 46 percent of the total land area was under cultivation.

The value of crop products sold has typically been 50 to 60 percent of the total value of agricultural products sold. Livestock, poultry, and their products account for most of the remainder (Table II-1-7).

Table II-1-8 shows historical acreages of major crops harvested, table II-1-9 the production of those crops, and table II-1-10 the livestock inventory for various years in the SPA.

TABLE II-1-7 FARM SIZE AND VALUE OF PRODUCTION FOR MISSOURI RIVER STATISTICAL PLANNING AREA[1]

	1949	1954	1959	1964	1969	1974	1978[2]
Number of Farms	22,773.0	21,341.0	19,290.0	17,370.0	17,027.0	15,960.0	15,137.0
Land in Farms (000's)	18,942.3	19,364.2	19,255.1	20,383.5	20,396.0	19,739.7	19,232.2
Average Farm Size (Acres/Farm)	831.8	907.4	998.2	1,173.5	1,197.9	1,236.8	1,270.5
Total Value of Ag. Products Sold ($1,000)	120,602.4	109,690.8	138,430.1	172,876.4	245,731.0	534,112.0	524,540.0
Value of Crops Sold ($1,000)	64,074.9	62,467.5	51,162.9	90,390.6	115,253.0	322,723.0	262,680.0
Percent of Total	53.1	56.9	37.0	52.3	46.9	60.4	50.1
Value of Livestock, Poultry & Their Products Sold ($1,000)	55,913.7	47,202.7	87,053.7	82,253.9	130,467.0	185,386.0	246,652.0
Percent of Total[3]	46.4	43.0	62.8	47.6	53.1	34.7	47.0

[1] Source of data is U.S. Census of Agriculture for years 1949 through 1978.
[2] Preliminary data.
[3] Due to nondisclosure policies of Bureau of Economic Analysis, some data in some counties for categories (sectors, crop, etc.) labled "D" were suppressed; consequently the actual percentage for these sectors may be understated.

TABLE II-1-8 HISTORICAL ACRES OF MAJOR CROPS HARVESTED MISSOURI RIVER STATISTICAL PLANNING AREA[1]

Crop	Unit	1949	1954	1959	1964	1969	1974	1978[2]
Wheat	Ac.	3,933,888	3,055,885	2,552,853	2,453,773	2,500,813	3,315,510	3,383,724
Oats	Ac.	416,934	649,403	441,767	832,518	809,775	597,615	553,676
Barley	Ac.	234,681	491,899	701,352	477,896	296,090	220,181	220,331
Rye	Ac.	75,881	90,080	54,940	139,588	57,314	24,431	25,576
Sunflower[3]	Ac.	---	---	---	---	---	2,500	134,400
Flax[4]	Ac.	447,710	1,119,994	515,294	389,409	426,500	269,600	139,100
Corn Grain	Ac.	98,001	109,300	11,248	14,594	12,533	12,910	31,946
Corn Silage	Ac.	44,480	213,558	402,524	320,822	169,005	155,659	153,516
Hay	Ac.	1,611,741	1,602,866	1,980,488	1,689,103	1,461,611	1,923,265	1,728,492
Soybeans	Ac.	30	360	15	22	682	118	205
Potatoes	Ac.	4,779	3,199	1,504	1,045	1,626	727	669

[1] Source of data is U.S. Census of Agriculture for years 1949 through 1978.
[2] Preliminary data.
[3] Sunflower data are from North Dakota Crop and Livestock Statistics.
[4] Flax data for 1969, 1974, and 1978 were obtained from North Dakota Crop and Livestock Statistics.

TABLE II-1-9 HISTORICAL PRODUCTION OF MAJOR CROPS HARVESTED MISSOURI RIVER STATISTICAL PLANNING AREA[1]

Crop	Unit	1949	1954	1959	1964	1969	1974	1978[2]
Wheat	Bu.	33,415,572	23,397,607	25,209,267	47,045,263	63,724,084	59,659,077	85,450,011
Oats	Bu.	7,170,140	12,377,575	6,743,332	25,829,881	41,871,268	16,289,053	26,720,101
Barley	Bu.	2,657,880	7,593,113	7,987,515	13,789,015	11,081,526	5,087,515	8,411,932
Rye	Bu.	579,451	1,228,476	3,618,735	2,511,080	1,050,362	517,280	689,961
Sunflower[3]	(000 lbs)	---	---	---	---	---	---	154,872
Flax[4]	Bu.	2,427,049	5,687,859	1,618,027	2,810,163	4,868,000	1,784,300	1,465,400
Corn Grain	Bu.	1,773,362	1,959,678	15,276	276,873	412,756	473,672	1,511,208
Corn Silage	Tons	676,940	676,397	683,328	983,445	783,295	720,075	943,885
Hay	Tons	1,210,700	1,587,432	1,150,427	1,868,505	1,901,916	2,293,246	2,809,254
Soybeans	Bu.	145	2,612	60	140	11,538	540	D[5]
Potatoes	Cwt.	321,251	263,240	72,202	96,043	148,894	92,292	71,516

[1]Source is U.S. Census of Agriculture for years 1949 through 1978.
[2]Preliminary data.
[3]All sunflower data are from North Dakota Crop and Livestock Statistics.
[4]Flax data for 1969, 1974, and 1978 were obtained from North Dakota Crop and Livestock Statistics.
[5]Data withheld to avoid disclosing information for individuals.

TABLE II-1-10 NUMBER OF HEAD OF LIVESTOCK MISSOURI RIVER STATISTICAL PLANNING AREA

Livestock	1949	1954	1959	1964	1969	1974	1978[1]
All Cattle and Calves	779,752	1,046,992	952,850	1,289,779	1,142,733	1,354,015	1,095,329
Milk Cows	152,436	143,362	114,006	107,521	72,871	73,058	59,403
All Sheep and Lambs	114,091	209,952	285,846	240,109	200,336	140,572	101,717
All Hogs and Pigs	128,020	201,151	168,347	112,602	98,898	125,401	114,281
Horses and Ponies	68,117	44,891	31,496	N/A	20,412	14,018	15,989
Chickens 4 mo. and Older	1,063,773	1,411,867	1,029,362	701,094	336,439	232,923	141,260

[1]Preliminary data.

Source: U.S. Census of Agriculture for years 1949 through 1978.

Wholesale and Retail Trade

This sector is also a major contributor to the economy of the Missouri River SPA due to the presence of several trade centers; Bismarck, Mandan, Dickinson, and Williston. The percent of total earnings for the wholesale and retail trade sectors is typically 15 to 20 percent.

Services

The services sector is comprised of various enterprises such as hospitals, hotels, and recreation facilities. Demand for these and other types of services has grown largely because of the increases in new construction and energy development.

Mining

Employment in the mining sector increased 861 percent from 775 in 1970 to 7,448 in 1980. Most of the increase came about because of activity in coal mining, oil exploration, and sand and gravel mining for construction (Table II-1-3). Almost all of the State's fossil fuel production occurs in the SPA. About 16 million tons of lignite and over 22 million barrels of oil were produced in 1980.

Construction

The Missouri River SPA has experienced a rapid increase in building as a result of most of the factors which caused the increases in the services and mining sectors. Schools, hospitals, housing, water and sewage treatment facilities, and roadways are examples of the types of construction being done in the SPA.

NATURE AND OCCURRENCE OF WATER AND LAND RESOURCES

Surface Water

The Missouri River Basin is the largest in the State encompassing about 33,902 square miles. The Basin's drainage system includes the mainstem Missouri River and five major tributaries: the Yellowstone, Little Missouri, Knife, Heart, and Cannonball Rivers. Part of the headwaters of the Grand River lie within the Basin. Smaller tributaries drain the area adjacent to the Missouri River. Those tributaries on the south and west sides of the Missouri typically occupy small but sharply incised valleys. The small tributaries on the other side of the river are generally underfit streams, occurring in larger valleys that are glacial meltwater channels.

Streamflow within the Missouri River Basin is from two main sources: runoff and stream inflow. Runoff in the Basin is seasonally quite variable. Spring is the time of greatest runoff while summer and winter probably the periods of least runoff. However, summer thunderstorms cause dramatic variations in localized runoff within a watershed. Median annual runoff in the Basin ranges from less than 0.50 inches to more than 1.00 inches. Stream inflow occurs in three rivers entering the Basin from headwaters in Montana and Wyoming. These rivers are the Missouri, Yellowstone, and Little Missouri. The inflow is maintained mostly by the runoff of snow meltwater and ground-water inflow in the Missouri and Yellowstone. Flow on the mainstem Missouri within the Basin is controlled by Garrison Dam. The Missouri River flow typically reaches two peaks annually. The first occurs in early to mid-spring and is from the snowmelt within the Basin and from the plains of Montana and Wyoming. The second peak usually arrives in late spring to early summer and is the culmination of snowmelt runoff from the mountains. Streamflow of the tributaries arising in the Basin typically peaks once annually due to the runoff of snow meltwater. A network of 86 stream-gaging and stage-measuring stations monitor streamflow within the Missouri River Basin. A summary of streamflow records is presented in Table II-1-11.

TABLE II-1-11 SUMMARY STREAMFLOW RECORDS
MISSOURI RIVER BASIN

River	Measuring Location	Discharge (cfs)			Annual Average Discharge (AF)
		Average	Maximum	Minimum	
Missouri	Bismarck 1/	22,640	68,900	4,000	16,390,602
Yellowstone	Sidney, MT	13,100	159,000	470	9,483,961
Lit. Missouri	Watford City	600	110,000	0	434,380
Knife	Hazen	178	35,300	0	128,866
Heart	Mandan	258	30,500	0	186,783
Cannonball	Breien	249	94,800	0	180,268
Grand	Haley	28	14,100	0	20,271

1/ Records for post-completion of Garrison Dam

Storage of surface water within the Missouri River Basin is currently provided by 167 dams. Total normal storage capacity is about 18.66 million AF with a range from less than 25 AF to 18.4 million AF for Garrison Dam. Maximum storage capacity totals about 25.41 million AF with a range from 30 AF to 24.20 million AF for Garrison Dam.

The quality of surface water may fluctuate considerably in response to various factors including quantity of streamflow, time of year, climate, the type of geologic material over which the water is flowing, and land- and water-management practices. In general periods of low streamflow are characterized by poorer water quality than periods of high streamflow. This is because dilution is low due to the small volume of water at low flow and residence time of water within a given segment of stream channel is longer allowing for greater quantities of materials to enter the stream. Also influent ground water providing baseflow adds to the solution load of the stream. High streamflow may be characterized by greater turbidity because the sediment carrying capacity of the stream is greater.

Except for the mainstem Missouri River, the surface water of the Missouri River Basin is either a sodium sulfate or sodium bicarbonate type. The mainstem Missouri is a calcium-magnesium sulfate type. Dissolved solids concentrations of the Missouri fall in the 300-600 mg/l range and remain fairly constant. The same is not true for the tributaries to the Missouri. The dissolved solids concentrations for the Little Missouri River averages 300-600 mg/l, but the range is from about 200 mg/l during high flows to greater than 2,000 mg/l during low flows. Dissoloved solids concentrations fall within about the same range for the Knife, Heart, and Cannonball Rivers, although the Little Missouri carries greater quantities of sediment. Irrigation indices for the Missouri and Yellowstone Rivers are generally lower than those of the Knife, Heart, and Cannonball Rivers and other tributaries in the basin.

The importance of North Dakota's wetlands as wildlife habitat has been established. Of a more controversial nature is the manner in which these wetlands function in the State's surface-water and ground-water resources, that is their relationships in surface-water hydrology and quality and the interaction between surface water and ground water.

Within the Missouri River SPA, wetlands are most prevalent north and east of the Missouri River. The 1964 Wetlands Inventory indicated a total of 123,136 wetlands covering 540,393 acres in the Missouri River SPA (Table II-1-12) or about 2.6 percent of the SPA area. The results of the 1964 Inventory are considered to be conservative. A new wetlands inventory by the U.S. Fish and Wildlife Service is in progress and is based on a detailed classification hierarchy different from that used for the 1964 Inventory.

TABLE II-1-12 1964 WETLAND INVENTORY FOR THE MISSOURI RIVER STATISTICAL PLANNING AREA

Wetland Type		Total Number	Total Acres
I		46,176 1/	70,485 2/
III		61,244	133,829
IV		11,850	151,806
V		3,513	156,862
X 3/		100	3,400
XI 3/		253	24,011
	TOTAL	123,136	540,393

1/Type I wetland numbers were estimated at 60 percent of the total wetland numbers.

2/Type I wetland acres were estimated at 15 percent of the total wetland acres.

3/Some Types X and XI may have been classified as Types IV and V.

Note: The following counties were not included in the 1964 Inventory because few natural wetlands occur in them: Adams, Billings, Bowman, Golden Valley, Grant, Hettinger, McKenzie, Morton, Oliver, Slope, and Stark.

Source: U.S. Fish and Wildlife Service 1964 Inventory of Wetlands

Water quality of wetlands can be quite variable both in time and area. The variability is influenced by the combination of many factors such as climate, time, watershed characteristics, surface-water hydrology, and ground-water interaction.

Ground Water

Ground water within the Missouri River Basin occurs in bedrock aquifers and aquifers within glacial drift and alluvial deposits. Bedrock aquifers are found throughout the entire thickness of sedimentary rock preserved in the Williston Basin, from the Deadwood Formation of Cambrian Age to the Tertiary White River Group (Figure I-2-9). Although ground water from aquifers underlying the Cretaceous Fox Hills Formation is used in the oil industry, this water generally is too deep and the quality too poor to be of practical consideration for most other uses. These deeper aquifers, which underlie the whole basin, are mostly carbonate rocks with fine-grained clastic rocks less frequent overall. The bedrock aquifers that supply wells in the basin occur within the Fox Hills and Hell Creek Formations, the Fort Union Group, the Golden Valley Formation, and the White River Group.

The Fox Hills and Hell Creek aquifers are predominantly beds of fine-grained sandstone. The sandstone is interbedded with shale, siltstone, and some lignite in the Hell Creek Formation. The sandstone beds commonly are thin and lenticular, and are not areally extensive. At least one sandstone bed, but typically more than one bed, are present at all locations. Thickness of the sandstone beds varies from less than 10 feet to about 100 feet. The sandstone frequently contains much interstitial silt and clay. The sandstone beds of the Fox Hills Formation are hydrologically connected to those of the overlying Hell Creek Formation in most of the basin, so these formations are generally considered one aquifer. Wells tapping the Fox Hills-Hell Creek aquifer typically yield 10-30 gallons per minute, but may exceed 100 gallons per minute locally where the sandstone beds are thickest or contain little interstitial silt and clay. Wells will flow in low areas at rates usually of less than 50 gallons per minute. Ground water flows west to east with discharge occurring into overlying aquifers at the subcrop band in central North Dakota or by wells. The Fox Hills and Hell Creek aquifers underlie the entire Basin except for a small area in western Bowman County and Logan, eastern Kidder, and McIntosh Counties where erosion has removed it. Depth to these aquifers increases from the outcrop areas at land surface in the southeast and southwest corners of the Basin to more than 1,000 feet in Dunn and McKenzie Counties. Ground water in the Fox Hills - Hell Creek aquifer is generally a sodium-bicarbonate type with sodium accounting for over 90% of the cations and bicarbonate about 75% of the anions. The water typically is soft and has a high sodium adsorption ratio. Dissolved solids concentrations typically average 1,000-2,000 mg/l, but can vary between 300 to 3,700 mg/l. Recommended limits for iron and fluoride are commonly exceeded.

The Fort Union Group has undergone more erosion than the underlying Fox Hills and Hell Creek Formations. Also the younger formations within the Fort Union Group have experienced more erosion than the older ones. The result is that the Fort Union Group underlies a smaller portion of the Basin than the underlying Fox Hills and Hell Creek Formations, and younger formations within the Group underlie less area of the Basin than do the older formations. The

Ludlow, Cannonball, and Slope Formations crop out in the southern tier of counties in the Basin and reach their maximum depth in Dunn County. The overlying Bullion Creek and Sentinel Butte Formations are near land surface, but the Sentinel Butte has been eroded much more than the underlying Bullion Creek Formation. The aquifers of the Fort Union Group are predominantly beds of fine-grained sandstone separated by siltstone, claystone, and lignite. Where the lignite is fractured it too forms an aquifer. The beds of sandstone and lignite are commonly lenticular and of limited areal extent. Thickness of the sandstone beds commonly is less than 10 feet, but some are known to be over 150 feet thick. The sandstone commonly contains much interstitial silt and clay. The lignite beds are generally 2-5 feet thick, but some beds are 40 feet thick. Yields of wells developed in the sandstone beds generally are about 10 gallons per minute, but yields approaching 100 gallons per minute are possible where the aquifer is thick and little interstitial silt and clay is present. Aquifers of fractured lignite typically yield less than 5 gallons per minute to wells. Most wells tapping aquifers in the Fort Union Group are used for rural domestic and livestock supplies, although some are used for municipal and industrial supplies. Recharge to the Fort Union Group aquifers is through infiltration of precipitation and surface water and possibly some inflow from underlying aquifers. Ground water flows generally west to east within the Fort Union Group and discharges through wells and streams. Ground water in the Fort Union aquifers is typically high in sodium with this ion accounting for 50-80% of the cations. The common anions are bicarbonate, sulfate, and chloride with the chloride concentrations greatest in the deeper aquifers. Dissolved solids concentrations average 1,000-2,500 mg/l for deeper wells and are typically less than 3,000 mg/l for shallower wells. Irrigation indices are high making the water unsuitable for irrigation. Hydrocarbon compounds from the lignite beds produce varying shades of yellow and brown in the water from the lignite aquifers.

The Golden Valley Formation and White River Group occur as erosional remnants and buttes in Dunn, McKenzie, Stark, Hettinger, and Slope Counties. These formations consist of interbedded sandstone, siltstone, claystone, and some lignite. Where these formations are extensive enough to become saturated, the sandstone beds form aquifers capable of only small yields to domestic and stock wells on a sustained basis. The water is typically a sodium sulfate or sodium bicarbonate type with less dissolved solids present than in the underlying bedrock aquifers.

The glacial-drift aquifers are most prevalent north and east of the Missouri River in the area extensively modified by glaciation and where outwash sands and gravels are preserved (Plate I-2-1). The aquifers occur in glacial meltwater channels and diversion channels, as broad surficial outwash and buried outwash deposits, and in buried valleys eroded into bedrock or till. Some of these aquifers extend into adjacent hydrologic basins, particularly those aquifers found in buried valleys. Two examples are the aquifers in the valleys of the ancestral Missouri and Yellowston Rivers in Divide and Williams Counties. On the south and west side of the Missouri River the glacial-drift aquifers are considerably fewer occupying a series of glacial meltwater channels or glacial diversion channels (Plate I-2-1). The glacial-drift aquifers in the Basin consist chiefly of sand and gravel deposits which frequently are interbedded with lenses of silt and clay or layers of till. Thickness of these aquifers ranges from a few feet to several hundred feet and well yields vary accordingly. Well yields can exceed 500 gallons-per-minute and even 1,000 gallons-per-minute on a sustained basis where the aquifer is thickest and most permeable. Quality of the ground water in the glacial-drift aquifers is quite variable and is related to location and depth of the aquifer and the amount of recharge from precipitation or underlying bedrock aquifers. Sodium is present but not at concentrations associated with bedrock aquifers. Calcium and magnesium are also common cations. Bicarbonate and sulfate are the chief anions. The deeper water usually has higher levels of dissolved solids. Irrigation indices range from low to high making the water good to marginal for irrigation. Many irrigation wells tap the glacial-drift aquifers as do domestic, stock, and industrial wells. Intensive study of the geology, depositional history, and hydrology of these aquifers is necessary to achieve optimum development.

The alluvial aquifers are found in the sediments within the present drainage system. Most of these deposits are thin; consequently well yields are small. The Missouri River valley is a combination of glacial meltwater and diversion channels and recent river valley. The valley contains aquifers that are locally more than 100 feet thick. Well yields of more than 500 gallons-per-minute are possible in these area.

Land Resources

The counties comprising the Missouri River Statistical Planning Area (SPA) are mostly prairie of the short-grass type resulting from lesser rainfall amounts then the rest of North Dakota. Glacial influence is least in this area because only the eastern and northern fringes were subjected to the last glacial ice cover. Soil development is predominately dark colored from the original grassland cover. Well defined drainage is an important feature of this Statistical Planning Area.

Land Use and Ownership

The percentage of lands remaining in rangelands is highest in the Missouri River SPA. This is because of the terrain which can be gently rolling, but most often of a more rugged nature; the extreme exemplied by the Badland areas. Farming and ranching activities are adapted to the local physical identity of the land. Categories of Land Use by percentage are: Cropland 46%; Pastureland 2%; Rangeland 39%; Urban and Built-up 2%; Other Land 7%; Water Areas 3% 1/. The number of farms within the Missouri River Statistical Planning Area was 15,137 in 1978 2/. Land ownership estimates place the percentage breakdown of taxable lands or private lands as 85% and non-taxable lands at 15% 3/. The percentage of non-taxable lands is the highest of the five statistical planning areas. These percentages divide the total area of the SPA which is 20.4 million acres in size 3/.

Production Capability

Many factors influence the productivity of the Area's soils. Some of them include soil type, fertility, climate, and slope. The U.S. Soil Conservation Service has identified and mapped erodible soils, prime farmlands, and important farmlands.

Current and Projected Production

The total value of agricultural products sold has steadily increased since the late 1940's [4/]. The total value of agricultural products sold in 1978 amounted to $524.5 million [2/]. This figure can change drastically from year-to-year because of growing conditions or prices for agricultural products. The value of crops has followed almost a 50% share of the total value of the agriculture production sold traditionally. This demonstrates the importance of livestock value in this SPA, which is equal to that of crop production.

The general trends of crop and livestock production in relation to their role played in total value of agriculture products sold is not expected to significantly change. Prices received for agricultural products will affect the agricultural land use patterns. The Missouri River SPA has a large percentage of rangeland which can be subject to the breaking up into cropland should small grain prices rise. But offsetting factors such as the long-term suitability of this land to be cultivated as cropland, strip mining and urban development will serve to counter this type transition. Change in agricultural production and land use will likely occur because of genetic improvements of crops and yield potentials, introduction of raw or speciality crops and use of cost saving farming practices. The livestock segment is expected to become more efficient by improved forages and breeding stock as well as the strengthening of management of livestock operations.

Irrigation acreage will definitely increase and result in additional crop and livestock production.

Conservation tillage will become more widespread as a conservation technique to reduce soil erosion on cropland.

Land Treatment

Table II-1-13 shows the status of land treatment in the Missouri River SPA.

TABLE II-1-13 LAND TREATMENT IN THE MISSOURI RIVER STATISTICAL PLANNING AREA

Status	Cropland Acres	%	Pasture Acres	%	Range Acres	%	Forest Acres	%	Other Acres	%	Total Acres	%
	000		000		000		000		000		000	
Adequately Treated	4,996	53	885	62	4,769	54	83	61	440	68	11,173	
Needing Treatment	4,371	47	542	38	4,072	46	54	39	206	32	9,245	
Total	9,367	46	1,427	7	8,841	43	137	1	646	3	20,418	

Source: U.S.D.A. Soil Conservation Service, North Dakota Management Form No. 2, 1980.

References:
1/ U.S.D.A. Soil Conservation Service, Conservation Needs Inventory, July,1970
2/ U.S. Census of Agriculture 1978
3/ NDSU Soils Department from County Tax Information
4/ North Dakota Agriculture Statistics, 1981, No. 48, May 1981

THE JAMES RIVER BASIN

PHYSICAL DESCRIPTION

Geography

The James River rises in Wells County in the drift prairie of central North Dakota. It follows an erratic course south and east for 260 river miles until it leaves the State in southeastern Dickey County. In North Dakota, the drainage area of the James River is approximately 6,800 square miles (of which about 3,800 square miles are considered non-contributing). The valley through which the James River flows averages about 100 feet in depth and is from a few hundred feet to three miles wide. The river channel itself varies from 25 to 100 feet in width.

The most important tributary to the James River is Pipestem Creek, which enters the James on the west side near Jamestown and drains much of the northwestern portion of the Basin. Other important west-side tributaries include Beaver Creek, Bonehill Creek, Cottonwood Creek, and Maple River. Bear Creek, which rises in southwestern Barnes County and flows in a southerly direction to its confluence with the James River in northeastern Dickey County, is the only major east-side tributary (Figure II-2-1).

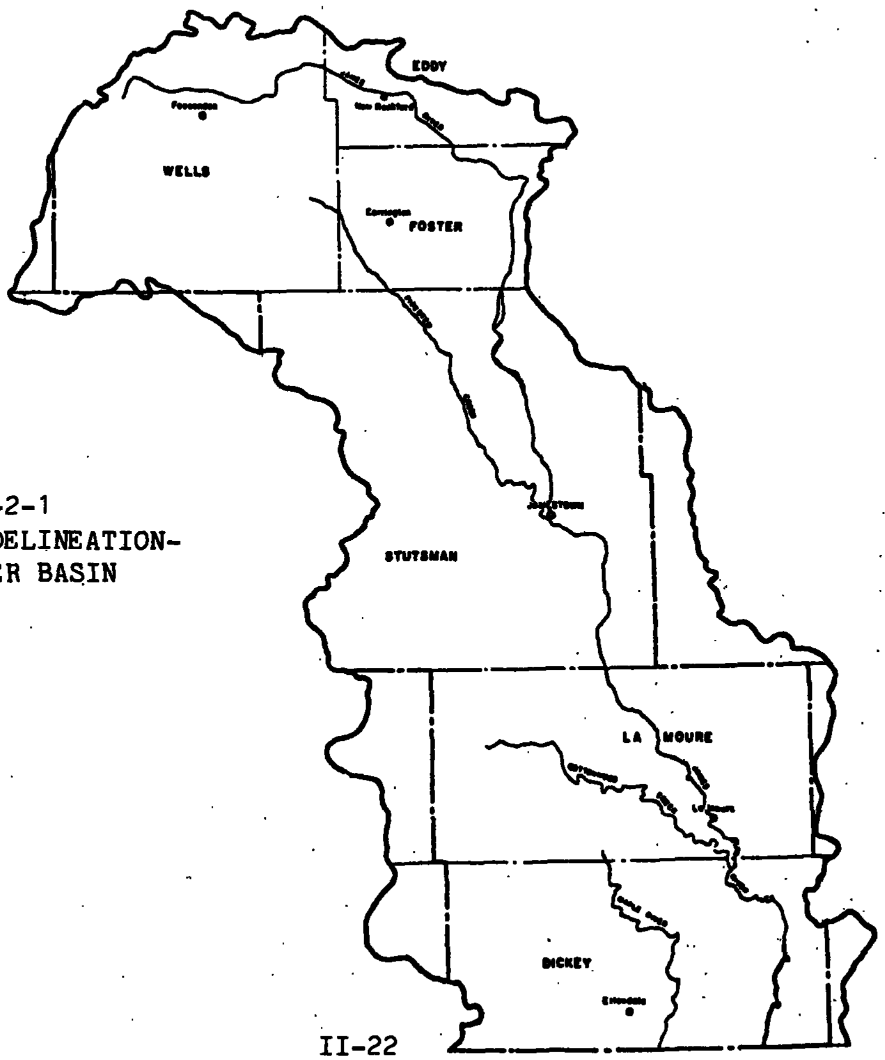


FIGURE II-2-1
SUBBASIN DELINEATION-
JAMES RIVER BASIN

Geology

Within the James River Basin, bedrock crops out in small isolated patches surrounded by glacial drift. The Cretaceous Pierre Formation directly underlies the glacial drift in most of the Basin. The Fox Hills Formation subcrops the drift in portions of Wells and Sheridan Counties; the Niobrara Formation in eastern Dickey and LaMoure Counties. The James River Basin is on the eastern flank of the Williston Basin. The preserved thickness of sedimentary rock decreases from about 6,000 feet in the west to around 2,500 feet in the east. Nondeposition or erosion of sediments marked by unconformities and the increasing elevation of the Precambrian bedrock surface account for the decrease in thickness of sedimentary rock. The rocks of Cambro-Ordovician, Silurian, Devonian, Pennsylvanian, and Triassic age (Figure I-2-9) pinch out within the James River Basin. The Mississippian rocks thin considerably. Only the Ordovician rocks as well as the Dakota Group and Pierre Formation carry through in the subsurface.

The glacial drift of Quaternary Age masks the bedrock surface and gives the James River Basin its present landforms. The Basin is defined on the west by the Missouri Coteau and on the remaining boundaries by end moraines. Broadly anastomosing meltwater channels carried outwash and glacial meltwater to the south from the last ice advance. Evidence of previous glacial advances was either buried or eroded by subsequent advances. The James River was established as a meltwater stream during the waning stages of the Wisconsinan glacial advance. Its course was not apparently influenced by the bedrock topography for the river is incised into glacial till and bedrock highs. Thickness of the drift varies from 50 to about 250 feet, but in buried valleys the thickness may exceed 300 feet. Within the glacial drift are beds of sand and gravel deposited in meltwater channels as outwash from the melting ice. These deposits are particularly thick in the buried valleys and form important aquifers in the basin. The most extensive system of such deposits is the Spiritwood Aquifer system, as series of hydrologically interconnected sand and gravel beds laid down in a network of meltwater and diversion channels within the James River Basin and the adjoining Red River, Souris River, and Devils Lake Basins. The Spiritwood Aquifer and its equivalents constitute a significant ground-water resource in North Dakota. Recent alluvial sediments occur in the stream valleys and are mostly reworked till and other glacial deposits.

SOCIO-ECONOMIC CHARACTERISTICS

The James River Statistical Planning Area (SPA) contains the counties of Dickey, Eddy, Foster, LaMoure, Stutsman, and Wells. The James River SPA is 7,123 square miles in size with a 1980 population estimate of 52,978 or about 8 percent of North Dakota's population (Table II-2-1). Jamestown is the largest city in the region with a population of 16,281 or about 31 percent of the total population of the James River SPA. Other major cities and their 1980 population estimates are Carrington, 2,636; Oakes, 2,110; Ellendale, 1,967; and New Rockford, 1,791. These five cities form about 47 percent of the total James River SPA population.

TABLE II-2-1 POPULATION ESTIMATES OF JAMES RIVER STATISTICAL PLANNING AREA

County	1960[1/]	1970[2/]	1980[3/]	% Change 1960-1970	% Change 1970-1980
Dickey	8,147	6,976	7,207	- 14.4	+ 3.3
Eddy	4,936	4,103	3,554	- 16.9	-13.4
Foster	5,361	4,832	4,616	- 9.9	- 4.5
LaMoure	8,705	7,117	6,473	- 18.2	- 9.0
Stutsman	25,137	23,550	24,154	- 6.3	+ 2.6
Wells	9,237	7,847	6,979	- 15.0	-11.1
James River SPA	61,523	54,425	52,978	- 11.5	- 2.7
North Dakota	632,446	617,761	652,437	- 2.3	+ 5.6
Percent of State	9.7	8.8	8.1	N/A	N/A

[1/] U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1960.

[2/] U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1970.

[3/] U.S. Bureau of the Census, Preliminary Population and Housing Unit Counts, November, 1980.

The urban population has increased due mainly to increased job opportunities in the urban areas. There has been a steady decline in the rural population due to increased mechanization of farms and increased farm size. The rural population of the James River SPA has dropped by 14,835, from 46,365 in 1960 to 31,530 in 1980 (Table II-2-2).

TABLE II-2-2 RURAL AND URBAN POPULATION FOR JAMES RIVER STATISTICAL PLANNING AREA[1]

	1960		1970		1980	
	Number	Percent	Number	Percent	Number	Percent
Urban[2]	15,158	24.6	15,385	28.3	21,448	40.5
Rural	46,365	75.4	39,040	71.7	31,530	59.5
Farm[3]	23,218	37.7	18,353	33.7	NA	NA
Nonfarm[4]	23,147	37.6	20,687	38.0	NA	NA
Total Population	61,523	100.0	54,425	100.0	52,978	100.0

[1] Source: U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1960 and 1970; Part 36, PC 80-1-A36, 1980.

[2] Urban inhabitants are persons living in all incorporated places and unincorporated places of 2,500 persons or more.

[3] Farm inhabitants are persons defined as actively farming 10 or more acres with sales of $50 or more per year and farms of less than 10 acres with sales of $250 or more per year.

[4] Nonfarm inhabitants are rural residents not actively farming.

In 1929 the population of the area totaled about 74,000. The population has declined to a low of about 53,000 in 1980.

The area has a 1980 population density of 7.4 persons per square mile compared to 8.7 persons per square mile for the whole state.

Employment Characteristics

Employment in the James River SPA has remained relatively stable from 24,715 in 1970 to 24,923 in 1980. The farm sector of the economy encompasses almost 67 percent of all individual proprietors but has a small portion of the total wage and salary employment. The reason for this is that most of the farms and ranches are owned and operated by the operator and his family with very little outside employment; whereas non-farm proprietors hire most of the labor force in the area.

Total employment and number of persons employed in each sector is shown in table II-2-3.

Stutsman County has the highest employment in the SPA because Jamestown is the state and local government and wholesale and retail trade center.

Annual unemployment for the area has typically been between four and five percent (Table II-2-4).

TABLE II-2-3 EMPLOYMENT BY TYPE AND BROAD INDUSTRIAL SOURCES - FULL AND PART-TIME WAGE AND SALARY EMPLOYMENT PLUS NUMBER OF PROPRIETORS FOR THE JAMES RIVER STATISTICAL PLANNING AREA

	1970	1975	1976	1977	1978	1979	1980
TOTAL EMPLOYMENT	24,715	26,518	26,729	26,864	27,265	26,188	24,923
Number of Proprietors	8,332	6,881	6,805	6,853	7,064	7,186	7,068
Farm Proprietors	5,534	4,917	4,864	4,810	4,830	4,826	4,706
Non-Farm Proprietors	2,798	1,964	1,941	2,043	2,234	2,360	2,362
Wage and Salary Employment	16,383	19,637	19,924	20,011	20,201	19,002	17,855
Farm	1,027	891	990	832	911	881	929
Non-Farm	15,356	18,746	18,934	19,179	19,290	18,121	16,926
Private Non-Farm	9,582	11,904	12,302	12,549	13,092	13,250	12,841
Mining	0	72	79	65	0	15	0
Construction	675	984	1,016	1,184	1,178	1,049	777
Manufacturing	464	1,289	1,236	1,213	1,398	1,532	1,261
Trans., Comm., and Pub. Util.	933	911	930	941	989	1,084	1,159
Wholesale and Retail Trade	3,986	4,452	4,694	4,672	4,562	4,490	4,187
Finance, Ins. and Real Estate	486	608	669	698	756	786	859
Services	2,675	3,464	3,560	3,651	3,822	3,746	3,916
Other	0	93	81	73	52	100	48
Government	5,774	6,842	6,632	6,630	6,198	4,871	4,085
Federal Civilian	658	614	546	558	538	518	522
Federal Military	19	390	359	340	365	400	354
State and Local	5,097	5,838	5,727	5,732	5,295	3,953	3,209

Source: U.S. Department of Commerce, Bureau of the Census, Regional Economics Information System, April 1982.

TABLE II-2-4 AVERAGE ANNUAL UNEMPLOYMENT RATE COUNTIES OF JAMES RIVER STATISTICAL PLANNING AREA

				Percent					
County	1972	1973	1974	1975	1976	1977	1978	1979	1980
Dickey	3.1	2.9	3.0	3.5	3.4	3.9	2.8	2.2	3.2
Eddy	10.3	10.2	9.3	7.8	8.4	8.0	7.7	8.3	7.9
Foster	5.5	5.5	5.4	5.3	5.1	5.3	3.6	3.8	4.3
LaMoure	4.1	4.7	3.8	5.0	4.9	3.7	3.0	2.7	3.5
Stutsman	4.2	4.6	4.0	4.3	4.5	4.5	3.5	3.8	5.2
Wells	5.6	5.5	5.2	5.0	4.6	5.5	4.7	4.5	4.6
James River SPA	5.5	5.6	5.1	5.2	5.2	5.2	4.2	4.2	4.8
North Dakota	4.9	5.1	4.6	5.2	5.1	5.5	4.3	4.2	5.0
United States	5.6	4.9	5.6	8.5	7.7	7.0	6.0	5.8	7.1

Source: North Dakota Employment Security Bureau, Unadjusted Annual Averages.

Income Characteristics

Total labor and proprietors income for the James River SPA increased from $124.1 million in 1970 to $253.4 million in 1980 (Table II-2-5). There has been a general increase in income with highs and lows having direct correlation to the price fluctuations of agricultural commodities.

TABLE II-2-5 PERSONAL INCOME BY MAJOR SOURCES FOR THE JAMES RIVER STATISTICAL PLANNING AREA

	1970	1975	1976	1977	1978	1979	1980
Total Labor and Proprietors Income (1000's)	124,129	238,799	200,457	195,638	279,490	260,314	253,373
Per Capita Personal Income	3,120	6,195	5,698	5,717	7,464	7,453	8,022
Labor Income by Industry (1000's)							
Farm	35,730	90,630	36,324	14,737	29,042	44,242	30,981
Manufacturing	3,056	13,655	14,475	15,892	18,313	23,017	21,651
Mining 1/	0	951	1,136	634	80	279	D
Contract Construction	6,269	11,718	13,358	19,601	19,559	18,300	14,396
Wholesale & Retail Trade	25,202	40,191	46,449	44,482	45,998	49,771	53,843
Finance Insurance & Real Estate	3,871	6,925	8,007	9,456	10,791	12,207	14,690
Transportation, Comm., and Pub. Util.	8,668	13,578	15,059	16,513	18,471	22,853	26,179
Services	13,484	21,461	23,660	28,846	33,050	36,876	39,171
Other	0	876	719	704	555	1,205	574
Federal Civilian	5,353	9,429	8,145	7,896	8,406	8,478	8,330
Federal Military	1,056	936	959	1,024	1,095	1,096	1,142
State and Local	19,225	28,414	31,927	32,923	39,012	35,119	33,204

1/ Due to nondisclosure policies of Bureau of the Census, some data for sectors labled "D" were suppressed.

Source: U.S. Department of Commerce, Bureau of the Census, Regional Economics Information System, April 1982.

Farm income in the James River SPA and for the State of North Dakota varies greatly from year to year. The major cause is commodity price instability, but weather, government farm programs, and other factors also contribute.

The percent of families in specified income brackets in the James River SPA for 1969 are: 13.9 percent earned less than $3,000; 14.9 percent earned $3,000 but less than $5,000; 18.0 percent earned $5,000 but less than $7,000; and 53.2 percent earned $7,000 or more. By using the same specified income brackets, the percentages for North Dakota are: 12.1, 14.3, 16.9, and 56.7, respectively.

ECONOMIC BASE

Description of the Study Area

One way to gain a perspective of the economic activity in the James River SPA is to trace each sector's contribution to the total economy. It is normal for a sector's contribution to the area's economy to fluctuate in respect to the other sectors. However, the major contributors remain the same; only their ranking varies with time and various stimuli (Table II-2-6).

TABLE II-2-6. PERCENT OF TOTAL EARNINGS BY SECTOR FOR THE JAMES RIVER STATISTICAL PLANNING AREA[1]

Sector	Percent of Total Earnings[2] 1970	1975	1976	1977	1978	1979	1980
Farm	28.8	38.0	18.1	7.5	10.4	17.0	12.2
Manufacturing	2.5	5.7	7.2	8.1	6.6	8.8	8.5
Mining[3]	0.0	0.4	0.6	0.3	0.0	0.1	D
Construction	5.1	4.9	6.7	10.0	7.0	7.0	5.7
Wholesale and Retail Trade	20.3	16.8	23.2	22.7	16.5	19.1	21.2
Finance, Ins. and Real Estate	3.1	2.9	4.0	4.8	3.9	4.7	5.6
Transportation, Comm., and Pub. Util.	7.0	5.7	7.5	8.4	6.6	8.8	10.3
Services	10.9	9.0	11.8	14.7	11.8	14.2	15.5
Other	0.0	0.4	0.4	0.4	0.2	0.5	0.2
Federal, Civilian	4.3	3.9	4.1	4.0	3.0	3.3	3.3
Federal, Military	0.9	0.4	0.5	0.5	0.4	0.4	0.5
State and Local	15.5	11.9	15.9	16.8	14.0	13.5	13.1

1/ Computed from Regional Economics Information System data compiled in table II-2-5.

2/ Total percentages will not add to 100 because of non-disclosure policies of U.S. Department of Commerce.

3/ Due to nondisclosure policies of Bureau of the Census, some data for sectors labled "D" were suppressed.

Agriculture

The James River SPA, like the rest of North Dakota, is highly dependent on agriculture for its livelihood. The health of North Dakota is directly related to the farm economy situation.

Farms have gradually gotten larger in size and fewer in number.

In 1970, approximately 71 percent of the total land area was under cultivation.

The value of crop products sold has ranged from 50 to 75 percent of the total value of agricultural products sold. Livestock, poultry, and their products account for most of the remainder or about 25 to 50 percent (Table II-2-7).

Table II-2-8 shows historical acreages of major crops harvested, table II-2-9 the production of those crops, and table II-2-10 the livestock inventory for various years in the SPA.

TABLE II-2-7 FARM SIZE AND VALUE OF PRODUCTION FOR JAMES RIVER STATISTICAL PLANNING AREA[1/]

	1949	1954	1959	1964	1969	1974	1978[2/]
Number of Farms	7,390.0	7,137.0	6,296.0	5,555.0	5,106.0	4,618.0	4,339.0
Land in Farms (000's)	4,349.5	4,447.5	4,353.6	4,377.1	4,413.2	4,362.9	4,368.6
Average Farm Size (Acres/Farm)	588.6	623.2	691.5	788.0	864.3	944.8	1,006.8
Total Value of Ag. Products Sold ($1,000)	36,997.2	40,407.7	49,343.9	67,373.6	94,574.0	203,057.0	223,583.0
Value of Crops Sold ($1,000)	18,746.2	24,333.8	23.899.0	38.071.9	55,895.0	150,847.0	149,830.0
Percent of Total	50.7	60.2	48.4	56.5	59.1	74.2	67.0
Value of Livestock, Poultry & Their Products Sold ($1,000)	18,250.2	16,073.9	25,349.5	29,167.4	38,678.0	38,751.0	48,432.0
Percent of Total[3/]	49.3	39.8	51.4	43.3	40.9	19.1	21.7

1/Source of data is U.S. Census of Agriculture for years 1949 through 1978.

2/Preliminary data.

3/Due to nondisclosure policies of Bureau of Economic Analysis, some data in some counties for categories (sectors, crop, etc.) labled "D" were suppressed; consequently the actual percentage for these sectors may be understated.

TABLE II-2-8. HISTORICAL ACRES OF MAJOR CROPS HARVESTED JAMES RIVER STATISTICAL PLANNING AREA[1/]

Crop	Unit	1949	1954	1959	1964	1969	1974	1978[2/]
Wheat	Ac.	1,087,650	765,332	627,167	626,144	673,259	1,247,051	1,149,687
Oats	Ac.	285,096	347,411	92,882	289,583	376,293	205,589	140,160
Barley	Ac.	194,445	388,715	372,595	220,368	261,450	221,003	200,405
Rye	Ac.	42,574	63,277	36,148	84,446	53,268	37,580	30,846
Sunflower[3/]	Ac.	---	---	---	---	---	62,000	440,400
Flax[4/]	Ac.	193,068	362,065	362,921	357,810	336,500	177,500	59,200
Corn Grain	Ac.	72,034	54,155	32,711	18,903	13,438	14,161	42,819
Corn Silage	Ac.	31,924	76,660	110,091	115,240	50,912	57,842	48,252
Hay	Ac.	486,110	524,657	514,335	474,267	341,592	454,903	354,112
Soybeans	Ac.	151	726	1,304	323	373	193	1,584
Potatoes	Ac.	1,036	1,007	636	573	359	702	24

1/Source of data is U.S. Census of Agriculture for years 1949 through 1978.

2/Preliminary data.

3/Sunflower data are from North Dakota Crop and Livestock Statistics.

4/Flax data for 1969, 1974, and 1978 were obtained from North Dakota Crop and Livestock Statistics.

TABLE II-2-9 HISTORICAL PRODUCTION OF MAJOR CROPS
HARVESTED JAMES RIVER STATISTICAL PLANNING AREA[1]

Crop	Unit	1949	1954	1959	1964	1969	1974	1978[2]
Wheat	Bu.	8,061,315	5,630,131	8,225,859	14,572,511	20,388,513	23,459,696	23,269,803
Oats	Bu.	4,042,540	7,424,897	6,340,060	11,789,274	21,391,123	6,552,175	6,975,628
Barley	Bu.	1,945,571	7,049,130	5,368,042	7,393,930	8,952,982	5,625,775	8,121,932
Rye	Bu.	490,773	1,032,690	578,222	1,631,025	1,439,443	1,003,748	1,105,882
Sunflower[3]	(000 lbs)	---	---	---	---	---	53,940	538,524
Flax[4]	Bu.	1,160,319	2,164,862	1,911,711	2,825,120	4,369,500	1,267,600	671,700
Corn Grain	Bu.	[illegible]379,192	994,217	518,492	442,340	551,480	482,977	2,537,034
Corn Silage	Tons	[illegible]396	291,877	311,599	446,523	289,711	338,366	320,214
Hay	Tons	401,769	585,767	426,803	593,711	524,600	672,102	630,184
Soybeans	Bu.	807	6,895	8,495	2,926	4,356	1,095	38,172
Potatoes	Cwt.	61,812	79,155	46,356	26,687	26,214	130,636	137,712

[1] Source is U.S. Census of Agriculture for years 1949 through 1978.
[2] Preliminary data.
[3] All sunflower data are from North Dakota Crop and Livestock Statistics.
[4] Flax data for 1969, 1974, and 1978 were obtained from North Dakota Crop and Livestock Statistics.

TABLE II-2-10 NUMBER OF HEAD OF LIVESTOCK
JAMES RIVER STATISTICAL PLANNING AREA

Livestock	1949	1954	1959	1964	1969	1974	1978[1]
All Cattle and Calves	199,385	267,133	238,869	337,865	266,738	310,403	254,954
Milk Cows	55,532	49,979	35,186	31,624	17,684	15,459	13,730
All Sheep and Lambs	89,639	148,525	150,308	102,955	69,692	44,522	34,551
All Hogs and Pigs	53,445	74,115	80,617	50,200	37,963	42,086	42,155
Horses and Ponies	16,797	9,536	5,324	N/A[2]	3,673	1,990	3,140
Chickens 4 mo. and Older	450,834	609,550	410,367	303,786	114,820	104,585	52,267

[1] Preliminary data.
[2] Not available.

Source: U.S. Census of Agriculture for years 1949 through 1978.

Wholesale and Retail Trade

This sector is also a major contributor to the economy of the James River SPA as several trade centers are located there. From 1975 to 1980 the percent of total earnings for the sector varied from a low of about 17 percent to a high of over 23 percent.

Services

The services sector is comprised of various enterprises such as hospitals, hotels, and recreation facilities. Demand for these and other types of services has grown largely because of increased business volume.

Surface Water

The James River Basin includes an area of about 6,800 square miles of which some 3,800 square miles are considered noncontributing. The drainage system is poorly to moderately integrated. The James River is the only major stream. Tributary streams are relatively small in comparison, the principal one of which is Pipestem Creek. The headwaters of the Maple and Elm Rivers, two major tributaries to the James in South Dakota, are in North Dakota. Streamflow in the basin originates from precipitation, ground-water outflow, and snow meltwater. Runoff is seasonally quite variable with spring typically the time of greatest runoff and summer characterized by no flow. Summer thunderstorms can cause dramatic increases in streamflow within a watershed. Median annual runoff ranges from less than 0.50 inches to more than 0.75 inches. All streamflow in the Basin originates within the State. A network of nine stream-gaging and stage-measuring stations monitor streamflow in the James Basin. Streamflow records are summarized in Table II-2-11.

TABLE II-2-11 SUMMARY OF STREAMFLOW RECORDS
JAMES RIVER BASIN

River	Measuring Location	Discharge (cfs) Average	Maximum	Minimum	Annual Average Discharge (AF)
James	Manfred	3.41	2,000	0	2,510
James	Grace City	28.3	3,100	0	20,830
James	Jamestown 1/	51.6	6,330	0.67	37,979
James	LaMoure	93.3	6,800	0	68,672
Pipestem Creek	Pingree	22.8	2,520	0	16,782
Maple	State Line	20.0	5,930	0	14,721

1/ Records for post-completion of Jamestown Dam

Surface-water storage in the James River Basin is currently provided by 47 dams. Normal storage capacity of these dams totals 70.6 thousand AF with a range from 40 AF to 30,000 AF for Jamestown Dam. Total maximum storage capacity is 614.5 thousand AF, ranging from 55 AF to 389.1 thousand AF for Jamestown Dam.

The quality of surface water can vary considerably in response to different factors including streamflow, time of year, climate, type of materials in the stream channel, ground-water inflow, and land- and water-management practices. Periods of low streamflow are generally characterized by poorer water quality than periods of high streamflow. Dilution is greater during high streamflow and the residence time of water is shorter in a given segment of stream channel.

Surface water in the James River Basin is of two predominant types. The river drains a drift prairie and has a calcium-magnesium bicarbonate type water with dissolved solids ranging between 200-1,000 mg/l. In the western part of the Basin, the surface water is generally a sodium sulfate type with calcium, magnesium, and bicarbonate ions commonly present.

The importance of North Dakota's wetlands as wildlife habitat has been established. Of a more controversial nature is the manner in which these wetlands function in the State's surface-water and ground-water resources, that is their relationships in surface-water hydrology and quality and the interaction between surface water and ground water.

The 1964 Wetlands Inventory indicated a total of 87,272 wetlands covering 265,993 acres in the James River SPA (Table II-2-12) or about 1.9 percent of the SPA area. The results of the 1964 Inventory are considered to be conservative. A new wetlands inventory by the U.S. Fish and Wildlife Service is in progress and is based on a detailed classification hierarchy different from that used for the 1964 inventory.

TABLE II-2-12 1964 WETLAND INVENTORY FOR THE JAMES RIVER STATISTICAL PLANNING AREA

Wetland Type		Total Number	Total Acres
I		32,727 1/	34,695 2/
III		46,008	101,549
IV		7,868	94,176
V		615	28,985
X 3/		12	440
XI 3/		42	6,148
	TOTAL	87,272	265,993

1/Type I wetland numbers were estimated at 60 percent of the total wetland numbers.

2/Type I wetland acres were estimated at 15 percent of the total wetland acres.

3/Some Types X and XI may have been classified as Types IV and V.

Source: U.S. Fish and Wildlife Service 1964 Invenstory of Wetlands.

Water quality of wetlands can be quite variable both in time and area. The variability is influenced by the combination of many factors such as climate, time, watershed characteristics, surface-water hydrology, and ground-water interaction.

Ground Water

Ground water occurs in both bedrock and glacial-drift aquifers in the James River Basin. The bedrock aquifers are found within formations of Cambrian to Cretaceous age. Rocks younger than the Fox Hills Formation are absent in the Basin. Aquifers that supply wells in the Basin are the Black Island Formation, the Dakota Group, the Niobrara Formation, the Montana Group, and glacial drift (Figure I-2-9).

Pre-Cretaceous rocks underlie all but the extreme southeastern part of the James River Basin. Potential aquifers may occur in rocks from the Big Horn Group (Ordovician) to the Piper Formation (Jurassic), but it is not known if any wells in the basin tap these aquifers. The Black Island Formation of the Winnipeg Group is used to supply a few wells in Dickey and LaMoure Counties. In this part of the James River Basin, depth to the Black Island Formation ranges from about 1,420 feet in the east to 3,000 feet in the west. The formation is approximately 140 feet thick and consists of interbedded fine to medium-grained sandstone, siltstone, and shale. The aquifer is confined and the wells are flowing artesian wells. Ground water moves northeasterly across the Basin and discharges into overlying beds or flows into the adjacent Red River Basin. The source of recharge is not known. The water in the Black Island aquifer is a sodium sulfate type and very hard. Sodium accounts for 90% of the cations. Dissolved solids concentrations range between 2,500 and 3,800 mg/l. Iron concentrations exceed the recommended standard and irrigation indices are very high. The Black Island aquifer underlies all of the James River Basin, but it is not known if it is used elsewhere except in Dickey and LaMoure Counties. The water is generally unsatisfactory for domestic use.

The sandstone formations of the Dakota Group comprise an aquifer system collectively called the Dakota aquifer. Included in this category are the Inyan Kara and Newcastle Formations. Depth to the Inyan Kara increases from 1,100 feet in the south part of the Basin to about 2,500 feet in the north. Thickness is quite variable because the broadly lenticular beds of this interval was deposited on an irrigular erosional surface. Thickness varies from less than 30 to over 100 feet, but locally there are areas of nondeposition. Flowing wells are common but only if the wells are located below certain land surface elevations. This varies from about 1,500 feet in Dickey County to about 1,600 feet in Wells County. Wells yields typically are low, in the 10-50 gallons-per-minute range. Potential yields to properly constructed wells are higher, exceeding 200-300 gallons per minute where the aquifer is sufficiently thick and permeable. Water from the Inyan Kara is a sodium sulfate, calcium sulfate, or sodium chloride type depending on location and depth. Dissolved solids concentrations vary from 2,000-4,850 mg/l. For the most part the water is hard and high in iron, sodium, and sulfate concentrations. It is used for domestic and livestock supplies although it generally does not meet recommended standards for domestic use. Depth to the Newcastle Formation varies from 800 feet in Dickey County to around 1,790 feet in western LaMoure County and 2,300 feet in western Wells County. The Newcastle is depositionally complex and is made up of many lenticular beds of sand, silt, and clay most of which have been partially or completely indurated. Formation thickness varies from less than 10 feet to over 160 feet. Well yields are in the 5-20 gallons-per-minute range. Flowing wells typically yield less than 10 gallons-per-minute. The water is a sodium chloride type with dissolved solids concentrations varying from around 2,000 mg/l to nearly 4,600 mg/l. Iron, sodium, and sulfate concentrations reduce the desireability of this water for domestic use although it is used for domestic, livestock, and some public supplies.

The Niobrara Formation directly underlies the glacial drift in southeastern LaMoure and eastern Dickey Counties, and western Ransom and Sargent Counties. The Niobrara Formation is a calcareous shale and is not generally considered an aquifer. There are some wells completed in the Niobrara that probably tap fracture zones in the erosional surface near the unconformity with the overlying glacial deposits.

Both of Pierre and Fox Hills Formations of the Montana Group are aquifers in the James River Basin. The Pierre is more extensive than the Fox Hills which occurs only in western Wells and eastern Sheridan Counties. The Pierre Formation is a black, siliceous, fissile shale containing localized fracture zones. These zones of interconnecting fractures form the Pierre aquifer where saturated. The yield to wells and the amount of water in storage is directly related to the extent and thickness of the fracture zone. The aquifer is recharged mainly by vertical leakage through the overlying glacial deposits. Yields to wells completed in the Pierre aquifer and small, typically less than 5 gallons per minute. The quality of water in the Pierre aquifer is highly variable due to patterns of local recharge. Dissolved solids concentrations range from less than 1,000 mg/l to over 8,600 mg/l. The water is high in sodium, sulfate, iron, and chloride ions. Hardness is high as are the irrigation indices. The Pierre aquifer is an important source of domestic and livestock water in the James Basin where the overlying glacial drift contains no sand and gravel units. The Fox Hills Formation underlies the glacial drift in the upper reaches of the James River Basin in western Wells and eastern Sheridan Counties. The formation consists of interbedded sandy shale, claystone, siltstone, and sandstone. The sandstone units, which form the aquifer system, are individual beds of very fine- to medium-grained sand from 1 to 100 feet thick. Total thickness of the system varies between 200-350 feet. Well yields are 5-20 gallons-per-minute of typically soft, sodium bicarbonate type water. Dissolved solids concentrations ranged from about 400-2,500 mg/l. The aquifer is used mostly for rural domestic and livestock supplies.

The deposits of glacial drift in the James River Basin average 100-200 feet thick, but may vary from 0-600 feet. Within the drift are deposits of sand and gravel found in buried valleys or as surficial and buried outwash. The sands and gravels in buried valleys are the most extensive aquifers in the basin. These aquifers are typically confined except where intercepted by a stream channel or overlain by other sand and gravel deposits. Recharge to these aquifers is chiefly by subsurface underflow, by precipitation and runoff where hydrologically connected to surficial deposits, and by vertical leakage of water through overlying till. The most extensive glacial-drift aquifer system in the Basin is a series of broadly anostomosing buried meltwater and diversion channels, a system which extends past the Basin's boundaries (Plate I-2-1). Well yields range from 50 gallons-per-minute to more than 500 gallons-per-minute, giving these aquifers the greatest potential for developing large supplies of water for irrigation, municipal, or industrial uses. Less extensive are surficial unconfined aquifers generally composed of outwash from the last glacial advance. These aquifers are recharged by precipitation and runoff. Well yields are typically in the 50-300 gallon-per-minute range. Other aquifers occur as isolated bodies of sand and gravel. Well yields are usually small ranging from 10-50 gallons-per-minute on a sustained basis. Water quality is widely variable within a particular aquifer and from one aquifer to another. Predominant cations are sodium and calcium; chief anions are bicarbonate, sulfate, and chloride. Dissolved solids ranges from less than 250 mg/l to over 2,200 mg/l. Irrigation indices vary from low to high.

Land Resources

The original land cover of the James River Statistical Planning Area was mixed grass prairie (tall and short grass species). Glacial action determined the natural identity of the area with wetlands being prevalent on the flat to rolling prairie. Soils which developed from the grassland are the black soils typical of eastern North Dakota.

Land Use and Ownership

Agriculture dominates the land use in the James River SPA. This statistical planning area is similar to most others in that the farming operations make small grains and livestock its basic economic activity. Land Use categories by percentage are: Cropland 71%; Pastureland 7%; Rangeland 14%; Forest 1%; Urban and Built-up 2%; Others Land 4%; Water Areas 1% 1/. The number of farms within the statistical planning area was 4,339 as of 1978 2/. The breakdown between taxable land or private land and non-taxable land for the James River Statistical Planning Area is 98% and 2% respectively. There are approximately 4.6 million acres in the James River Statistical Planning Area 3/.

Production Capability

Many factors affect the productivity of the area's soils. Some of them include soil type, fertility, climate and slope. The U.S. Soil Conservation Service has identified and mapped erodible soils, prime farmlands, and important farmlands.

Current and Projected Production

Through the decades, the value of agricultural products sold has steadily increased. The total value of agriculture products sold in 1978 was $222.6 million 2/. Crop products sold have ranged from 50 to 75% of the total value of agricultural products sold 2/. Increased production from crop and livestock sources is expected to continue its upward trend. Their rank of importance in terms of total agricultural production value is not expected to significantly shift. The production increases are anticipated from improved crop varieties and improved breeding stock. Row or specialty crops, particularly sunflowers, are becoming more favorable in light of greater profit potential. Acreages for these have come and will continue to come at the expense of traditional small grain acreage. Additional acreage will be brought into cropland from wetland and pasture/rangeland categories. A balancing occurs when land less suited as cropland reverts to a less intensive land use.

Prices received for agricultural products are an important part in the shift of land use and cropping patterns. Historically, prices have determined the degree of these shifts.

Irrigation which will increase in the future will also be a major determinant in increased production potential.

Land Treatment

Table II-2-13 shows the status of land treatment in the James River SPA.

TABLE II-2-13 LAND TREATMENT IN THE JAMES RIVER STATISTICAL PLANNING AREA

Status	Cropland Acres (000)	%	Pasture Acres (000)	%	Range Acres (000)	%	Forest Acres (000)	%	Other Acres (000)	%	Total Acres (000)	%
dequately Treated	1,959	66	377	62	314	54	10	56	199	53	2,859	6
eeding Treatment	1,028	34	235	38	264	46	8	44	173	47	1,708	37
Total	2,987	65	612	13	578	13	18	1	372	8	4,567	10

ource: U.S.D.A. Soil Conservation Service, North Dakota Management Form No. 2, 1980.

References:
1/ U.S.D.A. Soil Conservation Service, Conservation Needs Inventory, July 1970
2/ U.S. Census of Agriculture, 1978
3/ NDSU, Soils Department from County Tax Information

CHAPTER 3

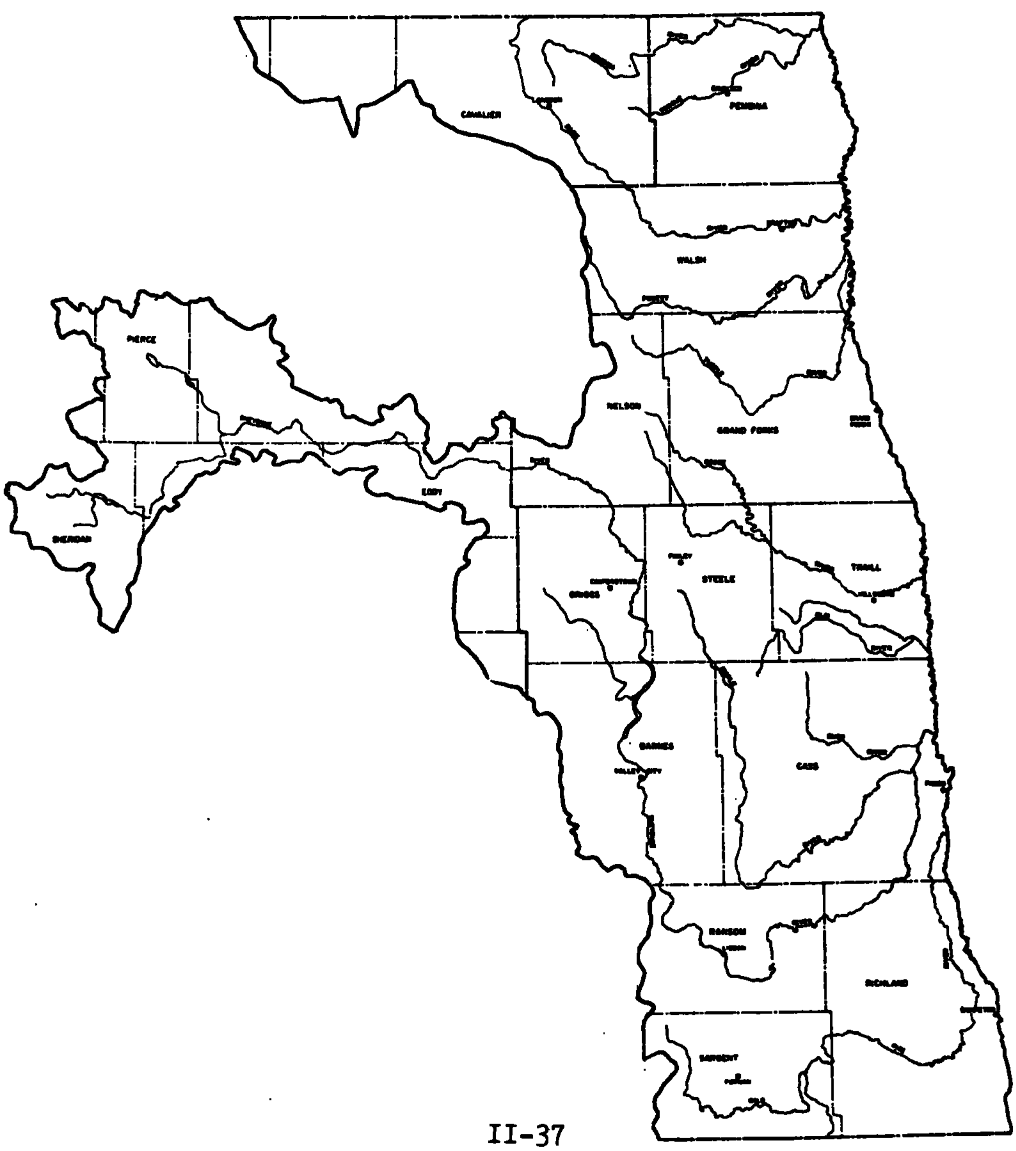
THE RED RIVER BASIN.

PHYSICAL DESCRIPTION

Geography

The Red River of the North (Figure II-3-1) is formed by the confluence of the Ottertail and Bois de Sioux Rivers at the twin cities of Wahpeton, North Dakota and Breckenridge, Minnesota. The Red River flows almost 400 river miles in a tortuous northerly course that forms the boundary between North Dakota and Minnesota to the International Boundary between the United States and Canada. From the Boundary, it flows generally northeast 155 river miles in Canada to Lake Winnipeg. The drainage area of the Red River Basin in North Dakota is approximately 17,250 square miles. The Red River flows through the ancient lake bed of Glacial Lake Agassiz. This lake bed is very flat, accounting for the meandering course of the river and its low gradient.

FIGURE II-3-1 SUBBASIN DELINEATION - RED RIVER BASIN



Principal Minnesota tributaries entering the Red River between the confluence of the Bois de Sioux and Ottertail Rivers and the international boundary are the Buffalo, Wild Rice, Red Lake, Sanke, Two, and Tamarac Rivers. Principal North Dakota tributaries to the Red River are the Wild Rice, Sheyenne, Elm, Goose, Turtle, Forest, Park, and Pembina Rivers. Tributaries in North Dakota generally flow east into the northward flowing Red River. Near the river, the tributaries tend to turn northward, flowing in some instances nearly parallel to the mainstem for many miles before finally entering it.

Most of the major North Dakota tributaries of the Red River have their headwaters in the drift prairie or in the Pembina Escarpment. In the upper reaches of these tributary courses, valleys are narrow, steep-sided, and relatively deep with considerably steep slopes. As the tributaries leave the drift prairie or escarpment and enter the lake plain, their valleys continue to be narrow. The depth of the valleys decreases as the rivers become more winding. In the lowlands, many tributaries have very flat slopes with poorly defined watershed boundaries.

Wild Rice Subbasin

The Wild Rice River rises in the glaciated uplands of south-central Sargent County. As it flows in an easterly direction across the county, it is joined by a number of tributaries whose headwaters are located in the Sisseton Hills of South Dakota. Shortly after the Wild Rice enters Richland County, it falls into the Red River Valley and flows in a winding course to the eastern part of the county. Here, it turns northward and enters the Red River in southeastern Cass County. The total area drained by the Wild Rice River in North Dakota is 2,020 square miles; the river's approximate length is 243 river miles. The principal tributary is Antelope Creek, which has a drainage area of 341 square miles.

Sheyenne River Subbasin

The Sheyenne River, North Dakota's longest river, rises in Sheridan County in central North Dakota. In its 506 river-mile course to the Red River, it flows generally eastward through Wells, Benson, Eddy, and Nelson Counties, and then turns south into Griggs, Barnes, and Ransom Counties, where it loops and heads northeastward into Richland and Cass Counties. It flows into the Red River north of Fargo in Cass County. Portions of Pierce, Foster, and Steele Counties are also drained by the Sheyenne. The total area drained is about 7,140 square miles.

The headwaters of the Sheyenne River are formed in the drift prairie with tributary coulees two to five miles long, 30 to 60 feet deep, and 1/8 to 3/8 of a mile wide. The main valley in the drift prairie is rather steep-sided and ranges in width from 3/8 to 3/4 of a mile in the lower reaches. The depth and width of the valley gradually decrease east of the drift prairie where the Sheyenne flows across the Red River Valley. The main tributary of the Sheyenne River is the Maple River which drains approximately 1,500 square miles in Steele, Barnes, Ransom, and Cass Counties. Other important tributaries are Baldhill Creek north of Valley City, and Swan Creek and Rush River, both tributaries to the Maple River in Cass County.

Elm River Subbasin

The Elm River rises in southeastern Steele and northwestern Cass Counties and flows generally eastward to its confluence with the Red River in southeastern Traill County. Total drainage area of the Elm River is approximately 510 square miles. Unlike most of the Red River's North Dakota tributaries, which tend to turn sharply north before entering the mainstem, the Elm River turns slightly southeastward near the end of its 69 river-mile course.

Goose River Subbasin

The headwaters of the Goose River are located in central Nelson County. Flowing eastward through the glacial-drift area, it passes through the southwestern part of Grand Forks County, the northeastern part of Steele County, and into Traill County where, east of Caledonia, it enters the Red River. The Subbasin has an approximate width of 50 miles. The Subbasin extends a distance of about 70 miles from north to south. The approximate length of the Goose River is 186 river miles; the total area drained is an estimated 1,280 square miles. Important tributaries include Goose Creek and the Goose River's north, middle, and south branches.

Turtle River Subbasin

The Turtle River has its source near Petersburg in east-central Nelson County. From the headwaters, it flows eastward and slightly southward, entering the Red River Valley near Arvilla in Grand Forks County. From this point, it flows northeastward to its confluence with the Red River in the northeast corner of the county. The Subbasin is slightly less than 50 miles long and approximately 20 miles wide with a total drainage area estimated at 730 square miles. Its major tributary is Salt Water Coulee.

Forest River Subbasin

The Forest River rises in western Walsh and northeastern Nelson Counties. It flows southeastward across the Pembina Delta to the vicinity of Inkster in Grand Forks County where it descends into the Red River Valley. It then flows northeasterly to its mouth at the Red River, about 11 miles north of the Walsh-Grand Forks County line. The Subbasin is approximately 55 miles long and 20 miles wide. The total estimated area drained by the Forest River is 1,030 square miles; river length is approximately 147 river miles.

Park River Subbasin

The Park River has its source in southeastern Cavalier County. It flows southeastward and descends into the Red River Valley near the City of Park River in central Walsh County. From this point, it flows generally eastward, but slightly northward in a winding course to its confluence with the Red River five miles south of the Walsh-Pembina County line. The Park River is composed of three branches which join about three miles west of Grafton. The Subbasin is approximately 60 miles long from east to west, and 25 miles wide from north to south. The total estimated area drained by the Park River over its 110 river-mile course is 1,010 square miles. Most of the Basin is in the Red River Valley, characterized by extremely sluggish drainage.

Pembina River Subbasin

The Pembina River has its source and a large portion of its drainage area in Canada. It enters North Dakota near Elkwood in Cavalier County and flows southeasterly to the Cavalier-Pembina County line, where it turns to flow northeasterly to Neche near the International Boundary. Between Neche and its confluence with the Red River at the City of Pembina, it follows a slightly southeasterly route. In North Dakota, the Pembina River and its major tributary, the Tongue, drain an estimated 1,960 square miles. Portions of Rolette, Towner, Cavalier, and Pembina Counties are in the Basin. From its western end in Rolette County to the Minnesota border, the area drained by the Pembina River extends a distance of approximately 135 river miles, reaching from the Turtle Mountains, through the Pembina Escarpment, to the Red River Valley. At its widest point, in central Cavalier County, the Subbasin is about 25 miles wide.

Minor Red River Tributaries

An estimated 1,560 square miles are drained by direct minor tributaries to the Red River, including the Bois de Sioux River. The area includes six minor watersheds which lie adjacent to the Red River and between the major subbasins. These areas contain the heaviest concentration of population in the State, as well as some of the most productive cropland.

The Bois de Sioux River usually contributes only in a minor way to the flow of the Red River, except during the spring and early summer. Although it drains only 195 square miles in North Dakota, the Bois de Sioux is an important landmark as it forms the border between North Dakota and Minnesota, south of Wahpeton.

Geology

The Red River Basin extends from the valley of the Red River west to include the headwaters of the Sheyenne River on the east side of the Missouri Coteau. The entire Basin is mantled with Quaternary sediments, chiefly ground and end moraines, deltaic and lacustrine deposits, beaches, and outwash. Bedrock crops out only where streams have cut down through the overlying unconsolidated sediments.

The Red River Basin extends across the eastern flank and to the edge of the Williston Basin. The sedimentary rocks underlying the River Basin thin eastward from around 6,000 feet in Sheridan County to less than 100 feet in the Red River valley. In a narrow elongate area between Richland and Grand Forks Counties, the sedimentary rocks are completely absent due to erosion or nondeposition and the Precambrian crystalline rocks directly underlie the Quaternary sediments. Westward from the Precambrian subcrop area, younger rocks directly underlie the Quaternary sediments. Within the Red River valley are the subcrops of the Ordovician and Jurassic rocks plus the Dakota Group and the Niobrara Formation. The Pierre Formation directly underlies most of the western half of the Basin. Toward the headwaters of the Sheyenne River, the Fox Hills and Hell Creek Formations and then the rocks of the basal Fort Union Group are in contact with the overlying glacial drift (Figure I-2-9).

The Quaternary sediments give the Red River Basin its present landforms. The western edge of the Basin is marked by end moraines of the last ice advance. The flat surface of the Red River valley is the bottom of former glacial Lake Agassiz. Beaches and deltas formed along the west edge of this lake and are significant landscape features today. Lake Agassiz existed for an estimated 5,000 years and covered some 110,000 square miles of North Dakota. The water is estimated to have been at least 330 feet deep at the site of the City of Grand Forks. The lake's demise came with final retreat of the continental ice sheets past the outlet of Hudson Bay. Both Lakes Winnipeg and Winnipegosis in Canada are remnants of this once vast lake.

Meltwaters flowing from the ice and along the ice margin deposited sands and gravels in a network of meltwater channels, diversion channels, or preexisting stream valleys. Such bodies of sand and gravel of earlier ice advances were buried by the deposits of later advances. Streams flowing into Lake Agassiz built into the lake large deltas of the sediments they were carrying. The coarser sands and gravels were deposited first while the finer silts and clays were carried farther into the lake before deposition as lake-bottom sediments. The depositional patterns of Quaternary sediments strongly influence the location and potential yield of the glacial-drift aquifers.

SOCIO-ECONOMIC CHARACTERISTICS

The Red River Statistical Planning Area (SPA) contains the counties of Barnes, Cass, Grand Forks, Griggs, Nelson, Pembina, Ransom, Richland, Sargent, Steele, Traill, and Walsh. The Red River SPA is 13,515 square miles in size with a 1980 population of 247,371, or about 38 percent of North Dakota's population (Table II-3-1). Fargo is the largest city in the region with a population of 61,281, or about 25 percent of the total population of the Red River SPA. Other major cities and their 1980 population estimates are Grand Forks, 43,760; West Fargo, 10,080; Wahpeton, 9,065; Valley City, 7,771; Grafton, 5,302; Lisbon, 2,286; and Mayville, 2,252. These cities, plus Fargo, form about 57 percent of the total Red River SPA population.

TABLE II-3-1 POPULATION ESTIMATES OF
RED RIVER STATISTICAL PLANNING AREA

County	1960[1/]	1970[2/]	1980[3/]	% Change 1960-1970	% Change 1970-1980
Barnes	16,719	14,669	13,960	- 12.3	- 4.8
Cass	66,947	73,653	88,247	+ 10.0	+19.8
Grand Forks	48,677	61,102	66,100	+ 25.5	+ 8.2
Griggs	5,023	4,184	3,714	- 16.7	-11.2
Nelson	7,034	5,776	5,233	- 17.9	- 9.4
Pembina	12,946	10,723	10,399	- 17.2	- 3.0
Ransom	8,078	7,102	6,690	- 12.1	- 5.7
Richland	18,824	18,089	19,407	- 3.9	+ 7.3
Sargent	6,856	5,937	5,512	- 13.4	- 7.2
Steele	4,719	3,749	3,106	- 20.6	-17.2
Traill	10,583	9,571	9,624	- 9.6	+ 0.6
Walsh	17,997	16,251	15,371	- 9.7	- 5.4
Red River SPA	224,403	230,806	247,371	+ 2.9	+ 7.2
North Dakota	632,446	617,761	652,437	- 2.3	+ 5.6
Percent of State	35.5	37.4	37.9	N/A	N/A

[1/] U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1960.

[2/] U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1970.

[3/] U.S. Bureau of the Census, Preliminary Population and Housing Unit Counts, November, 1980.

The urban population has increased due mainly to increased job opportunities in the urban areas. There has been a steady decline in the rural population due to increased mechanization of farms and increased farm size. The rural population of the Red River SPA has dropped by 19,351 persons from 119,462 in 1960 to 100,111 in 1980 (Table II-3-2).

TABLE II-3-2 RURAL AND URBAN POPULATION FOR RED RIVER STATISTICAL PLANNING AREA[1]

	1960		1970		1980	
	Number	Percent	Number	Percent	Number	Percent
Urban[2]	104,941	46.8	131,482	57.0	147,260	59.5
Rural	119,462	53.2	99,324	43.0	100,111	40.5
Farm[3]	60,293	26.9	42,477	18.4	NA	NA
Nonfarm[4]	59,169	26.4	57,019	24.7	NA	NA
Total Population	224,403	100.0	230,806	100.0	247,371	100.0

[1] Source: U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1960 and 1970; Part 36, PC 80-1-A36, 1980.

[2] Urban inhabitants are persons living in all incorporated places and unincorporated places of 2,500 persons or more.

[3] Farm inhabitants are persons defined as actively farming 10 or more acres with sales of $50 or more per year and farms of less than 10 acres with sales of $250 or more per year.

[4] Nonfarm inhabitants are rural residents not actively farming.

In 1929 the population of the area totaled about 210,000. The population then began a steady increase to the present high of about 247,000.

The area has a 1980 population density of 18.3 persons per square mile compared to 8.7 persons per square mile for the whole State.

Employment Characteristics

Employment in the Red River SPA increased from 107,159 in 1970 to 134,106 in 1980, or about 25 percent. The farm sector of the economy has almost 57 percent of all individual proprietors but has a small portion of the total wage and salary employment. The reason for this is that most of the farms and ranches are owned and operated by the operator and his family with very little outside employment; whereas non-farm proprietors hire most of the labor force in the area.

Total employment and number of persons employed in each sector is shown in table II-3-3.

TABLE II-3-3 EMPLOYMENT BY TYPE AND BROAD INDUSTRIAL SOURCES-FULL AND PART-TIME WAGE AND SALARY EMPLOYMENT PLUS NUMBER OF PROPRIETORS FOR THE RED RIVER STATISTICAL PLANNING AREA

	1970	1975	1976	1977	1978	1979	1980
TOTAL EMPLOYMENT	107,159	123,661	129,151	129,883	134,536	133,990	134,106
Number of Proprietors	23,532	19,859	19,811	20,053	20,807	21,276	21,345
Farm Proprietors	14,295	12,696	12,561	12,424	12,475	12,468	12,158
Non-Farm Proprietors	9,237	7,163	7,250	7,629	8,332	8,808	9,187
Wage and Salary Employment	83,627	103,802	109,340	109,830	113,729	112,714	112,761
Farm	4,284	4,276	4,749	3,991	4,371	4,228	4,462
Non-Farm	79,343	99,526	104,591	105,839	109,358	108,486	108,479
Private Non-Farm	52,121	68,333	73,457	74,841	78,462	80,368	78,327
Mining[1/]	0	52	64	31	D	D	D
Construction	3,899	5,563	6,540	6,337	6,748	6,674	5,291
Manufacturing	3,900	8,564	8,903	8,274	8,592	8,976	8,599
Trans., Comm., and Pub. Util.	4,876	5,414	5,653	5,867	6,191	6,665	6,882
Wholesale and Retail Trade	20,159	25,863	27,983	27,658	27,441	27,981	25,663
Finance, Ins. and Real Estate	3,541	4,443	4,624	4,992	5,249	5,437	5,672
Services	14,119	17,694	18,876	19,814	20,848	20,935	21,382
Other	1	341	376	204	233	118	318
Government	27,222	31,193	31,234	30,998	30,896	28,118	29,972
Federal Civilian	4,107	4,209	4,264	4,184	4,232	4,098	4,166
Federal Military	5,819	7,109	7,224	7,006	7,087	7,026	6,700
State and Local	17,296	19,875	19,646	19,808	19,577	17,003	19,106

1/ Data withheld to avoid disclosing information on individuals.

Source: U.S. Department of Commerce, Bureau of the Census, Regional Economics Information System, April 1982.

Cass County has the highest employment in the SPA because the county seat of Fargo is the center for much of the business activity in the SPA.

Annual unemployment for the area has typically been between four and five percent (Table II-3-4).

TABLE II-3-4 AVERAGE ANNUAL UNEMPLOYMENT RATE
COUNTIES OF RED RIVER STATISTICAL PLANNING AREA

	Percent								
County	1972	1973	1974	1975	1976	1977	1978	1979	1980
Barnes	3.2	3.6	3.3	3.9	3.9	5.0	3.7	3.6	4.6
Cass	3.2	3.1	3.0	4.3	3.9	3.9	3.4	3.3	4.0
Grand Forks	4.2	4.4	3.9	5.6	4.8	5.2	4.3	4.5	5.3
Griggs	3.6	3.2	3.4	3.8	4.6	6.3	3.8	3.4	2.9
Nelson	5.8	6.4	5.4	5.2	5.4	5.2	4.1	3.9	4.7
Pembina	7.2	6.8	6.7	5.9	6.4	7.4	6.1	6.2	6.7
Ransom	3.7	4.1	7.0	3.4	3.7	4.5	3.2	3.5	4.5
Richland	4.1	4.0	3.6	4.3	4.9	6.9	4.4	4.5	6.1
Sargent	3.5	3.6	3.5	4.1	4.7	7.0	4.2	3.5	7.7
Steele	4.0	5.0	3.4	3.7	4.8	4.0	2.8	3.6	3.8
Traill	3.3	3.6	3.0	3.5	3.9	5.7	4.3	4.5	4.5
Walsh	5.5	5.5	5.4	6.2	6.4	6.2	5.6	4.7	4.9
Red River SPA	4.3	4.4	4.3	4.5	4.8	5.6	4.2	4.1	5.0
North Dakota	4.9	5.1	4.6	5.2	5.1	5.5	4.3	4.2	5.0
United States	5.6	4.9	5.6	8.5	7.7	7.0	6.0	5.8	7.1

Source: North Dakota Employment Security Bureau, Unadjusted Annual Averages.

Income Characteristics

Total labor and proprietors income for the Red River SPA increased from $619.3 million in 1970 to $1,489.7 million in 1980 (Table II-3-5). There has been a general increase in income with highs and lows having direct correlation to the price fluctuations of agricultural commodities.

Farm income in the Red River SPA and for the State of North Dakota varies greatly from year to year. The major cause is commodity price instability, but weather, government farm programs, and other factors also contribute.

The percent of families in specified income brackets in the Red River SPA for 1969 are: 10.0 percent earned less than $3,000; 13.2 percent earned $3,000 or more but less than $5,000; 16.7 percent earned $5,000 but less than $7,000; and 60.1 percent earned $7,000 or more. By using the same specified income brackets, the percentages for North Dakota area: 12.1, 14.3, 16.9, and 56.7, respectively.

TABLE II-3-5 PERSONAL INCOME BY MAJOR SOURCES
FOR THE RED RIVER STATISTICAL PLANNING AREA

	1970	1975	1976	1977	1978	1979	1980
Total Labor and Proprietors Income (1000's)	619,258	1,219,577	1,194,789	1,190,201	1,509,397	1,462,625	1,489,701
Per Capita Personal Income	3,361	6,291	6,166	6,215	7,656	7,676	8,333
Labor Income by Industry (1000's)							
Farm[1/]	84,977	264,156	109,555	30,496	220,136	33,610	(-44,000)
Manufacturing	29,903	98,787	115,835	114,008	123,552	139,637	145,584
Mining	0	779	1,117	566	126	169	137
Contract Construction	41,938	87,519	112,557	107,188	123,104	130,516	117,880
Wholesale & Retail Trade	131,239	238,538	271,160	282,963	280,608	313,516	343,449
Finance Insurance & Real Estate	29,923	52,761	59,489	74,157	84,141	92,982	48,001
Transportation, Comm., and Pub. Util.	45,986	85,266	98,779	109,538	123,745	146,566	156,307
Services	78,697	139,156	158,422	179,965	203,393	229,030	266,898
Other	58	2,254	2,394	1,867	1,892	1,380	3,502
Federal Civilian	33,905	61,901	56,000	59,529	65,056	67,480	73,611
Federal Military	48,216	61,737	67,254	67,531	70,021	72,633	72,585
State and Local	81,523	122,933	138,075	160,150	173,854	194,496	202,455

Source: U.S. Department of Commerce, Bureau of the Census, Regional Economics Information System, April 1982.

ECONOMIC BASE

Description of the Study Area

One way to gain a perspective of the economic activity in the Red River SPA is to trace each sector's contribution to the total economy. It is normal for a sector's contribution to the area's economy to fluctuate in respect to the other sectors. However, the major contributors remain the same; only their ranking varies with time and various stimuli (Table II-3-6).

TABLE II-3-6 PERCENT OF TOTAL EARNINGS BY SECTOR
FOR THE RED RIVER STATISTICAL PLANNING AREA[1/]

Sector	1970	1975	1976	1977	1978	1979	1980
	Percent of Total Earnings[2/]						
Farm[3/]	13.7	21.7	9.2	2.6	14.6	2.3	0.0
Manufacturing	4.8	8.1	9.7	9.6	8.2	9.5	9.8
Mining	0.01	0.1	0.1	0.01	0.01	0.01	0.01
Construction	6.8	7.2	9.4	9.0	8.6	8.9	7.9
Wholesale and Retail Trade	21.2	19.6	22.7	23.8	18.6	21.4	23.1
Finance, Ins. and Real Estate	4.8	4.3	5.0	6.2	5.6	6.4	3.2
Transportation, Comm., and Pub. Util.	7.4	7.0	8.3	9.2	8.2	10.0	10.5
Services	12.7	11.4	13.3	15.1	13.5	15.7	17.9
Other	0.0	0.2	0.2	0.2	0.1	0.1	0.2
Federal, Civilian	5.5	5.1	4.7	5.0	4.3	4.6	4.9
Federal, Military	7.8	5.1	5.6	5.7	4.6	5.0	4.9
State and Local	13.2	10.1	11.6	13.5	11.5	13.3	13.6

1/ Computed from Regional Economics Information System data compiled in table II-3-5.

2/ Total percentages will not add to 100 because of non-disclosure policies of U.S. Department of Commerce.

3/ Red River Statistical Planning Area had a negative farm income of $44 million in 1980.

Agriculture

The Red River SPA, like the rest of North Dakota, is highly dependent on agriculture for its livelihood. The health of North Dakota's economy is directly related to the farm economy situation.

Farms have gradually gotten larger in size and fewer in number.

In 1970, approximately 81 percent of the total land area was under cultivation.

The value of crop products sold has typically been about 70 to 75 percent, but has risen in recent years to almost 90 percent of the total value of agricultural products sold. Livestock, poultry, and their products account for most of the remainder (Table II-3-7).

TABLE II-3-7 FARM SIZE AND VALUE OF PRODUCTION FOR RED RIVER STATISTICAL PLANNING AREA[1/]

	1949	1954	1959	1964	1969	1974	1978[2/]
Number of Farms	19,138.0	18,341.0	16,172.0	14,096.0	12,875.0	11,537.0	10,904.0
Land in Farms (000's)	8,328.8	8,359.4	8,251.5	8,301.5	8,482.9	8,382.0	8,296.7
Average Farm Size (Acres/Farm)	435.2	455.8	510.2	589.2	658.9	726.5	760.9
Total Value of Ag. Products Sold ($1,000)	144,276.0	145,007.0	178,544.0	197,597.0	252,402.0	678,764.0	678,419.0
Value of Crops Sold ($1,000)	104,880.0	109,072.0	127,619.0	142,059.0	189,294.0	360.181.0	584,244.0
Percent of Total[3/]	72.7	75.2	71.5	71.9	75.0	53.1	86.1
Value of Livestock, Poultry & Their Products Sold ($1,000)	39,388.0	35,931.0	50,613.0	55,473.0	63,091.0	77,835.0	78,797.0
Percent of Total	27.3	24.8	28.3	28.1	25.0	11.5	11.6

[1/]Source of data is U.S. Census of Agriculture for years 1949 through 1978.

[2/]Preliminary data.

[3/]Due to nondisclosure policies of Bureau of Economic Analysis, some data in some counties for categories (sectors, crop, etc.) labled "D" were suppressed; consequently the actual percentage for these sectors may be understated.

Table II-3-8 shows historical acreages of major crops harvested, table II-3-9 the production of those crops, and table II-3-10 the livestock inventory for various years in the SPA.

TABLE II-3-8 HISTORICAL ACRES OF MAJOR CROPS HARVESTED RED RIVER STATISTICAL PLANNING AREA[1/]

Crop	Unit	1949	1954	1959	1964	1969	1974	1978[2/]
Wheat	Ac.	2,162,010	1,593,624	1,291,466	1,333,377	1,467,719	2,713,477	2,276,099
Oats	Ac.	603,668	680,086	613,141	670,575	898,656	285,402	189,785
Barley	Ac.	737,581	1,230,171	1,375,809	905,199	956,836	866,794	1,174,800
Rye	Ac.	57,698	65,493	43,394	66,223	33,132	23,763	18,355
Sunflower[3/]	Ac.	---	---	---	---	105,000	296,000	1,072,600
Flax[4/]	Ac.	600,263	872,122	594,350	558,064	461,000	231,500	80,500
Corn Grain	Ac.	328,090	226,905	223,548	149,584	100,104	135,609	214,337
Corn Silage	Ac.	52,162	126,579	152,947	143,206	76,317	78,467	53,017
Hay	Ac.	614,156	709,963	585,534	538,182	386,869	459,702	346,866
Soybeans	Ac.	19,845	47,057	201,681	188,739	180,339	151,449	155,910
Potatoes	Ac.	88,078	86,209	94,371	91,319	107,459	98,737	133,293

1/ Source of data is U.S. Census of Agriculture for years 1949 through 1978.
2/ Preliminary data.
3/ Sunflower data are from North Dakota Crop and Livestock Statistics.
4/ Flax data for 1969, 1974, and 1978 were obtained from North Dakota Crop and Livestock Statistics.

TABLE II-3-9 HISTORICAL PRODUCTION OF MAJOR CROPS HARVESTED RED RIVER STATISTICAL PLANNING AREA[1/]

Crop	Unit	1949	1954	1959	1964	1969	1974	1978[2/]
Wheat	Bu.	28,956,496	19,690,129	30,061,747	34,148,261	47,280,761	65,105,107	72,760,348
Oats	Bu.	13,966,533	20,233,387	20,912,412	28,949,319	55,532,618	11,123,858	10,700,276
Barley	Bu.	13,032,838	30,361,992	34,117,186	30,768,126	41,448,703	29,857,130	57,629,791
Rye	Bu.	884,305	1,179,450	698,290	1,436,769	1,026,765	637,950	564,588
Sunflower[3/]	(000 lbs)	---	---	---	---	94,560	291,430	1,547,919
Flax[4/]	Bu.	5,151,809	6,977,184	4,957,539	3,936,806	5,839,750	1,989,000	1,050,700
Corn Grain	Bu.	8,155,370	6,053,865	5,108,874	4,582,355	6,226,607	6,852,251	15,764,778
Corn Silage	Tons	229,862	566,198	660,904	711,766	544,186	587,151	409,499
Hay	Tons	596,742	874,874	683,173	734,679	662,567	761,403	670,198
Soybeans	Bu.	131,066	681,750	2,421,655	2,591,666	2,089,454	2,501,578	4,109,423
Potatoes	Cwt.	10,008,624	10,909,140	11,757,381	10,214,249	15,759,077	20,387,453	22,588,265

1/ Source is U.S. Census of Agriculture for years 1949 through 1978.
2/ Preliminary data.
3/ All sunflower data are from North Dakota Crop and Livestock Statistics.
4/ Flax data for 1969, 1974, and 1978 were obtained from North Dakota Crop and Livestock Statistics.

TABLE II-3-10 NUMBER OF HEAD OF LIVESTOCK
RED RIVER STATISTICAL PLANNING AREA

Livestock	1949	1954	1959	1964	1969	1974	1978[1]
All Cattle and Calves	316,981	404,469	359,649	446,982	336,536	373,524	273,743
Milk Cows	95,126	86,249	109,156	47,800	22,681	16,175	12,752
All Sheep and Lambs	121,284	224,784	245,398	156,205	100,745	54,195	36,486
All Hogs and Pigs	124,821	199,009	215,022	152,352	125,305	142,217	127,736
Horses and Ponies [2]	29,033	14,394	8,180	N/A	5,035	3,629	4,858
Chickens 4 mo. and Older	1,250,790	1,615,664	1,022,081	632,450	269,264	318,206	141,310

1/Preliminary data.
2/Not available.

Source: U.S. Census of Agriculture for years 1949 through 1978.

Manufacturing

The manufacturing sectors contribution to the SPA's total economy has doubled from 4.8 percent in 1970 to 9.8 percent in 1980. This contribution is relatively small when compared to the total economy, but the percentage increase within the sector is significant because much of North Dakota's manufactured goods, primarily farm equipment, come from the Red River SPA.

Wholesale and Retail Trade

The presence of several large trade centers accounts for the large contribution by the wholesale and retail trade sector. This contribution has typically been between 19 and 24 percent of the total economy.

Surface Water

The Red River Basin encompasses an area of about 17,250 square miles in North Dakota of which an estimated 3,000 square miles are noncontributing. The drainage system consists of the mainstem Red River and its tributaries. The principal ones in North Dakota are the Wild Rice, Sheyenne, Goose, Forest, Park, and Pembina Rivers. Drainage is poorly developed at the headwaters of these tributaries in the drift prairie and not well defined topographically in the Red River valley.

Runoff in the Basin is greatest in early spring when snow meltwater is moving down the drainage system. Median annual runoff for the North Dakota part of the Basin varies from less than 0.25 inches to over 1.00 inches. Flow in the mainstem Red River also is the result of runoff from Minnesota portion of the Basin where annual precipitation and annual runoff are higher than in North Dakota. The Red River is prone to widespread flooding because of low stream gradients, subdued stream banks, and flat topography of the valley. A network of 45 stream-gaging and stage-measuring stations monitor streamflow in the Red River Basin. Streamflow records are summarized in Table II-3-11.

TABLE II-3-11 SUMMARY OF STREAMFLOW RECORDS
RED RIVER BASIN

River	Measuring Location	Discharge (cfs) Average	Maximum	Minimum	Annual Average Discharge (AF)
Red	Wahpeton	535	9,200	1.7	387,322
Red	Hickson	550	9,600	0	398,182
Red	Fargo	558	25,300	0	403,973
Red	Grand Forks	2,551	85,000	1.8	1,846,839
Red	Drayton	3,843	92,900	7.7	2,782,203
Red	Emerson, Manitoba	3,310	95,500	0.9	2,396,329
Wild Rice	Abercrombie	75.3	9,540	0	54,515
Sheyenne	West Fargo	173	3,480	1.0	125,246
Goose	Hillsboro	69	14,800	0	49,954
Forest	Minto	51	16,600	0	36,922
Park	Grafton	57.9	12,600	0	41,918
Pembina	Neche	195	10,700	0	141,173

Note: The period of record for the Red River at Emerson, Manitoba exceeds that at Drayton. This accounts for the lower average discharge and annual discharge shown for Emerson.

Storage of surface in the Red River Basin is currently provided by 117 dams. Normal storage capacity of these dams totals 151.9 thousand AF, ranging from 11 AF to 70,700 AF for Lake Ashtabula. Maximum storage capacity totals 305.0 thousand AF with a range between 52 AF and 116,500 AF for Lake Ashtabula.

Surface-water quality is quite variable, responding to such diverse factors as changes in streamflow, time of year, climate, substances in and entering the stream channel, ground-water inflow, and practices of land and water management. There generally is an inverse relationship between water quality and amount of water flowing in the channel.

Surface water in the Red River Basin is predominantly a calcium-magnesium bicarbonate type, very hard, with dissolved solids concentrations averaging 330-460 mg/l. The range, however, is 150 mg/l during high streamflow to 3,650 mg/l during low-flow conditions. Water quality in the tributaries is about the same as on the mainstem Red.

The importance of North Dakota's wetlands as wildlife habitat has been established. Of a more controversial nature is the manner in which these wetlands function in the State's surface-water and ground-water resources, that is their relationships in surface-water hydrology and quality and the interaction between surface water and ground water.

The 1964 Wetlands Inventory indicated a total of 73,865 wetlands covering 230,594 acres in the Red River SPA (Table II-3-12) or about 2.7 percent of the SPA area. The results of the 1964 Inventory are considered to be conservative. A new wetlands inventory by the U.S. Fish and Wildlife Service is in progress and is based on a detailed classification hierarchy different from that used for the 1964 inventory.

TABLE II-3-12 1964 WETLAND INVENTORY FOR THE RED RIVER STATISTICAL PLANNING AREA

Wetland Type		Total Number	Total Acres
I		27,699 1/	30,078 2/
III		42,233	96,206
IV		3,609	66,771
V		268	29,653
X 3/		28	2,766
XI 3/		28	5,120
	TOTAL	73,865	230,594

1/Type I wetland numbers were estimated at 60 percent of the total wetland numbers.

2/Type 2 wetland acres were estimated at 15 percent of the total wetland acres.

3/Data were available only for Grand Forks, Nelson, and Pembina Counties.

Source: U.S. Fish and Wildlife Service 1964 Inventory of Wetlands.

Water quality of wetlands can be quite variable both in time and area. The variability is influenced by the combination of many factors such as climate, time, watershed characteristics, surface-water hydrology, and ground-water interaction.

Ground Water

Aquifers occur both in the bedrock and Quaternary sediments in the Red River Basin. Bedrock aquifers include fractured Precambrian crystalline rocks, the sandstones and carbonates of the Ordovician Winnipeg and Big Horn Groups, Jurassic limestones and sandstones, the Dakota Group sandstones, the Niobrara Formation, the Pierre and Fox Hills Formations of the Montana Group, the Hell Creek Formation, and the basal Fort Union Group (Figure I-2-9).

Fractured zones occur locally in the Precambrian crystalline rocks. Such zones form aquifers where they are saturated. In local areas of Richland and Cass Counties where the overlying Quaternary sediments are lacustrine silts and clays, these aquifers are the only source of ground water. The water, typically used for rural domestic and livestock supplies, is soft and high in sodium. Well yields are generally small.

The sandstone, limestone, and dolomite of the Ordovician Black Island, Red River, Stony Mountain, and Stonewall Formations form aquifers overlying the Precambrian basement rocks. Several wells and testholes are completed in this group of aquifers in Pembina County and a few testholes have been drilled in Griggs and Steele Counties. The testholes in Pembina County flowed at rates of less than 10 gallons per minute, and one well flowed at 500-700 gallons per minute. The water is very high in dissolved solids and can be classified as a brine. The significance of these aquifers is their hydrologic relationship to overlying formations and possible upward flow of ground water into the overlying aquifers.

The basal Jurassic rocks are chiefly sandstones with minor interbedded limestones which form the aquifer. Overlying the aquifer are confining beds of shale and siltstone. Available data indicate the confining shales and siltstones separate the brines of the Ordovician and Jurassic aquifers from the less mineralized water in the younger aquifers. The ground-water flow systems within these aquifers needs further study.

The sandstone beds of the Dakota Group, the Inyan Kara and Newcastle Formations constitute the deepest bedrock aquifer of practical importance in the Red River Basin. Depth to the Dakota aquifer increases from less than 100 feet in parts of the Red River valley to around 3,000 feet in the west part of the Basin. The Dakota aquifer is of importance in the east part of the Basin because it is the only source of ground water in areas where shallower aquifers are absent. Also, in many areas the water is under sufficient hydrostatic pressure to produce flowing wells. The Dakota aquifer consists of lenticular sandstone units interbedded with shale and siltstone. Total thickness of the sandstone beds is widely variable, ranging from less than 10 feet to over 650 feet. Well yields are also quite variable depending on the thickness of the aquifer present, how much of the aquifer thickness is screened in the well, and the presence of interstitial silt and clay. Wells that are pumped yield between 50 and 500 gallons per minute. Flowing wells generally yield 50 gallonsper-minute or less. The ground water in the Dakota aquifer is a sodium chloride type with dissolved solids concentrations ranging from around 3,000 to nearly 30,000 mg/l. Concentrations of sulfate and iron are typically high. The quality of the water generally worsens from east to west across the Basin as depth of the aquifer increases.

The Niobrara Formation is locally an important aquifer in western Pembina and northeastern Cavalier Counties. The aquifer consists of large interconnected joints and fractures in the calcareous shale. Recharge is from vertical leakage from the overlying glacial drift. The water is hard with dissolved solids concentrations ranging from about 400 to 2,500 mg/l.

The Pierre aquifer occurs in the upper 50 to 200 feet of the Pierre Formation where the hard siliceous shale is fractured. The fracture system is locally variable in thickness and areal extent. The Pierre aquifer is the source of water for many farms and cities in many areas in east-central North Dakota where the overlying drift is thin and glacial-drift aquifers are absent. Recharge to the Pierre aquifer is chiefly by downward percolation from the overlying drift. Well yields typically are less than 10 gallons-per-minute, but may approach 300 gallons per minute where the aquifer is thick and extensive. The water becomes more mineralized with depth in the aquifer and changes from a sodium bicarbonate or sodium sulfate type to a sodium chloride type. Dissolved solids concentrations vary from about 300 to 4,000 mg/l. The concentrations of dissolved solids and sulfate generally exceed the recommended standards for drinking water.

In the extreme western part of the Red River Basin in the Sheyenne River Subbasin, sandstone beds of the Fox Hills and Hell Creek Formations and of the basal Fort Union Group yield small quantities of water mostly to rural domestic and livestock wells. The aquifer consists of beds of semiconsolidated, very fine- to medium-grained sandstone which vary in thickness from one to about 100 feet. Interbedded with the sandstone are mostly shales, siltstones, and claystones. Well yields range from less than 10 to 50 gallons-per-minute depending upon thickness of the sandstone beds. The water is typically soft and a sodium bicarbonate type with dissolved solids concentrations varying between 380 and 2,470 mg/l. The water is generally suitable for domestic and livestock use, but marginal to unsuitable for irrigation.

The glacial-drift aquifers are glaciofluvial deposits of sand and gravel buried in meltwater and diversion channels or preglacial and interglacial stream valleys. The most extensive of these aquifers is in the western part of the Basin and is part of a broad system of aquifers more or less hydrologically connected. This system extends from the Souris River Basin in McHenry County and the Devils Lake Basin in Ramsey County across the boundaries of the James and Red River Basins to the south exiting into South Dakota (Plate I-2-1). Potential yields to wells tapping these aquifers range from less than 50 to more than 500 gallons-per-minute. Water quality is highly variable with calcium, magnesium, sodium, bicarbonate, and sulfate the predominant ions. Dissolved solids range from 200-2,000 mg/l. Other important aquifers in the Basin occur into the deltas deposited in near-shore environments of glacial Lake Agassiz. The aquifers consist of lenticular deposits of sand and gravel which are interbedded with lacustrine silts and clays, and till. Due to the nature of the aquifer, potential well yields are typically less than 500 gallons-per-minute. Major aquifers of deltaic origins are located in Richland and eastern Ransom Counties, northwestern Cass and southeastern Steele Counties, and western Grand Forks Counties. Scattered throughout the drift in the Basin are buried lenses and stringers of sand and gravel that are relatively thin and of limited areal extent. Sustained yields to wells completed in these aquifers are small, suitable for domestic or livestock supplies.

Land Resources

The Red River Statistical Planning Area consists of a combination of drift prairie and nearly level lacustrine former lake bottom drained by the Red River. The physical landscape is due to glacial action and the action of glacial meltwater. The predominant natural vegetative cover was that of tall grass. Glacial till and lake deposited sediments created the parent material for the black soils of the region resulting from the grassland cover.

Land Use and Ownership

The Red River SPA possesses the largest percentage of cropland of all the statistical areas. The annual generations of grass decaying to form humus has created fertile soils as a direct result of the more humid characteristics of eastern North Dakota. Land Use categories and the precentage of each is: Cropland 81%; Pastureland 4%; Rangeland 5%; Forest 2%; Urban and Built-up 3%; Other Land 4%; and Water Areas 1% 1/. The number of farms with this statistical planning area was 10,904 as of 1978 2/. Land ownership estimates place taxable land or private land at roughly 98% and non-taxable land at 2% of the total area which is almost 8,700 acres in size 3/.

Production Capability

Many factors influence the productivity of the area's soils. Some of these include soil type, fertility, climate, and slope. The U.S. Soil Conservation Service has identified and mapped erodible soils, prime farmlands, and important farmlands.

Current and Projected Production

The total value of agricultural products sold has increased gradually over the last thirty years with yearly advances outstripping declines. The total value of agricultural products sold in 1978 amounted to $678.4 million 2/. Growing season conditions and commodity prices determine the yearly aberrations in the total value of this trend. The value of crop products in the most recent years has risen to over 85% of the total value of agricultural products sold in 1978 2/.

In the long-term, improvement in crop varieties will continue to gradually increase crop yields per acre.

Although small grains dominate in acreage and production for the Red River SPA, changes in types of crops grown could readily occur. The area is best suited, statewide, for the growth of row or specialty crops with locally important crops of corn, sugar beets, potatoes, sunflowers, and beans historically being produced. Small grain production is not expected to significantly wane due to its place in cropping rotations, or patterns. Prices received for crops or livestock will determine the degree of change.

Irrigation has potential to increase production, but will be largely dependent on suitable and reliable water supplies.

Any additional acreage brought into the cropland will be at the expense of the pasture, range or forest land use categories. This acreage would probably be somewhat limited because of the existing high percentage of cropland. Lands which are taken out of the cropland category are expected to offset the new cropland acres which would be added. Increased production will probably come from approximately the same number of acres now in cropland.

Land Treatment

Table II-3-13 shows the status of land treatment in the Red River SPA.

TABLE II-3-13 LAND TREATMENT IN THE RED RIVER STATISTICAL PLANNING AREA

Status	Cropland Acres	%	Pasture Acres	%	Range Acres	%	Forest Acres	%	Other Acres	%	Total Acres	%
	000		000		000		000		000		000	
Adequately Treated	4,515	64	246	53	257	53	65	40	371	70	5,454	63
Needing Treatment	2,539	36	215	47	225	47	99	60	157	30	3,235	37
Total	7,054	81	461	5	482	6	164	2	528	6	8,689	100

Source: U.S.D.A. Soil Conservation Service, North Dakota Management Form No. 2, 1980.

References:
1/ U.S.D.A. Soil Conservation Service Needs Inventory, July 1970
2/ U.S. Census of Agriculture, 1978
3/ NDSU Soils Department from County Tax Information

CHAPTER 4

THE DEVILS LAKE BASIN

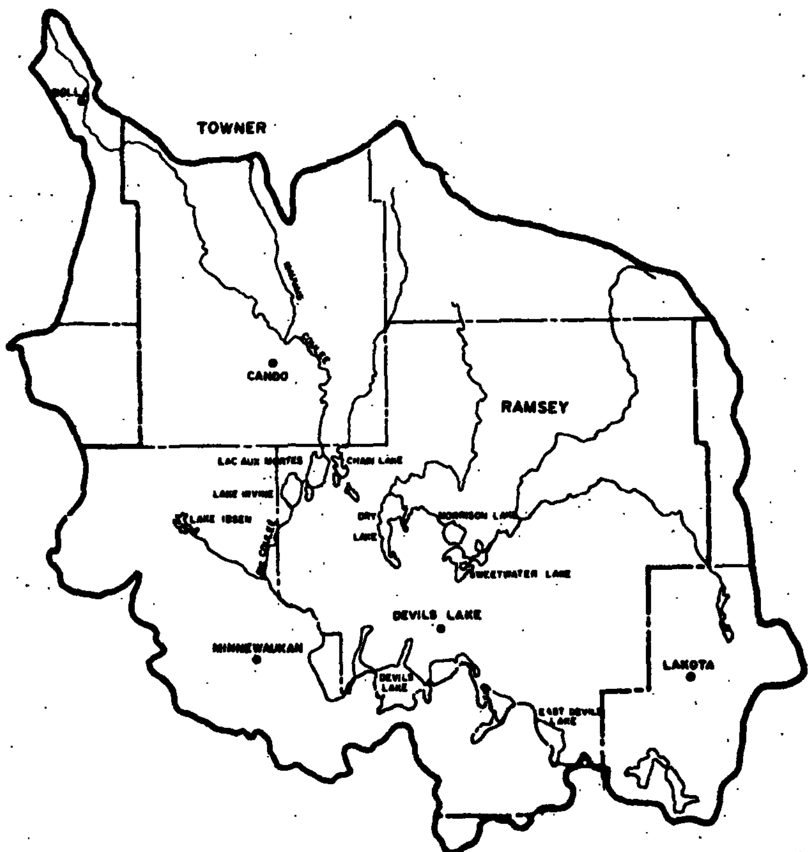
PHYSICAL DESCRIPTION

Geography

The Devils Lake Basin, located in northeastern North Dakota, is a closed or noncontributing basin encompassing approximately 3,580 square miles or five percent of the State's land surface. Runoff is trapped within the Basin and prevented from leaving by the topography. Devils Lake serves as the ultimate collecting point for a majority of the Basin's surface runoff. Of the total drainage area, about 1,300 square miles are noncontributing. Extensive areas, particularly in the upper Basin, are noncontributing or partially contributing, depending on climatic conditions.

It is believed that the highest water elevation of Devils Lake, which occurred sometime around 1830, was 1,441 feet or 40 feet above the lowest known stage. The maximum elevation of Devils Lake recorded by the U.S. Geological Survey was 1,438.3 feet in 1867, after which the level showed a gradual downward trend to a low of 1,400.9 feet in 1940. Since then, the trend has reversed; the Lake level reached 1426.50 feet by September of 1982 and appears to be still rising.

FIGURE II-4-1 SUBBASIN DELINEATION - DEVILS LAKE BASIN



Within the Devils Lake Basin lies a chain of waterways beginning with the Sweetwater group and extending through Mauvais Coulee, Devils Lake, East Bay Devils Lake, and East Devils Lake to Stump Lake. At times when lake levels are high, Mauvais Coulee drains the Sweetwater group, discharging considerable water into Devils Lake. Mauvais Coulee, principal tributary to Devils Lake, is the largest drainage channel in the Devils Lake system. Water flows in it intermittently, largely in response to snowmelt and excessive precipitation during the spring.

The Sweetwater group of lakes, which includes Sweetwater Lake, Dry Lake, Lac Aux Mortes (Lake Alice), and Lake Irvine, is the first link in the Devils Lake chain. Unlike Devils Lake and other major lakes located in the lower portion of the basin, the Sweetwater group, as suggested by the name, consists of fresh-water lakes. Prior to the time of a general decrease of lake levels in the basin, the Sweetwater lakes were connected, and at times discharged by a series of small coulees. The general decline in lake levels ended the flow between lakes, causing the Sweetwater group to become disconnected bodies of water whose depths vary with climatological changes. Under average runoff conditions, these lakes are shallow, often marshy or nearly dry; in fact, portions of Sweetwater Lake, Lake Irvine, and Dry Lake were cropped during the 1960's. Sweetwater Lake was nearly dry during the drought years of the 1930's; yet it has overflowed numerous times in the last two decades. During such overflow periods, extensive sheet-water flooding occurs in the Sweetwater-Dry Lake area. In earlier times, before the channels linking the Sweetwater group of lakes became partially filled with blow-dirt and choked with vegetation, normal runoff could escape without causing the damaging floods which now occur periodically.

Geology

The bedrock geology of the Devils Lake Basin is similar to that of the James River Basin and western Red River Basin. The Devils Lake Basin is located on the eastern flank of the Williston Basin with the preserved thickness of sedimentary rock increasing from about 2,000 feet in the east to nearly 4,000 feet in the west. Rocks of Ordovician through Mississippian unconformably underlie the Pierre and Fox Hills Formations which are overlain by glacial deposits (Figure I-2-9).

The Devils Lake Basin is a closed basin of some 3,580 square miles. It is the result of the last advance of continental ice sheets in North Dakota. The west and south drainage divides of the Basin are defined by end moraines; the rest of the Basin is enclosed by broad, low divides in the ground moraine mantling the basin. Glacial Devils Lake was maintained at about elevation 1,450 feet by glacial meltwater flowing from the retreating ice sheet to the north, by precipitation, and snow meltwater. Drainage was to the south and down the ancestral Sheyenne River. The Devils Lake Basin became a closed basin when the southerly drainage ceased and the amount of water flowing into the Basin became less than subsurface outflow or water lost by evapotranspiration. Evidence in the Basin suggests that water levels have fluctuated from the time the ice sheets completely melted away from the Basin through recent recorded time. The underlying causes of the long-term changes in water levels are not fully understood.

SOCIO-ECONOMIC CHARACTERISTICS

The Devils Lake Statistical Planning Area (SPA) contains the counties of Benson, Cavalier, Ramsey, and Towner. The Devils Lake SPA is 5,206 square miles in size with a 1980 population of 32,644 or about five percent of North Dakota's population (Table II-4-1). Devils Lake is the largest city in the region with a population of 7,441 or about 23 percent of the total population of the Devils Lake SPA. Other major cities and their 1980 population estimates are Cando, 1,496; and Langdon, 2,335. These three cities combine to form about 34 percent of the total Devils Lake SPA population.

TABLE II-4-1 POPULATION ESTIMATES OF DEVILS LAKE STATISTICAL PLANNING AREA

County	1960[1/]	1970[2/]	1980[3/]	% Change 1960-1970	% Change 1970-1980
Benson	9,435	8,245	7,944	- 12.6	-3.7
Cavalier	10,064	8,213	7,636	- 18.4	-7.0
Ramsey	13,443	12,915	13,048	- 3.9	+1.0
Towner	5,624	4,645	4,052	- 17.4	-12.8
Devils Lake SPA	38,566	34,018	32,680	- 11.8	-3.9
North Dakota	632,446	617,761	652,437	- 2.3	+ 5.6
Percent of State	6.1	5.5	5.0	N/A	N/A

[1/] U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1960.

[2/] U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1970.

[3/] U.S. Bureau of the Census, Preliminary Population and Housing Unit Counts, November, 1980.

The urban population has increased due mainly to increased job opportunities in the urban areas. There has been a steady decline in the rural population due to increased mechanization of farms and increased farm size. The rural population of the Devils Lake SPA has dropped by 7,023 persons, from 32,261 in 1960 to 25,238 in 1980 (Table II-4-2).

In 1929, the population of the area totaled about 52,000. The population has declined to a low of 32,680 in 1980.

The area has a 1980 population density of 6.3 persons per square mile compared to 8.7 persons per square mile for the whole State.

TABLE II-4-2 RURAL AND URBAN POPULATION FOR DEVILS LAKE STATISTICAL PLANNING AREA[1/]

	1960		1970		1980	
	Number	Percent	Number	Percent	Number	Percent
Urban[2/]	6,305	16.3	7,078	20.8	7,442	22.8
Rural	32,261	83.7	26,940	79.2	25,238	77.2
Farm[3/]	17,002	44.1	12,858	37.8	NA	NA
Nonfarm[4/]	15,259	39.6	13,906	40.9	NA	NA
Total Population	38,566	100.0	34,018	100.0	32,680	100.0

[1/]Source: U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1960 and 1970; Part 36, PC 80-1-136, 1980.

[2/]Urban inhabitants are persons living in all incorporated places and unincorporated places of 2,500 persons or more.

[3/]Farm inhabitants are persons defined as actively farming 10 or more acres with sales of $50 or more per year and farms of less than 10 acres with sales of $250 or more per year.

[4/]Nonfarm inhabitants are rural residents not actively farming.

Employment Characteristics

Employment in the Devils Lake SPA dropped from 16,049 in 1970 to 15,522 in 1980, or three percent. The farm sector of the economy encompasses over 70 percent of all individual proprietors but has a small portion of the total wage and salary employment. The reason for this is that most of the farms and ranches are owned and operated by the operator and his family with very little outside employment; whereas non-farm proprietors hire most of the labor force in the area.

Total employment and number of persons employed in each sector is shown in Table II-4-3.

Ramsey County has the highest employment in the SPA because Devils Lake is the state and local government and wholesale and retail trade center.

Annual unemployment for the area has typically been between five and six percent (Table II-4-4).

TABLE II-4-3 EMPLOYMENT BY TYPE AND BROAD INDUSTRIAL SOURCES
FULL AND PART-TIME WAGE AND SALARY EMPLOYMENT PLUS NUMBER
OF PROPRIETORS FOR THE DEVILS LAKE STATISTICAL PLANNING AREA

	1970	1975	1976	1977	1978	1979	1980
TOTAL EMPLOYMENT	16,049	17,386	16,914	16,199	16,530	12,973	15,522
Number of Proprietors	6,174	5,217	5,188	5,217	5,276	5,273	5,242
Farm Proprietors	4,237	3,887	3,845	3,803	3,818	3,814	3,719
Non-Farm Proprietors	1,936	1,330	1,343	1,414	1,458	1,459	1,523
Wage and Salary Employment	9,876	12,169	11,726	10,982	11,254	11,000	10,280
Farm	753	609	678	570	625	604	637
Non-Farm	9,123	11,560	11,048	10,412	10,629	10,396	9,643
Private Non-Farm	6,330	7,434	7,420	7,142	7,305	7,460	7,242
Mining1/	0	0	0	0	0	0	0
Construction	250	634	687	595	525	514	469
Manufacturing	N/A	544	466	443	542	632	543
Trans., Comm., and Pub. Util.	350	502	480	505	517	510	484
Wholesale and Retail Trade	2,271	2,752	2,777	2,784	2,559	2,475	2,548
Finance, Ins. and Real Estate	169	339	364	379	397	410	407
Services	1,500	2,596	2,580	2,365	2,190	2,335	2,449
Other	0	41	41	N/A	24	14	37
Government	2,793	4,126	3,628	3,270	3,324	2,936	2,401
Federal Civilian	445	582	440	377	365	367	365
Federal Military	27	767	517	272	258	262	209
State and Local	2,321	2,777	2,671	2,621	2,701	2,307	1,827

1/Data withheld to prevent disclosing information on individuals.

Source: U.S. Department of Commerce, Bureau of the Census, Regional Economics Information System, April 1982.

TABLE II-4-4 AVERAGE ANNUAL UNEMPLOYMENT RATE
COUNTIES OF DEVILS LAKE STATISTICAL PLANNING AREA

County	1972	1973	1974	Percent 1975	1976	1977	1978	1979	1980
Benson	9.9	10.3	8.3	8.3	7.2	7.8	7.1	5.8	7.7
Cavalier	3.7	4.7	4.9	5.9	6.1	6.5	5.9	4.4	4.2
Ramsey	4.4	4.5	4.3	4.2	4.0	5.5	4.4	3.7	4.3
Towner	3.2	3.6	3.7	3.0	3.5	3.7	2.8	2.3	2.6
Devils Lake SPA	5.3	5.8	5.3	5.4	5.2	5.9	5.1	4.1	4.7
North Dakota	4.9	5.1	4.6	5.2	5.1	5.5	4.3	4.2	5.0
United States	5.6	4.9	5.6	8.5	7.7	7.0	6.0	5.8	7.1

Source: North Dakota Employment Security Bureau, Unadjusted Annual Averages.

Income Characteristics

Total labor and proprietors income for the Devils Lake SPA increased from $77.9 million in 1970 to $146.3 million in 1980 (Table II-4-5). There has been a general increase in income with highs and lows having direct correlation to the price fluctuations of agricultural commodities.

Table II-4-5 PERSONAL INCOME BY MAJOR SOURCES FOR THE DEVILS LAKE STATISTICAL PLANNING AREA

	1970	1975	1976	1977	1978	1979
Total Labor and Proprietors Income (1000's)	77,946	195,152	149,205	112,942	192,106	
Per Capita Personal Income	2,826	6,896	5,821	5,385	8,119	
Labor Income by Industry (1000's)						
Farm	16,504	95,551	48,036	14,500	85,759	
Manufacturing	D	6,655	5,208	4,277	5,078	
Mining	D	D	55	D	D	
Contract Construction	2,235	8,890	9,875	9,265	9,108	
Wholesale & Retail Trade	14,198	25,026	28,135	27,257	25,038	
Finance Insurance & Real Estate	1,657	3,843	4,533	5,881	6,629	
Transportation, Comm., and Pub. Util.	3,507	8,491	8,478	9,475	10,337	
Services	7,535	19,233	21,022	20,464	19,490	
Other	D	395	378	57	227	
Federal Civilian	3,519	9,002	6,421	5,247	5,533	
Federal Military	774	6,418	4,080	1,099	926	
State and Local	7,400	11,408	12,773	14,769	16,787	

Source: U.S. Department of Commerce, Bureau of the Census, Regional Economics Information System, April 1980.

Farm income in the Devils Lake SPA and for the State of North Dakota varies greatly from year to year. The major cause is commodity price instability, but weather, government farm programs, and other factors also contribute.

The percent of families in specified income brackets in the Devils Lake SPA for 1969 are: 14.2 percent earned less than $3,000; 18.0 percent earned $3,000 or more but less than $5,000; 17.2 percent earned $5,000 but less than $7,000; and 50.6 percent earned $7,000 or more. By using the same specified income brackets, the percentages for North Dakota are: 12.1, 14.3, 16.9, and 56.7, respectively.

ECONOMIC BASE

Description of the Study Area

One way to gain a perspective of the economic activity in the Devils Lake SPA is to trace each sector's contribution to the area's total economy. It is normal for a sector's contribution to the area's economy to fluctuate significantly in respect to the other sectors. However, the major contributors remain the same; only their ranking varies with time and various stimuli (Table II-4-6).

TABLE II-4-6 PERCENT OF TOTAL EARNINGS BY SECTOR FOR THE DEVILS LAKE STATISTICAL PLANNING AREA[1/]

Sector	1970	1975	1976	1977	1978	1979	1980
	Percent of Total Earnings[2/]						
Farm	21.2	49.0	32.2	12.8	44.6	18.7	12.9
Manufacturing[3/]	D	3.4	3.5	3.8	2.6	4.8	4.7
Mining	D	D	.04	D	D	D	D
Construction	2.9	4.6	6.6	8.2	4.7	6.2	6.4
Wholesale and Retail Trade	18.2	12.8	18.9	24.1	13.0	18.6	21.7
Finance, Ins. and Real Estate	2.1	2.0	3.0	5.2	3.5	4.8	5.5
Transportation, Comm., and Pub. Util.	4.5	4.4	5.7	8.4	5.4	7.9	8.5
Services	9.7	9.9	14.1	18.1	10.1	15.3	19.6
Other	D	2.0	0.3	.05	.01	0.1	0.3
Federal, Civilian	4.5	4.6	4.3	4.6	2.9	3.9	3.9
Federal, Military	1.0	3.3	2.7	1.0	0.5	0.6	0.4
State and Local	9.5	5.8	8.6	13.1	8.7	14.0	12.8

[1/]Computed from Regional Economics Information System data compiled in table II-4-5.

[2/]Total percentages will not add to 100 because of non-disclosure policies of U.S. Department of Commerce.

[3/]Due to non-disclosure policies of Bureau of Economic Analysis, some data in some counties for categories (sectors, crop, etc.) labeled "D" were suppressed; consequently, the actual percentage for these sectors may be understated.

Agriculture

The Devils Lake SPA, like the rest of North Dakota, is highly dependent on agriculture for its livelihood. The health of North Dakota's economy is directly related to the farm economy situation.

In 1970, approximately 78 percent of the total land area was under cultivation.

The value of crop products sold has typically been about 80 percent of the total value of agricultural products sold. Livestock, poultry, and their products account for most of the remainder, or slightly less than 20 percent (Table II-4-7).

Table II-4-8 shows the acreages of major crops harvested, table II-4-9 the production of those crops, and II-4-10 the livestock inventory for various years in the SPA.

TABLE II-4-7 FARM SIZE AND VALUE OF PRODUCTION FOR DEVILS LAKE STATISTICAL PLANNING AREA[1]

	1949	1954	1959	1964	1969	1974	1978[2]
Number of Farms	5,551.0	5,278.0	4,346.0	4,192.0	3,861.0	3,597.0	3,366.0
Land in Farms (000's)	3,138.4	3,133.3	3,050.8	3,169.8	3,207.7	3,239.6	3,201.1
Average Farm Size (Acres/Farm)	565.4	593.7	702.0	756.2	830.8	900.6	951.0
Total Value of Ag. Products Sold ($1,000)	31,884.0	22,889.0	42,759.0	50,989.0	58,818.0	149,627.0	141,356.0
Value of Crops Sold ($1,000)	24,887.0	16,022.0	34,740.0	41,325.0	48,871.0	72,439.0	126.796.0
Percent of Total[3]	78.0	70.0	81.2	81.0	83.1	48.4	89.7
Value of Livestock, Poultry & Their Products Sold ($1,000)	7,006.0	6,866.0	7,991.0	9,652.0	9,948.0	9,775.0	6,226.0
Percent of Total	21.0	30.0	18.7	18.9	16.9	6.5	4.4

1/ Source of data is U.S. Census of Agriculture for years 1949 through 1978.

2/ Preliminary data.

3/ Due to nondisclosure policies of Bureau of Economic Analysis, some data in some counties for categories (sectors, crop, etc.) labled "D" were suppressed; consequently the actual percentage for these sectors may be understated.

TABLE II-4-8. HISTORICAL ACRES OF MAJOR CROPS HARVESTED DEVILS LAKE STATISTICAL PLANNING AREA[1]

Crop	Unit	1949	1954	1959	1964	1969	1974	1978[2]
Wheat	Ac.	1,064,486	809,768	701,644	700,223	791,091	1,036,269	992,417
Oats	Ac.	92,620	120,362	77,895	106,740	161,962	47,045	32,651
Barley	Ac.	281,310	459,845	659,770	449,268	348,277	362,950	477,411
Rye	Ac.	6,040	15,144	7,533	14,963	2,784	4,410	1,529
Sunflower[3]	Ac.	N/A	N/A	N/A	N/A	N/A	1,500	131,700
Flax[4]	Ac.	96,863	122,768	71,521	85,724	70,500	59,700	25,600
Corn Grain	Ac.	1,947	1,185	99	35	80	815	2,897
Corn Silage	Ac.	8,225	20,730	18,314	13,363	4,567	3,385	4,553
Hay	Ac.	199,684	193,860	190,035	170,678	104,696	140,023	98,995
Soybeans	Ac.	---	13	20	N/A	42	N/A	540
Potatoes	Ac.	4,577	2,359	2,651	2,622	3,311	2,214	2,548

1/ Source of data is U.S. Census of Agriculture for years 1949 through 1978.

2/ Preliminary data.

3/ Sunflower data are from North Dakota Crop and Livestock Statistics.

4/ Flax data for 1969, 1974, and 1978 were obtained from North Dakota Crop and Livestock Statistics.

TABLE II-4-9 HISTORICAL PRODUCTION OF IRRIGATED AND NONIRRIGATED CROPS IN THE DEVILS LAKE STATISTICAL PLANNING AREA[1/]

Crop	Unit	1949	1954	1959	1964	1969	1974	1978[2/]
Wheat	Bu.	11,842,447	3,904,892	13,777,993	20,329,661	25,724,610	21,113,533	29,142,165
Oats	Bu.	1,619,705	2,359,102	1,873,664	4,450,821	8,279,185	1,436,565	1,416,286
Barley	Bu.	3,344,545	9,033,261	13,484,155	13,815,780	13,104,065	7,839,764	19,700,116
Rye	Bu.	56,268	216,689	96,945	320,471	37,078	79,434	42,600
Sunflower[3/]	(000 lbs)	N/A	N/A	N/A	N/A	N/A	1,200	172,151
Flax[4/]	Bu.	529,935	801,457	316,819	692,176	1,269,250	467,000	324,600
Corn Grain	Bu.	35,514	31,168	3,453	1,050	5,155	32,250	115,593
Corn Silage	Tons	44,044	78,797	49,197	45,916	24,180	17,142	27,167
Hay	Tons	212,231	249,899	184,686	204,735	134,237	183,613	149,736
Soybeans[5/]	Bu.	Z	60	400	N/A	1,760	N/A	7,640
Potatoes	Cwt.	366,361	209,177	259,562	252,771	439,612	279,770	411,050

[1/]Source is U.S. Census of Agriculture for years 1949 through 1978.
[2/]Preliminary data.
[3/]All sunflower data are from North Dakota Crop and Livestock Statistics.
[4/]Flax data for 1969, 1974, and 1978 were obtained from North Dakota Crop and Livestock Statistics.
[5/]Less than half of the unit reported.

TABLE II-4-10 NUMBER OF HEAD OF LIVESTOCK DEVILS LAKE STATISTICAL PLANNING AREA

Livestock	1949	1954	1959	1964	1969	1974	1978[1/]
All Cattle and Calves	91,250	112,220	80,536	109,152	71,916	81,289	54,837
Milk Cows	29,801	28,609	17,480	13,139	5,273	3,022	2,231
All Sheep and Lambs	28,156	51,176	54,295	42,133	22,877	11,869	7,141
All Hogs and Pigs	13,470	25,254	18,091	11,718	13,487	14,252	15,815
Horses and Ponies	11,739	6,759	3,934	N/A	1,993	2,073	2,305
Chickens 4 mo. and Older	190,092	242,718	140,959	106,065	33,238	18,212	10,580

[1/]Preliminary data.

Source: U.S. Census of Agriculture for years 1949 through 1978.

Wholesale and Retail Trade

This sector is also a major contributor to the economy of the Devils Lake SPA due to the presence of the City of Devils Lake. From 1975 to 1980 the percent of total earnings for the wholesale and retail trade sector varied from a low of about 13 to a high of over 24 percent.

Services

The services sector is comprised of various enterprises such as hospitals, hotels, and recreation facilities. Hunting, fishing, and camping demand has grown considerably in recent years creating a need for those types of services.

Surface Water

The Devils Lake Basin is a closed basin of about 3,580 square miles. Approximately 1,300 square miles of the drainage area are considered non-contributing. The drainage system is poorly integrated over most of the Basin. The chain of lakes in the Basin originated with the former glacial Devils Lake.

Runoff in the Basin is greatest during spring when the water of melting snow moves down the drainage system. Median annual runoff ranges from less than 0.25 inches to nearly 0.75 inches. A network of seven stream-gaging and stage-monitoring stations monitor streamflow in the Devils Lake Basin. The streamflow records are summarized in Table II-4-11.

TABLE II-4-11 SUMMARY OF STREAMFLOW RECORDS
DEVILS LAKE BASIN

Stream	Measuring Location	Discharge (cfs) Average	Maximum	Minimum	Annual Average Discharge (AF)
Mauvais Coulee	Cando	19.1	2,660	0	13,828
Edmore Coulee	Edmore	13.7	1,110	0	9,918
Starkweather Coulee 1/	Webster	0.88	44	0	637
Little Coulee	Brinsmade	8.96	425	0	6,487
Big Coulee	Churchs Ferry	42.8	1,420	0	30,986
Devils Lake 2/	Devils Lake	--	1,438.40'	1,400.87'	--

1/ Period of record is Water Year 1980
2/ Lake elevation for period of record 1867-1980

Surface-water storage is currently provided by 10 dams. Normal storage capacity of the impoundments totals 18.7 thousand AF, ranging from 100 AF to 9,220 AF for Lake Alice Dam. Maximum storage capacity totals 18.9 AF with the same range as the normal storage capacity.

The quality of surface is quite variable. It is related to such factors as volume and rate of streamflow, time of year, climate, substances in and entering the stream channel, ground-water inflow, and land- and water-management practices. There usually is an inverse relationship between surface-water quality and volume of water in a stream channel or lake basin. Devils Lake is a good example of this relationship. When the lake level is high, the water quality is good (dissolved solids concentrations are low) because of dilution.

Surface water in the Devils Lake Basin is of two main types. In the northern part of the Basin the water is a calcium-magnesium bicarbonate type; in the southern part, a sodium sulfate type. The water is very hard with dissolved solids concentrations ranging from 300-700 mg/l in the north to over 1,500 mg/l in the south.

The importance of North Dakota's wetlands as wildlife habitat has been established. Of a more controversial nature is the manner in which these wetlands function in the State's surface-water and ground-water resources, that is their relationships in surface-water hydrology and quality and the interaction between surface water and ground water.

The 1964 Wetlands Inventory indicated a total of 91,027 wetlands covering 241,779 acres in the Devils Lake SPA (Table II-4-12) or about 7.3 percent of the SPA area. The results of the 1964 Inventory are considered to be conservative. A new wetlands inventory by the U.S. Fish and Wildlife Service is in progress and is based on a detailed classification hierarchy different from that used for the 1964 inventory.

TABLE II-4-12 1964 WETLAND INVENTORY FOR THE DEVILS LAKE STATISTICAL PLANNING AREA

Wetland Type		Total Number	Total Acres
I		34,135 1/	31,536 2/
III		54,637	138,319
IV		1,906	39,369
V		144	20,886
X		97	2,831
XI		108	8,838
	TOTAL	91,027	241,779

1/ Type I wetland numbers were estimated at 60 percent of the total wetland numbers.

2/ Type I wetland acres were estimated at 15 percent of the total wetland acres.

Source: U.S. Fish and Wildlife Service 1964 Inventory of Wetlands

Water quality of wetlands can be quite variable both in time and area. The variability is influenced by the combination of many factors such as climate, time, watershed characteristics, surface-water hydrology, and ground-water interaction.

Ground Water

Although aquifers occur in rocks older than the Dakota Group of Early Cretaceous age, they are not of practical consideration for use in the Devils Lake Basin because of depth below land surface and the very poor quality of the water. Bedrock aquifers used in the Devils Lake Basin occur in the Dakota and Montana Groups of Cretaceous age (Figure I-2-9).

The Dakota Group underlies all of the Devils Lake Basin. The aquifers consist of fine- to coarse-grained sandstone beds that range in thickness from 10 to about 100 feet. Shale and siltstone are interbedded with the sandstone units. Depth to the Dakota aquifer increases from around 1,000 feet in the east part of the Basin to about 1,900 feet in the west. Ground-water movement is from west to east across the Basin. The water is under sufficient hydrostatic pressure to produce flowing wells over much of the Basin. Yields of flowing wells range between 10 to 150 gallons per minute. Pumping rates vary from less than 50 to more than 250 gallons per minute depending on the thickness and permeability of the aquifer screened. Water from the Dakota aquifer is typically soft with high concentrations of sodium, dissolved solids, sulfate, chloride, iron, and boron. Several types of water are present: sodium sulfate, sodium sulfate-bicarbonate, or sodium sulfate-chloride. Dissolved solids range from around 3,600 to 6,000 mg/l. The high salinity and sodium hazards of the water make it unsuitable for irrigation. The degree of mineralization, general availability of water from shallower aquifers, depth to the aquifer, and unsuitability of the water for use in modern plumbing and appliances have reduced use of the Dakota aquifer. Primary uses now are livestock watering and industrial water supply.

The Pierre Formation directly underlies the glacial drift in much of the Devils Lake Basin. Small quantities of water are available where saturated joints and fractures or silty layers are present. The Pierre aquifer is locally an important source of water where shallower aquifers are absent in the overlying glacial drift. Well yields are typically low, from one to ten gallons per minute. The water is mainly of three types - sodium bicarbonate, sodium sulfate, or sodium chloride. Concentrations of iron and dissolved solids are usually high, but the water is most commonly soft. The water is used mostly for rural domestic and livestock purposes.

The Fox Hills aquifer, consistsing of the sandstone beds of the Fox Hills Formation, directly underlies the glacial deposits in extreme western Devils Lake Basin. Well yields fall in the 5-100 gallon-per-minute range as determined by aquifer thickness and permeability. The water is a sodium bicarbonate-sulfate type with dissolved solids ranging from less than 400 mg/l to over 1,400 mg/l. The water is soft with sodium the chief cation and bicarbonate, sulfate, and chloride the major anions. Although the water is generally unsuited for irrigation, it is satisfactory for domestic and livestock water.

The most productive aquifer in the Devils Lake Basin in terms of high sustained yields are those found in glacial-drift deposits. The most extensive of the glacial-drift aquifers in the Basin occur as outwash sands and gravels buried in valleys incised into bedrock or till. The major buried-valley aquifer system is located in the southern part of the Basin and is part more or less of a much larger complex which also underlies parts of the James and Red River Basins (Plate I-2-1). Thickness of the aquifer varies from less than five feet to more than 330 feet. Yields from buried-valley aquifers range from 50 to more than 500 gallons per minute depending on thickness and permeability of the aquifer material. Quality of the water is variable from one location to the next and to some extent with depth. The water is usually very hard with calcium and sodium the chief cations and bicarbonate, sulfate, and sometimes chloride the main anions. Concentrations of iron, manganese, and sulfate ions, and dissolved solids often exceed recommended standards for drinking water. Suitability of the water for irrigation varies from good to marginal. Other major glacial-drift aquifers occur as buried and surficial outwash deposits. Well yields from these aquifers usually are less than 500 gallons per minute, but the water quality is generally better than that of the buried-valley aquifers.

Also present in the glacial deposits are bodies of sand and gravel which occur as isolated buried lenses and stringers of variable thickness. The aquifers are of limited area but are locally important sources of domestic and livestock water. Yields are generally less than 50 gallons per minute, but the quality of the water varies considerably.

Land Resources

The Devils Lake SPA originally was covered by mixed grass prairie (tall and short grass varieties). The character of the area was determined entirely by the glacial action on the area with wetlands being widespread. Soils which have developed are black in color, due to the centuries of grass cover.

Land Use and Ownership

Farming encompasses most of the land area of the Devils Lake SPA. The raising of small grain crops and livestock has been the traditional economic pursuit of the lands. Land Use categories and percentage of each are classified as follows: Cropland 78%; Pastureland 3%; Rangeland 7%; Forest 2%; Urban and Built-up 3%; Other Land 4%; Water Areas 3% 1/. The number of farms within the SPA was 3,366 as of 1978 2/. Land ownership estimate place taxable land or private land at 97% and non-taxable land at 3% of the area involved which is comprised of $3.5 million acres 3/.

Production Capability

Many factors influence the productivity of the area's soils, including soil type, fertility, climate, and slope. The U.S. Soil Conservation Service has identified and mapped erodible soils, prime farmlands and important farmlands.

Current and Projected Production

Keeping with the state and national trends, the total of agricultural products for the SPA has increased. The total value of agricultural products sold in 1978 totaled $141.5 million 2/. This total value of agricultural products sold is indicative as to what total value may be produced from agriculture in a given year. Yearly growing season conditions as well as agriculture product price level combine to determine annual total value. Past crop production has been approximately 80% of the total value sold yearly. Significant changes in the type and amount of agricultural products produced as a percentage of total value of agricultural products produced are not expected. Changes will occur however, in total production as a result of improved yielding varieties or the expanded use of row or specialty crops. Agricultural prices for crops or livestock have a direct bearing on land use with changes between cropland and pasture/rangelands.

Increases in the cropland category are expected due to additional wetland drainage, at the expense of forest lands or the breaking of pasturelands. This may be offset somewhat by marginal land less suited to cultivation reverting to pastureland.

Land Treatment

Table II-4-13 shows the current status of land treatment in the Devils Lake SPA.

TABLE II-4-13 LAND TREATMENT IN THE DEVILS LAKE STATISTICAL PLANNING AREA

Status	Cropland Acres	%	Pasture Acres	%	Range Acres	%	Forest Acres	%	Other Acres	%	Total Acres	%
	000		000		000		000		000		000	
Adequately Treated	1,892	71	159	70	103	57	48	91	280	84	2,482	72
eeding Treatment	775	29	68	30	79	43	5	9	52	16	979	28
Total	2,667	77	227	7	182	5	53	2	332	9	3,461	100

urce: U.S.D.A. Soil Conservation Service, North Dakota Management Form No. 2, 1980.

References:
1/ U.S.D.A. Soil Conservation Service, Conservation Needs Inventory, July 1970
2/ U.S. Census of Agriculture 1978
3/ N.D.S.U. Soils Department form County Tax Information

THE SOURIS RIVER BASIN

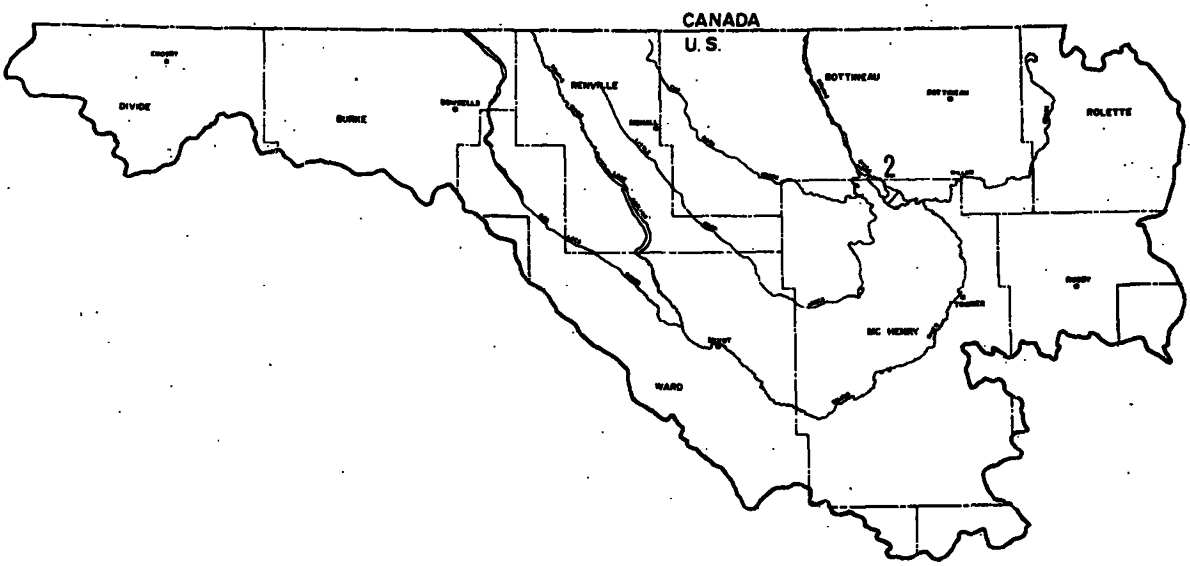
PHYSICAL DESCRIPTION

Geography

The Souris River heads in southeastern Saskatchewan and flows southeasterly to enter North Dakota near the northwestern corner of Renville County. From this point, it continues to flow in a southeasterly direction through the City of Minot in Ward County to Velva in McHenry County where its course changes to the northeast until north of Towner. Here the River curves gradually to the northwest until it reenters Canada west of the Turtle Mountains in north-central Bottineau County. The Souris River drains portions of Saskatchewan, Montana, North Dakota, and Manitoba. In North Dakota, the area drained by the Souris River is 9,112 square miles. Stream length in the State is 357 river miles.

In North Dakota above Minot, the Souris River Valley is comparatively straight with a fairly constant width of about one-half mile. Throughout this 64-mile reach of the river, valley walls rise sharply 100 feet or more to broad, comparatively level benches. Between Minot and Verendrye, the valley displays the same general characteristics; however, it is wider in places and has benches which are somewhat lower and more broken. Below Verendrye, the north-side bench diminishes to a low ridge and the lands toward Bantry and Upham tend to merge with the valley. The channel of the Souris River follows a meandering course, averaging slightly less than 100 feet wide and 15 to 25 feet deep, and meanders such that the total length of the channel is about double the length of the valley through which it flows.

FIGURE II-5-1 SUBBASIN DELINEATION - SOURIS RIVER BASIN



Principal tributaries above Minot are the Des Lacs River, which enters the Souris River about seven miles north of Minot near Burlington; Moose Creek, which receives runoff from the Moose Mountains in Canada; and Long Creek. Of these three streams only the Des Lacs River, which rises just north of the United States-Canada boundary, enters the Souris River in North Dakota.

Other important tributaries outside the Souris River "Loop" include the Wintering River, which flows through southern McHenry County, and Willow Creek, which rises in the Turtle Mountains and flows in a southwesterly direction to its confluence with the Souris River about eight miles east of Upham. The interior of the Souris River "Loop" is drained principally by a single stream system, the Deep River. Principal tributaries of the Deep River are Cut Bank Creek (north), Little Deep Creek, and Cut Bank Creek (south).

Geology

The Souris River Basin extends from the northeastern flank to near the middle of the Williston Basin. The Late Cretaceous Pierre Formation directly underlies the glacial deposits along the eastern edge of the Souris Basin. Younger bedrock up to and including the Sentinel Butte Formation subcrops the glacial drift in the Turtle Mountains and to the west across the Basin. The preserved thickness of sedimentary rock decreases from 12,000 feet in Divide County to 5,000 feet in Pierce County. Rocks of Cambro-Ordovician and Mississippian through Jurassic age (Figure I-2-9) thin considerably across the Souris River Basin. The bedrock generally dips toward the center of the Williston Basin.

Glacially derived sediments varying in thickness from 0 to over 650 feet overlie the bedrock in most of the Souris River Basin. Bedrock crops out along portions of the valleys of the Souris and Des Lacs Rivers. The glacial drift was deposited by possibly four major continental glaciations each of which, except for the last one, left deposits modified or buried by subsequent glaciation. The drainage divide of the Souris Basin follows a band of dead-ice moraine on the east and southwest boundaries and a series of end moraines to the southeast. The surficial glacial deposits are mostly ground moraine which contain a broad pattern of meltwater channels. In the east-central portion of the basin is the bottom of glacial Lake Souris. This ice-marginal lake covered some 11,900 square miles of the Souris River Basin. Wave action built beach ridges along the shoreline and streams emptying into the lake built deltas at their mouths from the sediments being transported. Glaciation also disrupted the existing drainage system, diverting the streams southward. The valleys of these streams were buried by outwash sands and gravels and by till where the ice sheets overrode them. The two best examples of this type of valley are those of the ancestral Missouri and Yellowstone Rivers in Divide County.

SOCIO-ECONOMIC CHARACTERISTICS

The Souris River Statistical Planning Area (SPA) contains the counties of Bottineau, Burke, Divide, McHenry, Pierce, Renville, Rolette, and Ward. The Souris River SPA is 10,856 square miles in size with a 1980 population of 104,756, or about 16 percent of North Dakota's population (Table II-5-1). Minot, the largest city in the region, with a population of about 33,000 and the Minot Air Force Base with about 5,000 inhabitants combine to form the largest urban area in the region. This urban area accounts for almost 36 percent of the total population of the Souris River SPA. Other major cities and their 1980 population estimates are: Bottineau, 2,828; Crosby, 1,461; Kenmare, 1,461; and Rugby, 3,343. These four cities combine to form about nine percent of the total Souris River SPA population.

TABLE II-5-1 POPULATION ESTIMATES OF SOURIS RIVER STATISTICAL PLANNING AREA

County	1960[1/]	1970[2/]	1980[3/]	% Change 1960-1970	% Change 1970-1980
Bottineau	11,315	9,496	9,239	- 16.1	- 2.7
Burke	5,886	4,739	3,822	- 19.5	-19.4
Divide	5,566	4,564	3,494	- 18.0	-23.4
McHenry	11,099	8,977	7,858	- 19.1	-12.5
Pierce	7,394	6,323	6,166	- 14.5	- 2.5
Renville	4,698	3,828	3,608	- 18.5	- 5.7
Rolette	10,641	11,549	12,177	+ 8.5	+ 5.4
Ward	47,072	58,560	58,392	+ 24.4	- 0.3
Souris River SPA	103,671	108,036	104,756	+ 4.2	- 3.0
North Dakota	632,446	617,761	652,437	- 2.3	+ 5.6
Percent of State	16.4	17.5	16.0	N/A	N/A

[1/] U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1960.

[2/] U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1970.

[3/] U.S. Bureau of the Census, Preliminary Population and Housing Unit Counts, PHC80-P-36, November, 1980.

The urban population of the region has increased due mainly to increased job opportunities in the urban areas. There has been a steady decline in the rural population due to increased mechanization of farms and increased farm size. The rural population of the Souris River SPA has dropped by 11,638 persons from 67,507 in 1960 to 55,869 in 1980 (Table II-5-2).

TABLE II-5-2 RURAL AND URBAN POPULATION FOR SOURIS RIVER STATISTICAL PLANNING AREA[1/]

	1960		1970		1980	
	Number	Percent	Number	Percent	Number	Percent
Urban[2/]	36,164	34.9	50,016	46.3	48,887	46.7
Rural	67,507	65.1	58,020	53.7	55,869	53.3
Farm[3/]	30,546	29.5	24,278	22.5	NA	NA
Nonfarm[4/]	36,961	35.7	33,742	31.2	NA	NA
Total Population	103,671	100.0	108,036	100.0	104,756	100.0

1/Source: U.S. Bureau of the Census, General Social and Economic Characteristics, Final Report PC(1) - 36C, 1960 and 1970; Part 36, PC 80-1-A36, 1980.

2/Urban inhabitants are persons living in all incorporated places and unincorporated places of 2,500 persons or more.

3/Farm inhabitants are persons defined as actively farming 10 or more acres with sales of $50 or more per year and farms of less than 10 acres with sales of $250 or more per year.

4/Nonfarm inhabitants are rural residents not actively farming.

In 1929 the population of the area totaled about 110,000. The population then began a decline to a low of about 97,000 in 1950 when it again began increasing, reaching 104,756 in 1980. The decline is attributable to a high outmigration rate preceding 1950. A general increase followed due to a high birth-to-death ratio, particularly in Ward and Rolette Counties. The area has a 1980 population density of 10.2 persons per square mile compared to 8.7 persons per square mile for the whole State.

Employment Characteristics

Employment in the Souris River SPA increased from 47,219 in 1970 to 50,146 in 1980, or 6 percent. The farm sector of the economy has over twice as many individual proprietors as the non-farm sector but has a very small portion of the total wage and salary employment. The reason for this is that most of the farms and ranches are owned and managed by the operator and his family with very little outside employment; whereas non-farm proprietors hire most of the labor force in the area.

Total employment and number of persons employed in each sector is shown in Table II-5-3.

TABLE II-5-3 EMPLOYMENT BY TYPE AND BROAD INDUSTRIAL SOURCES FULL AND PART-TIME WAGE AND SALARY EMPLOYMENT PLUS NUMBER OF PROPRIETORS FOR THE SOURIS RIVER STATISTICAL PLANNING AREA

	1970	1975	1976	1977	1978	1979	1980
TOTAL EMPLOYMENT	47,219	53,573	52,362	51,379	52,705	51,331	50,146
Number of Proprietors	12,252	10,845	10,733	10,778	10,938	10,951	10,971
Farm Proprietors	8,127	7,556	7,460	7,370	7,370	7,363	7,182
Non-Farm Proprietors	4,125	3,289	3,273	3,408	3,568	3,588	3,789
Wage and Salary Employment	34,967	41,028	41,629	40,601	40,767	39,159	39,175
Farm	1,105	1,018	1,130	949	1,039	1,005	1,060
Non-Farm	33,862	40,010	40,499	39,652	40,728	39,375	38,115
Private Non-Farm	18,773	22,374	23,173	23,268	23,934	24,594	24,259
Mining	153	295	413	411	577	537	583
Construction	1,244	2,109	2,063	1,951	2,035	1,962	1,841
Manufacturing	1,163	1,982	1,570	1,339	1,358	1,420	1,413
Trans., Comm., and Pub. Util.	1,936	1,936	2,021	2,004	2,000	2,183	2,279
Wholesale and Retail Trade	7,149	8,307	8,940	9,062	8,828	9,100	9,263
Finance, Ins. and Real Estate	887	1,103	1,208	1,332	1,350	1,342	1,401
Services	5,078	7,376	6,747	7,011	7,384	7,543	7,266
Other	251	93	111	103	94	92	87
Government	15,089	17,636	17,326	16,384	18,187	14,781	13,856
Federal Civilian	2,271	2,556	2,433	2,370	2,277	2,141	2,193
Federal Military	6,088	6,884	6,943	6,839	6,745	6,409	6,320
State and Local	6,730	8,196	7,950	7,155	7,772	6,231	5,343

Source: U.S. Department of Commerce, Bureau of the Census, Regional Economics Information System, April 1982.

Ward County has the highest employment of the eight counties in the Souris River SPA because Minot, the wholesale/retail trade center and the Minot Air Force Base are in the area.

Annual unemployment for the area has typically been 5 to 6 percent (Table II-5-4).

TABLE II-5-4 AVERAGE ANNUAL UNEMPLOYMENT RATE
COUNTIES OF SOURIS RIVER STATISTICAL PLANNING AREA

County	1972	1973	1974	1975	Percent 1976	1977	1978	1979	1980
Bottineau	5.5	5.9	5.2	4.3	4.9	6.1	4.9	4.7	4.6
Burke	5.3	5.6	5.0	5.3	5.9	4.1	3.2	2.5	3.3
Divide	3.4	3.7	2.9	4.8	4.0	4.9	3.1	2.3	2.3
McHenry	10.1	10.7	6.5	8.1	8.8	10.7	9.0	8.0	8.9
Pierce	3.5	3.9	3.6	4.2	4.3	4.8	4.0	3.5	3.9
Renville	4.7	5.4	4.0	4.4	4.5	4.2	2.9	3.0	2.9
Rolette	10.8	11.0	10.5	10.2	10.7	11.0	9.3	11.1	11.7
Ward	3.7	4.2	3.5	4.4	4.7	5.5	4.3	4.3	5.2
Souris River SPA	5.9	6.3	5.2	5.7	6.0	6.4	5.1	4.9	5.4
North Dakota	4.9	5.1	4.6	5.2	5.1	5.5	4.3	4.2	5.0
United States	5.6	4.9	5.6	8.5	7.7	7.0	6.0	5.8	7.1

Source: North Dakota Employment Security Bureau, Unadjusted Annual Averages.

Income Characteristics

Total labor and proprietors income for the Souris River SPA increased from $245 million in 1970 to $584 million in 1980. There has been a general increase in income with highs and lows having direct correlation to the price fluctuations of agricultural commodities.

Farm income in the Souris River SPA and for the State of North Dakota varies greatly from year to year. The major cause is commodity price instability, but weather, government farm programs, and other factors also contribute (Table II-5-5).

The percent of families in specified income brackets in the Souris River SPA for 1969 are: 11.3 percent earned less than $3,000; 14.7 percent earned $3,000 dollars or more but less than $5,000; 17.8 percent earned $5,000 but less than $7,000; and 56.2 percent earned $7,000 or more. By using the same specified income brackets, the percentages for North Dakota are: 12.1, 14.3, 16.9 and 56.7, respectively.

TABLE II-5-5 PERSONAL INCOME BY MAJOR SOURCES
FOR THE SOURIS RIVER STATISTICAL PLANNING AREA

	1970	1975	1976	1977	1978	1979	1980
Total Labor and Proprietors Income (1000's)	244,953	478,755	462,573	444,472	565,033	564,220	584,317
Per Capita Personal Income	2,953	5,694	5,482	5,768	7,038	7,418	8,482
Labor Income by Industry (1000's)							
Farm	26,575	105,444	65,734	30,456	109,780	69,840	55,174
Manufacturing	10,423	25,453	18,689	15,801	17,480	19,890	22,733
Mining	1,492	6,167	11,395	9,300	13,417	13,191	17,869
Contract Construction	12,373	35,387	33,971	33,658	37,495	38,570	39,070
Wholesale & Retail Trade	44,286	74,428	82,985	84,822	90,141	102,710	116,225
Finance Insurance & Real Estate	7,128	10,674	14,209	17,776	20,036	21,451	24,583
Transportation, Comm., and Pub. Util.	18,296	30,189	33,853	36,801	40,060	48,243	53,468
Services	26,588	45,167	54,182	60,065	69,570	77,740	85,768
Other	729	818	997	970	892	1,183	1,000
Federal Civilian	15,206	32,708	28,636	30,078	31,563	31,279	33,099
Federal Military	48,207	68,421	70,970	71,929	74,261	80,655	75,943
State and Local	27,056	40,294	45,460	50,867	56,815	59,179	57,376

Source: U.S. Department of Commerce, Bureau of the Census, Regional Economics Information System, April 1982.

ECONOMIC BASE

Description of the Study Area

One way to gain a perspective of the economic activity in the Souris River SPA is to trace each sector's contribution to the total economy. It is normal for a sector's contribution to the area's economy to fluctuate significantly in respect to the other sectors. However, the major contributors remain the same; only their ranking varies with time and various stimuli (Table II-5-6).

TABLE II-5-6 PERCENT OF TOTAL EARNINGS BY SECTOR
FOR THE SOURIS RIVER STATISTICAL PLANNING AREA[1]

Sector	1970	1975	1976	1977	1978	1979	1980
	Percent of Total Earnings[2]						
Farm	10.8	22.0	14.2	6.9	19.4	12.4	9.4
Manufacturing	4.3	5.5	4.0	3.6	3.1	3.5	3.9
Mining	0.6	1.3	2.5	2.1	2.4	2.3	3.1
Construction	5.1	7.4	7.3	7.6	6.6	6.8	6.7
Wholesale and Retail Trade	18.1	15.5	17.9	19.1	16.0	18.2	19.9
Finance, Ins. and Real Estate	2.9	2.2	3.1	4.0	3.5	3.8	4.2
Transportation, Comm., and Pub. Util.	7.5	6.3	6.3	8.2	7.1	8.6	9.2
Services	10.9	9.4	11.7	13.5	12.3	13.8	14.7
Other	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Federal, Civilian	6.2	6.8	6.2	6.8	5.6	5.5	5.7
Federal, Military	19.7	14.3	15.3	16.2	13.1	14.3	13.0
State and Local	11.0	8.4	9.8	11.4	10.1	10.5	9.8

[1] Computed from Regional Economics Information System data compiled in table II-5-5.

[2] Total percentages will not add to 100 because of non-disclosure policies of U.S. Department of Commerce.

Agriculture

The Souris River SPA, like the rest of North Dakota, is highly dependent on agriculture for its livelihood. The health of North Dakota's economy is directly related to the farm economy situation.

Farms in the SPA have gotten larger in size and fewer in number.

In 1970 approximately 68 percent of the total land area was under cultivation.

The value of crop products sold has typically been from 75 to 80 percent of the total value of agricultural products sold. Livestock, poultry and their products account for most of the remainder (Table II-5-7).

TABLE II-5-7 FARM SIZE AND VALUE OF PRODUCTION FOR SOURIS RIVER STATISTICAL PLANNING AREA1/

	1949	1954	1959	1964	1969	1974	19782/
Number of Farms	10,549.0	9,846.0	8,514.0	7,623.0	7,512.0	6,305.0	6,614.0
Land in Farms (000's)	6,465.0	6,572.5	6,468.5	6,485.5	6,618.0	6,663.2	6,394.0
Average Farm Size (Acres/Farm)	612.9	667.5	759.7	850.8	881.0	1,056.8	966.7
Total Value of Ag. Products Sold ($1,000)	67,102	56,599	59,633	81,623	97,385	288,417	218,648
Value of Crops Sold ($1,000)	52,680	43,228	40,197	61,903	71,220	225,399	166,197
Percent of Total	78.5	76.4	67.4	75.8	73.1	78.2	76.0
Value of Livestock, Poultry & Their Products Sold ($1,000)	14,376	13,577	19,383	19,696	26,152	22,221	39,563
Percent of Total3/	21.4	24.0	32.5	24.1	26.9	7.7	18.1

1/Source of data is U.S. Census of Agriculture for years 1949 through 1978.

2/Preliminary data.

3/Due to nondisclosure policies of Bureau of Economic Analysis, some data in some counties for categories (sectors, crop, etc.) labled "D" were suppressed; consequently the actual percentage for these sectors may be understated.

Table II-5-8 shows historical acreages of major crops harvested, Table II-5-9 the production of those crops, and Table II-5-10 the livestock inventory for various years in the SPA.

TABLE II-5-8 HISTORICAL ACRES OF MAJOR CROPS HARVESTED SOURIS RIVER STATISTICAL PLANNING AREA[1/]

Crop	Unit	1949	1954	1959	1964	1969	1974	1978[2/]
Wheat	Ac.	1,860,015	1,433,000	1,210,730	1,153,423	1,421,282	1,887,129	2,302,436
Oats	Ac.	228,267	293,690	209,897	247,602	369,857	197,925	160,171
Barley	Ac.	174,792	475,301	638,139	442,515	244,857	253,773	323,583
Rye	Ac.	31,398	70,535	50,552	179,292	65,783	10,270	23,002
Sunflower[3/]	Ac.	N/A	N/A	N/A	N/A	N/A	N/A	130,400
Flax[4/]	Ac.	437,980	618,176	196,528	194,841	206,500	138,700	105,600
Corn Grain	Ac.	9,900	2,755	281	167	1,750	2,248	4,009
Corn Silage	Ac.	18,657	41,801	65,610	45,931	18,900	12,668	12,662
Hay	Ac.	491,333	522,335	562,176	494,845	401,626	516,335	466,440
Soybeans	Ac.	N/A	82	5	N/A	209	151	259
Potatoes	Ac.	2,339	1,735	903	552	500	119	173

1/ Source of data is U.S. Census of Agriculture for years 1949 through 1978.
2/ Preliminary data.
3/ Sunflower data are from North Dakota Crop and Livestock Statistics.
4/ Flax data for 1969, 1974, and 1978 were obtained from North Dakota Crop and Livestock Statistics.

TABLE II-5-9 HISTORICAL PRODUCTION OF IRRIGATED AND NONIRRIGATED CROPS IN THE SOURIS RIVER STATISTICAL PLANNING AREA

Crop	Unit	1949	1954	1959	1964	1969	1974	1979
Wheat	Bu.	23,303,814	11,920,849	17,523,954	29,546,000	43,456,317	39,609,214	50,808,120
Oats	Bu.	5,421,333	5,854,082	3,967,455	9,715,680	19,782,706	6,349,511	7,932,884
Barley	Bu.	2,954,971	9,251,709	10,321,473	13,230,782	9,466,709	6,062,025	13,610,095
Rye	Bu.	414,611	1,090,034	561,139	3,913,227	1,140,345	202,858	536,168
Sunflower[3/]	(000 lbs)	N/A	N/A	N/A	N/A	N/A	N/A	166,234
Flax[4/]	Bu.	2,950,846	4,621,007	650,481	1,892,850	2,491,500	1,180,100	1,202,600
Corn Grain	Bu.	222,239	52,669	4,679	3,231	67,322	95,965	191,541
Corn Silage	Tons	60,319	126,101	151,519	157,825	92,180	56,598	85,581
Hay	Tons	479,532	614,346	414,734	530,921	472,404	658,419	653,532
Soybeans	Bu.	z[5/]	651	20	z	5,666	D[6/]	4,226
Potatoes	Cwt.	162,990	115,713	22,977	44,279	53,090	13,531	3,226

1/ Source is U.S. Census of Agriculture for years 1949 through 1978.
2/ Preliminary data.
3/ All sunflower data are from North Dakota Crop and Livestock Statistics.
4/ Flax data for 1969, 1974, and 1978 were obtained from North Dakota Crop and Livestock Statistics.
5/ Less than half of the unit reported.
6/ Data withheld to avoid disclosing information for individuals.

TABLE II-5-10 NUMBER OF HEAD OF LIVESTOCK
SOURIS RIVER STATISTICAL PLANNING AREA

Livestock	1949	1954	1959	1964	1969	1974	1978[1/]
All Cattle and Calves	200,532	273,087	199,924	280,940	213,221	284,459	213,704
Milk Cows	56,353	82,019	35,957	30,454	17,289	13,738	11,648
All Sheep and Lambs	22,583	48,416	26,238	55,503	39,945	24,268	17,347
All Hogs and Pigs	32,751	63,206	73,388	15,059	19,364	28,061	27,572
Horses and Ponies	22,874	13,235	8,538	N/A	5,833	3,900	5,408
Chickens 4 mo. and Older	385,624	483,742	319,632	195,370	190,869	65,403	39,321

1/ Preliminary data.

Source: U.S. Census of Agriculture for years 1949 through 1978.

Mining

Employment in the mining sector increased 281 percent from 153 in 1970 to 583 in 1980. Most of the increase came about because of activity in coal mining, oil exploration, and sand and gravel mining for construction (Table II-5-3). Over ten percent of the State's coal and slightly less than ten percent of its oil production is in the SPA.

Wholesale and Retail Trade

This sector contributes from 15 to 20 percent of the total earnings in the SPA.

Surface Water

The Souris River Basin encompasses an area of 9,112 square miles of which about 2,300 square miles are considered to be noncontributing. The drainage system includes the mainstem Souris River and its tributaries. The major tributaries are the Des Lacs River, Moose and Long Creeks, the Wintering River, Willow Creek and Cutbank Creek, and Deep River. For the most part, the drainage is poorly integrated within the Basin.

Streamflow in the Basin arises from precipitation and runoff in North Dakota, and stream inflow from Canada and Montana. Spring is the time of greatest runoff with snow meltwater moving along the drainage system. Median annual runoff varies from around 0.25 inches in the western part of the Basin to over 1.00 inches in the Turtle Mountains in the eastern part of the Basin. A network of 22 stream-gaging or stage-measuring stations monitors streamflow in the Souris Basin. Streamflow records are summarized in Table II-5-11.

TABLE II-5-11 SUMMARY OF STREAMFLOW RECORDS
SOURIS RIVER BASIN

River	Measuring Location	Discharge (cfs) Average	Maximum	Minimum	Annual Average Discharge (AF)
Souris	Sherwood	142	14,800	0	102,803
Souris	Minot	171	12,000	0	123,798
Souris	Westhope	264	12,600	0	191,127
Des Lacs	Foxholm	32.1	4,260	0	23,239
Long Creek	Noonan	55.6	6,310	0	40,253
Wintering	Karlsruhe	12.8	3,000	0	9,267
Willow Creek	Willow City	46.9	5,900	0	33,954
Cutbank Creek 1/	Upham	13.8	820	0	9,991

1/ Period of record is 6 years

Storage of surface water in the Souris River Basin is provided by 50 dams. Normal storage capacity of these impoundments totals 583.9 thousand acre-feet (AF), ranging from 50 AF to 102,400 AF for dam 83 on the Souris River in Ward County. Total maximum storage capacity is 609.4 thousand AF with a range from 80 AF to 112,100 AF for dam 83 in Ward County.

The quality of surface water changes considerably in response to various factors including rate and volume of streamflow, climate, time of year, type of substances in and entering the stream channel, ground-water inflow, and practices of land- and water-resources management. Better quality surface water is generally associated with larger volumes of streamflow.

The surface water of the western Souris Basin is typically sodium bicarbonate type with dissolved solids averaging 700-1,100 mg/l. Surface water in the eastern Souris Basin is mainly a calcium-magnesium bicarbonate type with average dissolved solids concentrations in the 300-700 mg/l range.

The importance of North Dakota's wetlands as wildlife habitat has been established. Of a more controversial nature is the manner in which these wetlands function the State's surface-water and ground-water resources, that is their relationships in surface-water hydrology and quality and the interaction between surface water and ground water.

The 1964 Wetlands Inventory indicated a total of 117,345 wetlands covering 397,693 acres in the Souris River SPA (Table II-5-12) or about 5.7 percent of the SPA area. The results of the 1964 Inventory are considered to be conservative. A new wetlands inventory by the U.S. Fish and Wildlife Service is in progress and is based on a detailed classification hierarchy different from that used for the 1964 inventory.

TABLE II-5-12 1964 WETLAND INVENTORY FOR THE SOURIS RIVER STATISTICAL PLANNING AREA

Wetland Type		Total Number	Total Acres
I		44,004 1/	51,899 2/
III		60,125	152,549
IV		9,391	106,755
V		3,362	49,600
X		116	3,049
XI		347	33,841
	TOTAL	117,345	397,693

1/Type I wetland numbers were estimated at 60 percent of the total wetland numbers.
2/Type I wetland acres were estimated at 15 percent of the total wetland acres.

Source: U.S. Fish and Wildlife Service 1964 Inventory of Wetlands

Water quality of wetlands can be quite variable both in time and area. The variability is influenced by the combination of many factors such as climate, time, watershed characteristics, surface-water hydrology, and ground-water interaction.

Ground Water

Ground water within the Souris River Basin occurs both in bedrock aquifers and aquifers composed of glacially-derived sediments. The bedrock aquifers are found throughout the entire thickness of sedimentary rock underlying the Souris Basin, from the Deadwood Formation of Cambro-Ordovician age to the Sentinel Butte Formation of Mid-Tertiary age (Figure I-2-9). Although the bedrock aquifers from the Dakota Group sandstones and deeper are very productive, they generally are too deep and the ground water too mineralized to be of practical consideration for most uses other than in the oil industry. The Pierre Formation directly underlies the glacial drift in the extreme eastern part of the Basin in Benson and Pierce Counties. Saturated fracture systems in the upper part of the Pierre Formation are localized aquifers elsewhere in the State. It is not known whether this aquifer is utilized in the Souris Basin. Important bedrock aquifers in terms of domestic, livestock, municipal, and industrial supply in the Souris Basin include the Fox Hills and Hell Creek Formations and the Fort Union Group.

The Fox Hills and Hell Creek aquifers are lithologically similar, consisting of very fine- to medium-grained sandstone that occurs as broadly lenticular beds varying in thickness from 10 to 200 feet. Intervening beds of claystone, siltstone, and shale separate the sandstone beds which occur mainly in the middle and upper Fox Hills and lower to middle Hell Creek Formation. Well yields range from less than 10 to about 50 gallons per minute depending on the thickness of the aquifer and presence of interstitial silt and clay. The water is mainly either a sodium bicarbonate or sodium chloride type, generally soft, and unsuitable for irrigation because of very high sodium and salinity hazards. The water is generally satisfactory to most domestic and livestock users, but the concentrations of dissolved solids, fluoride, and sulfate often exceed recommended standards for drinking water.

The Fort Union Group underlies most of the Souris River Basin. The aquifers within the Fort Union Group consist of marine sandstone beds in the basal Fort Union Group and nonmarine sandstone and lignite beds in the middle and upper Fort Union Group. The very fine- to medium-grained sandstones occur in lenticular beds from 5 to 50 feet thick separated by intervening beds of claystone and siltstone. Lignite beds also form aquifers where fracture zones are present. Yields to wells completed in a sandstone aquifer range between 5 and 50 gallons per minute depending on thickness and permeability of the aquifer. Well yields from fractured lignite aquifers, typically less than 10 gallons per minute, depend on the degree, size, and extent of the fractures and rate of recharge from the surrounding lithologic units. Water from the Fort Union aquifers generally is high in sodium, bicarbonate, sulfate, and chloride ion concentrations with magnesium prevalent in the shallower aquifers. The water is usually soft. The high salinity and sodium hazards make the water unsuitable for irrigation. Although the recommended standards for concentrations of dissolved solids, sulfate, iron, and chloride are exceeded, the water is satisfactory to most domestic and livestock users.

The deposits of glacially derived sediments in the Souris River Basin average 100 to 200 feet thick, but can exceed 600 feet in buried preglacial valleys. Within the glacial drift are deposits of sand and gravel that occur in buried valleys incised into bedrock or till and as buried or surficial outwash in meltwater channels. The largest buried-valley aquifers occur in the eastern and western parts of the Souris Basin. The aquifer system in the eastern part of the Basin in Ward and McHenry Counties is associated with the New Rockford Aquifer which extends eastward into the Red and James River Basins. In the western part of the Souris Basin, buried-valley aquifers exist in the valleys of the ancestral Yellowstone and Missouri Rivers. The aquifers in these valleys extend from the Missouri River Basin into the Souris Basin and on into Canada. Yields to wells tapping these buried-valley aquifers commonly exceed 500 gallons per minute. The glacial-drift aquifers in Burke, Renville, Ward, and Bottineau Counties are commonly associated with a network of relatively narrow meltwater channels. The outwash deposits of sand and gravel are generally thinner than the buried-valley aquifers, so well yields from these aquifers usually are less than 500 gallons per minute. Also present in the glacial-drift and scattered throughout are buried lenses and stringers of sand and gravel. These aquifers are generally thin, of limited extent, and completely surrounded by till. Well yields from such aquifers are typically less than 50 gallons per minute on a sustained basis. The quality of water in the glacial-drift aquifers varies considerably throughout the basin as a function of depth, sources of recharge, material through which the ground water flows, and chemical processes occurring in the subsurface. The water is typically hard with calcium and sodium the chief cations, and bicarbonate and sulfate the chief anions. Dissolved solids varies from 500 to 2500 mg/l. The sodium hazard for irrigation ranges from low to high and the salinity hazard from low to medium. Recommended standards for drinking water are exceeded for dissolved solids, sulfate, iron, and in the shallower aquifers by nitrate concentrations. However, the water is usually satisfactory for most uses including domestic, livestock, industrial, municipal, and irrigation.

Land Resources

The Souris Statistical Planning Area, with the most notable exception being the Turtle Mountains, was naturally a mixed tall and short-grass prairie. The glacial effects on the area created numerous shallow wetlands on the flat to rolling expanses of grassland. Glacial till, the predominant soil parent material, lead to the formation of the soils which are black to dark colored resulting from the centuries of grass cover.

Land Use and Ownership

As with all of North Dakota, the Souris River SPA is dominated by the mixed farming operations of small grain and livestock quite suited to the original grass land environment. Land Use categories and percentage of each is as follows: Cropland 68%; Pastureland 2%; Rangeland 19%; Forest 2%; Urban and Built-up 3%; Other Land 4%; and Water Areas 2% 1/. The number of farms within this SPA was 6,614 as of 1978 2/. Land ownership estimates place taxable land or private land at approximately 95% and non-taxable land at 5% of the total area which is about 7 million acres in size 3/.

Production Capability

Many factors affect the productivity of the area's soils. Some of these include soil type, fertility, climate, and slope. The U.S. Soil Conservation Service has identified and mapped erodible soils, prime farmlands, and important farmlands.

Current and Projected Production

The total value of agricultural products sold has increased gradually over the last thirty years. The total value of agricultural products sold in 1978 as an example, amounted to $218.6 million [2/]. This figure changes yearly reflecting growing season conditions, thereby affecting crop yields, and also commodity prices influenced by the world market. Crop production is historically between 75-80% of the total value of the agricultural products sold in 1978 [2/]. In the future, improvement in crop varieties grown through the introduction of new varieties will continue to increase per acre crop yields.

No significant changes are expected for the near term in crop and livestock production trends for the Souris SPA. Row or specialty crops, particularly sunflowers, are gaining additional acreages because of wider profit potential. This trend is not expected to encroach on the small grain dominance of the region. Prices received for agricultural products will dictate minor changes in cropping or agricultural patterns. In the longer term, as in the past, the improvements will continue to be made in crop varieties and in livestock operations resulting in increased production.

Additional acreage may be brought into the cropland category due to continued wetland drainage, at the expense of forested lands or the breaking of pasture or rangelands. The rate at which this will occur will likely be tied directly to prices of agriculture commodities. An equal number of acres may be taken out of cropland because of the reversion of land less suited for cropland use, thereby offsetting any sizeable increase.

Land Treatment

Table II-5-13 shows the status of land treatment in the Souris River SPA.

TABLE II-5-13 LAND TREATMENT IN THE SOURIS RIVER STATISTICAL PLANNING AREA

Status	Cropland Acres	%	Pasture Acres	%	Range Acres	%	Forest Acres	%	Other Acres	%	Total Acres	%
	(000)		(000)		(000)		(000)		(000)		(000)	
Adequately Treated	2,690	57	159	64	658	49	145	90	336	83	3,988	58
Needing Treatment	2,056	43	88	36	690	51	17	10	70	17	2,921	42
Total	4,746	68	247	4	1,348	20	162	2	406	6	6,909	100

Source: U.S.D.A. Soil Conservation Service, North Dakota Management Form No. 2, 1980.

References:
1/ U.S. Department of Agriculture, Soil Conservation Service, Conservation Needs Inventory, July 1970.
2/ U.S. Census of Agriculture 1978.
3/ N.D.S.U. Soils Department from County Tax Information.

PART THREE

THE FUTURE-WITHOUT-PLAN CONDITIONS

INTRODUCTION

An important reason for presenting a description of the Future Without Plan (FWO) conditions is the need to develop an understanding of where we are now and where we are currently headed with regard to utilizing North Dakota's water resources. In developing the FWO scenario, the planning process is, in effect, establishing a baseline against which the impact of plan recommendations can be measured. Accurately projecting baseline conditions into the time frames considered in this study is made difficult by the variable nature of a number of determining factors. The planning process recognizes that factors such as government programs and regulations, the economic outlook, and social attitudes and perceptions can vary, sometimes dramatically, through time. Because variations in these and other factors are unpredictable, it is necessary to prepare the FWO scenario around a set of prescribed assumptions. These assumptions will be discussed at appropriate points in the following sections.

Information presented here concerning the FWO is organized by major resource elements which include Land Resources; Rural Domestic Water; Municipal-Industrial Water; Agriculture; Self-supplied Industrial Water; Flooding; and Fish, Wildlife, and Outdoor Recreation. In each case, a summary of existing water use and water problems, and a statement about the expected FWO condition and pertinent assumptions will be outlined.

LAND RESOURCES

As indicated in the Statewide description of North Dakota's land resources in Chapter Two of Part One, there exists a strong interrelationship between water and land management objectives. Water management decisions typically require information concerning soil type, topography, and land cover to gain a comprehensive understanding of a watershed's hydrologic characteristics. While changes in soil type and topography are nearly imperceptible, land cover, on the other hand, is subject to rapid changes. These changes can be the result of natural phenomenon such as climate or can be attributed to a variety of man's activities. North Dakota is an agricultural state with about 63 percent of its land area currently used in the production of various crops. Since agricultural use of the land can have a significant effect on the quality and quantity of runoff water, it is important that appropriate measures be taken to minimize the potential for negative impacts. Several federal and state governmental entities work cooperatively to promote wise use of land resources by encouraging implementation of protective management practices. Roughly 60 percent of all lands in the State are considered adequately protected under established criteria at this time. Tables III-1-1 through III-1-5 indicate current and projected status of land treatment for each of the five statistical planning areas. Also included in the tables is an estimation of implementation costs and an explanation of assumptions.

TABLE III-1-1 CURRENT & PROJECTED STATUS OF WATERSHED MANAGEMENT AND LAND TREATMENT IN THE MISSOURI RIVER STATISTICAL PLANNING AREA

Land Use	Total Acres (000)	Adequately Treated 1980 Acres (000)	Adequately Treated 1980 %	Projected 1/ 1990 Acres (000)	1990 %	1990 Cost (000)	2000 Acres (000)	2000 %	2000 Cost (000)	2020 Acres (000)	2020 %	2020 Cost (000)	Remaining Acres Needing Treatment (000)
Cropland	9,367	4,996	53 2/	5,464	58	$5,148 3/	5,932	63	$10,296	6,868	73	$20,592	2,499
Pasture	1,427	885	62	956	67	391	1,027	72	781	1,170	82	1,568	257
Range	8,841	4,769	54	5,216	59	2,459	5,658	64	4,890	6,542	74	9,752	2,299
Forest	137	83	61	89	65	330	96	70	715	110	80	1,485	27
Other	646	440	68	NA		NA	NA		NA	NA		NA	NA
TOTAL 4/	20,418	11,173	55	11,725		8,328	12,713		16,682	14,690		33,397	5,082

1/ 1980 acreages were obtained from United States Department of Agriculture, Soil Conservation Service, North Dakota Management Form No. 2, 1980. An implementation rate of one-half (0.5) percent per year was used.

2/ Percent of total item.

3/ Costs are updated from 1967 to 1980 dollar values by using the Index of Prices Paid by Farmers. The costs for land treatment measures were obtained from the Souris-Red-Rainy Basins Comprehensive Study, 1972. Acres are cumulative. Costs are cumulative beginning 1980-1990 period.

4/ Totals for the 1990, 2000, and 2020 time frames do not include acreages and costs for the Other land-use category. No attempt was made to develop projections because of the diverse nature of those lands.

TABLE III-1-2 CURRENT & PROJECTED STATUS OF WATERSHED MANAGEMENT AND LAND TREATMENT IN THE JAMES RIVER STATISTICAL PLANNING AREA

Land Use	Total	Adequately Treated 1980		Projected 1/ 1990			Projected 1/ 2000			Projected 1/ 2020			Remaining Acres Needing Treatment
	Acres (000)	Acres (000)	%	Acres (000)	%	Cost (000)	Acres (000)	%	Cost (000)	Acres (000)	%	Cost (000)	(000)
Cropland	2,987	1,959	66 2/	2,121	71	$1,782 3/	2,270	76	$3,421	2,569	86	$6,710	418
Pasture	612	377	62	410	67	182	441	72	352	502	82	688	110
Range	578	314	54	341	59	149	370	64	308	430	74	638	148
Forest	18	10	56	11	61	55	12	67	110	14	78	220	4
Other	372	199	53	NA		NA	NA		NA	NA		NA	NA
TOTAL 4/	4,567	2,859	63	2,883		2,168	3,093		4,191	3,515		8,256	680

1/ 1980 acreages were obtained from United States Department of Agriculture, Soil Conservation Service, North Dakota Management Form No. 2, 1980. An implementation rate of one-half (0.5) percent per year was used.

2/ Percent of total item.

3/ Costs are updated from 1967 to 1980 dollar values by using the Index of Prices Paid by Farmers. The costs for land treatment measures were obtained from the Souris-Red-Rainy Basins Comprehensive Study, 1972. Acres are cumultive. Costs are cumulative beginning 1980-1990 period.

4/ Totals for the 1990, 2000 and 2020 time frames do not include acreages and costs for the Other land-use category. No attempt was made to develop projections because of the diverse nature of those lands.

TABLE III-1-3 CURRENT & PROJECTED STATUS OF WATERSHED MANAGEMENT AND LAND TREATMENT IN THE RED RIVER STATISTICAL PLANNING AREA

Land Use	Total Acres (000)	Adequately Treated 1980 Acres (000)	1980 %	Projected 1/ 1990 Acres (000)	1990 %	1990 Cost (000)	2000 Acres (000)	2000 %	2000 Cost (000)	2020 Acres (000)	2020 %	2020 Cost (000)	Remaining Acres Needing Treatment (000)
Cropland	7,054	4,515	64 2/	4,867	69	3,872 3/	5,220	74	7,755	5,925	84	$15,510	1,129
Pasture	461	246	53	267	58	210	290	63	440	337	73	910	124
Range	482	257	53	280	58	230	304	63	470	352	73	950	130
Forest	164	65	40	72	44	497	80	49	1,065	89	54	1,704	75
Other	528	371	70	NA		NA	NA		NA	NA		NA	NA
TOTAL 4/	8,689	5,454	63	5,486		4,809	5,894		9,730	6,703		19,074	1,458

1/ 1980 acreages were obtained from United States Department of Agriculture, Soil Conservation Service, North Dakota Management Form No. 2, 1980. An implementation rate of one-half (0.5) percent per year was used.

2/ Percent of total item.

3/ Costs are updated from 1967 to 1980 dollar values by using the Index of Prices Paid by Farmers. The costs for land treatment measures were obtained from the Souris-Red-Rainy Basins Comprehensive Study, 1972. Acres are cumulative. Costs are cumulative beginning 1980-1990 period.

4/ Totals for the 1990, 2000 and 2020 time frames do not include acreages and costs for the Other land-use category. No attempt was made to develop projections because of the diverse nature of those lands.

TABLE III-1-4 CURRENT & PROJECTED STATUS OF WATERSHED MANAGEMENT AND LAND TREATMENT IN THE DEVILS LAKE STATISTICAL PLANNING AREA

Land Use	Total Acres (000)	Adequately Treated 1980 Acres (000)	Adequately Treated 1980 %	Projected 1/ 1990 Acres (000)	1990 %	1990 Cost (000)	2000 Acres (000)	2000 %	2000 Cost (000)	2020 Acres (000)	2020 %	2020 Cost (000)	Remaining Acres Needing Treatment (000)
Cropland	2,667	1,892	71	2,027	76	$1,485	2,160	81	$2,948	2,427	91	$5,885	240
Pasture	227	159	70	170	75	61	182	80	127	204	90	248	23
Range	182	103	57	113	62	55	122	67	105	140	77	204	42
Forest	53	48	91	50	94 4/	110	-		-	-		-	3
Other	332	280	84	NA		NA	NA		NA	NA		NA	NA
TOTAL 5/	3,461	2,482	72	2,360		1,711	2,464		3,180	2,771		6,337	308

1/ 1980 acreages were obtained from United States Department of Agriculture, Soil Conservation Service, North Dakota Management Form No. 2, 1980. An implementation rate of one-half (0.5) percent per year was used.

2/ Percent of total item.

3/ Costs are updated from 1967 to 1980 dollar values by using the Index of Prices Paid by Farmers. The costs for land treatment measures were obtained from the Souris-Red-Rainy Basins Comprehensive Study, 1972. Acres are cumulative. Costs are cumulative beginning 1980-1990 period.

4/ Assumed to be highest level of treatment attainable.

5/ Total for the 1990, 2000 and 2020 time frames do not include acreages and costs for the Other land-use category. No attempt was made to develop projections because of the diverse nature of those lands.

TABLE III-1-5 CURRENT & PROJECTED STATUS OF WATERSHED MANAGEMENT AND LAND TREATMENT IN THE SOURIS RIVER STATISTICAL PLANNING AREA

Land Use	Total	Adequately Treated 1980		Projected 1/ 1990			2000			2020			Remaining Acres
	Acres	Acres	%	Acres	%	Cost	Acres	%	Cost	Acres	%	Cost	Needing Treatment
	(000)	(000)		(000)		(000)	(000)		(000)	(000)		(000)	(000)
Cropland	4,746	2,690	57 2/	2,990	63	$3,300 3/	3,227	68	$5,907	3,702	78	$11,132	1,044
Pasture	247	159	64	170	69	61	183	74	132	207	84	264	40
Range	1,348	658	49	728	54	385	795	59	754	930	69	1,496	418
Forest	162	145	90	154	95 4/	495	-	-	-	-	-	-	8
Other	406	336	83	NA		NA	NA		NA	NA		NA	NA
TOTAL 5/	6,909	3,988	58	4,042		4,241	4,205		6,793	4,839		12,892	1,510

1/ 1980 acreages were obtained from United States Department of Agriculture, Soil Conservation Service, North Dakota Management Form No. 2, 1980. An implementation rate of one-half (0.5) percent per year was used.

2/ Percent of total item.

3/ Costs are updated from 1967 to 1980 dollar values by using the Index of Prices Paid by Farmers. The costs for land treatment measures were obtained from the Souris-Red-Rainy Basins Comprehensive Study, 1972. Acres are cumulative. Costs are cumulative beginning 1980-1990 period.

4/ Assumed to be highest level of treatment attainable.

5/ Totals for the 1990, 2000 and 2020 time frames do not include acreages and costs for the Other land-use category. No attempt was made to develop projections because of the diverse nature of those lands.

RURAL DOMESTIC WATER

In nearly all instances, people living in rural areas of North Dakota have relied on wells as their primary source of domestic water. Although most areas of the State have adequate quantities of water available, the quality of the supply is poor, sometimes well below Federal Drinking Water Standards. Since 1970, the Farmers Home Administration has provided economic support through grants and low interest loans for the construction and operation of rural water supply systems. Nearly 30 systems were either in operation or nearing completion by 1980 and are serving approximately 66 thousand people. Many of the completed systems are located in the Red River Valley area. Although operational systems have relieved much of the problem in meeting rural domestic water needs, there remains several problem areas; Stutsman County and extensive areas south and west of the Missouri River are examples. Ten areas are currently either undergoing feasibility studies or are in the process of organizing for rural water systems. Unfortunately, eventual construction of rural water systems in these and other areas is being threatened by cut-backs in federal funding assistance. Refer to Water-Use Tables III-1-6 through III-1-11 for current and projected FWO requirements for rural domestic water.

MUNICIPAL-INDUSTRIAL WATER SUPPLY

Throughout this report the reference to Municipal-Industrial (M&I) water use means water that is supplied via a municipal water supply system. The source of water for M&I use varies from town to town across North Dakota. Presently, nearly 215 thousand people living in 21 communities rely on surface water supplies, 202 cities are utilizing ground water while two have combination surface/ground-water sources. The planning process anticipates for purposes of the FWO that the current trend of increasing urban population will continue at least through the year 2020 which means a corresponding increase will be required in M&I supplies. This increased demand will likely result in problems in the area of both water availability and the capacity of existing water treatment facilities. The severity of the problem will depend largely on the specific circumstances facing each community. Currently 28 North Dakota communities are in need of improved and/or enlarged fresh water treatment facilities and about 180 waste treatment facility projects have been prioritized for work between now and the year 2000 by the State Department of Health.

The Planning process assumes for the FWO that the West River Water Supply Project will be implemented by 1990, thus meeting the water needs of about 32 communities in southwestern North Dakota, particularly the needs of Dickinson. Another FWO assumption is that the 85 thousand acre Garrison Diversion Phase I development will be in place also by 1990, thus meeting the M&I needs of 20 communities within the Missouri, James, Devils Lake, Sheyenne, and Red River Basins 1/. Phase II of the Garrison Diversion Unit or its equivalent in terms of water required is assumed for the FWO to be in place by the year 2020 and capable of supplying additional M&I needs. Refer to the Water-Use Tables III-1-6 through III-1-11 for current and projected FWO requirements for M&I water.

1/ These include Cogswell, Fargo, Fessenden, Forman, Garrison, Gwinner, Harvey, Jamestown, Lakota, Leeds, Mayville, McClusky, Mercer, Milnor, New Rockford, Sheyenne, Tolna, Turtle Lake, Underwood, and West Fargo.

TABLE III-1-6 SUMMARY OF GROSS REQUIREMENTS, DEVELOPED SUPPLY, AND NET REQUIREMENTS FOR WATER USES - MISSOURI RIVER SPA

		GROSS REQUIREMENTS						NET REQUIREMENTS[2/]			
WATER USE CATEGORY	UNITS	BASE YEAR 1980	S-Surface G-Ground	1990	2000	2020	DEVELOPED SUPPLY[1/]	BASE YEAR 1980	1990	2000	2020
	Annual Acre-Feet (AF)										
Municipal	AF	20,250	16,205 S 4,045 G	25,375	31,850	48,435	20,250	-0-	5,125	11,600	28,185
Other Public[3/]	AF	905	77 S 828 G	985	1,195	915	905	-0-	80	290	10
Rural Water Supply											
Rural Water Systems (self-supplied)	AF	645	129 S 516 G	610	2,775	2,495	645	-0-	-35[5/]	2,130	1,850
Domestic[4/]	AF	4,810	G	4,530	4,315	3,885	4,810	-0-	-280	-495	-925
Livestock	AF	13,040	5,220 S 7,820 G	13,510	15,395	16,180	13,040	-0-	470	2,355	3,140
Irrigation											
Land Irrigated	Acres	100,000		143,915	181,315	256,115	100,000	-0-	43,915	81,315	156,115
Water Required[6/]	AF	186,250	150,000 S 36,250 G	260,385	321,490	443,700	186,250	-0-	74,135	135,240	257,450
Industrial (self-supplied)	AF	4,480	3,360 S 1,120 G	4,935	5,075	5,365	4,480	-0-	455	595	885
Thermoelectric Power (coal conversion)	AF	1,035,575	S	1,050,570	1,095,570	1,140,570	1,035,575	-0-	14,995	59,995	104,995
TOTAL		1,265,955	1,210,566 S 55,389 G	1,360,900	1,477,665	1,661,545	1,265,955	-0-	94,945	211,710	395,590

1/ The developed supply for most categories of water use was assumed to equal the base year gross requirement for that use.

2/ A positive number indicates a gross requirement (population estimates x per person daily water consumption) which is in excess of the developed water supply (meaning a deficient supply), while a negative number indicates that the developed water supply exceeds the gross requirement (meaning a surplus supply).

3/ Other public includes trailer courts, businesses, parks, golf courses, etc. which have their own source of water.

4/ Domestic water requirements are expected to decline through 2020 due to the projected decrease in rural and farm population.

5/ Demand for rural water in the Missouri Statistical Planning Area (SPA) is expected to remain constant. Most rural water system development in the Missouri SPA is anticipated to be developed after 1990 but before 2000.

6/ A farm efficiency factor of 60 percent necessitates the diversion of 1.45 acre-feet of water per acre of land irrigated via ground water sources and 2 acre-feet via surface water. This factor allows for water loss within the farm unit through seepage, evaporation, waste from the distribution system, and deep percolation in the fields.

TABLE III-1-7 SUMMARY OF GROSS REQUIREMENTS, DEVELOPED SUPPLY, AND NET REQUIREMENTS FOR WATER USES - JAMES RIVER SPA

WATER USE CATEGORY	UNITS	GROSS REQUIREMENTS: BASE YEAR 1980	S-Surface G-Ground	1990	2000	2020	DEVELOPED SUPPLY[1]	NET REQUIREMENTS[2]: BASE YEAR 1980	1990	2000	2020
	Annual Acre-Feet (AF)										
Municipal	AF	4,675	G	5,040	5,854	8,655	4,675	-0-	365	1,179	3,980
Other Public[3]	AF	110	G	115	140	105	110	-0-	5	30	-5
Rural Water Supply											
Rural Water Systems (self-supplied)	AF	25	G	215	420	380	25	-0-	190	395	355
Domestic[4]	AF	1,650	G	1,555	1,480	1,335	1,650	-0-	-95	-170	-315
Livestock	AF	3,150	1,260 S 1,890 G	3,215	3,635	3,825	3,150	-0-	65	485	675
Irrigation											
Land Irrigated	Acres	28,000		90,575	98,650	114,800	28,000	-0-	62,575	70,650	86,800
Water Required[6]	AF	43,218	9,520 S 33,698 G	169,989	179,760	207,303	43,218	-0-	126,771	136,542	164,085
Industrial (self-supplied)	AF	1,735	465 S 1,270 G	1,770	1,805	1,880	1,735	-0-	35	70	145
Thermoelectric	AF	-0-		-0-	9,995	9,995	-0-	-0-	-0-	9,995	9,995
TOTAL		54,563	11,245 S 43,318 G	181,899	203,089	233,478	54,563	-0-	127,336	148,526	178,915

1/The developed supply for most categories of water use was assumed to equal the base year gross requirement for that use.

2/A positive number indicates a gross requirement (population estimates x per person daily water consumption) which is in excess of the developed water supply (meaning a deficient supply), while a negative number indicates that the developed water supply exceeds the gross requirement (meaning a surplus supply).

3/Other public includes trailer courts, businesses, parks, golf courses, etc. which have their own source of water.

4/Domestic water requirements are expected to decline through 2020 due to the projected decrease in rural and farm population.

5/Demand for rural water in the Missouri Statistical Planning Area (SPA) is expected to remain constant. Most rural water system development in the Missouri SPA is anticipated to be developed after 1990 but before 2000.

6/A farm efficiency factor of 60 percent necessitates the diversion of 1.45 acre-feet of water per acre of land irrigated via ground water sources and 2 acre-feet via surface water. This factor allows for water loss within the farm unit through seepage, evaporation, waste from the distribution system, and deep percolation in the fields.

TABLE III-1-8 SUMMARY OF GROSS REQUIREMENTS, DEVELOPED SUPPLY, AND NET REQUIREMENTS FOR WATER USES - RED RIVER SPA

		GROSS REQUIREMENTS						NET REQUIREMENTS 2/			
WATER USE CATEGORY	UNITS	BASE YEAR 1980	S-Surface G-Ground	1990	2000	2020	DEVELOPED SUPPLY 1/	BASE YEAR 1980	1990	2000	2020
	Annual Acre-Feet (AF)										
Municipal	AF	23,780	17,460 S 6,320 G	28,035	35,110	50,830	23,780	-0-	4,255	11,330	27,050
Other Public 3/	AF	485	75 S 410 G	515	620	475	485	-0-	30	135	-10
Rural Water Supply											
Rural Water Systems (self-supplied)	AF	3,950	G	3,740	3,785	3,405	3,950	-0-	-210	-165	-545
Domestic 4/	AF	2,365		2,230	2,125	1,910	2,365	-0-	-135	-240	-455
Livestock	AF	3,835	1,635 S 2,300 G	4,200	4,690	4,965	3,835	-0-	365	855	1,130
Irrigation											
Land Irrigated 6/	Acres	45,000		63,750	91,273	146,319	45,000	-0-	18,750	46,273	101,319
Water Required 6/	AF	69,458	15,300 S 54,158 G	98,021	149,130	241,347	69,458	-0-	28,563	79,672	171,889
Industrial (self-supplied)	AF	4,255	3,235 S 1,020 G	4,980	5,070	5,245	4,255	-0-	725	815	990
Thermoelectric Power (coal conversion)	AF	275	S	275	275	275	275	-0-	-0-	-0-	-0-
TOTAL		108,403	37,880 S 70,523 G	141,996	200,805	308,452	108,403	-0-	33,593	92,402	200,049

1/ The developed supply for most categories of water use was assumed to equal the base year gross requirement for that use.

2/ A positive number indicates a gross requirement (population estimates x per person daily water consumption) which is in excess of the developed water supply (meaning a deficient supply), while a negative number indicates that the developed water supply exceeds the gross requirement (meaning a surplus supply).

3/ Other public includes trailer courts, businesses, parks, golf courses, etc. which have their own source of water.

4/ Domestic water requirements are expected to decline through 2020 due to the projected decrease in rural and farm population.

5/ Demand for rural water in the Missouri Statistical Planning Area (SPA) is expected to remain constant. Most rural water system development in the Missouri SPA is anticipated to be developed after 1990 but before 2000.

6/ A farm efficiency factor of 60 percent necessitates the diversion of 1.45 acre-feet of water per acre of land irrigated via ground water sources and 2 acre-feet via surface water. This factor allows for water loss within the farm unit through seepage, evaporation, waste from the distribution system, and deep percolation in the fields.

TABLE III-1-9 SUMMARY OF GROSS REQUIREMENTS, DEVELOPED SUPPLY, AND NET REQUIREMENTS FOR WATER USES - DEVILS LAKE SPA

		GROSS REQUIREMENTS						NET REQUIREMENTS[2/]			
WATER USE CATEGORY	UNITS	BASE YEAR 1980	S-Surface G-Ground	1990	2000	2020	DEVELOPED SUPPLY[1/]	BASE YEAR 1980	1990	2000	2020
	Annual Acre-Feet (AF)										
Municipal	AF	2,090	280 S 1,810 G	2,635	3,620	6,115	2,090	-0-	545	1,530	4,025
Other Public[3/]	AF	45	G	40	45	35	45	-0-	-5	-0-	-10
Rural Water Supply											
Rural Water Systems (self-supplied)	AF	160	G	155	155	140	160	-0-	-5	-5	-20
Domestic[4/]	AF	1,400	G	1,320	1,260	1,120	1,400	-0-	-80	-140	-280
Livestock	AF	670	270 S 400 G	765	865	920	670	-0-	95	195	250
Irrigation											
Land Irrigated	Acres	4,000		31,875	42,150	62,700	4,000	-0-	27,875	38,150	58,700
Water Required[6/]	AF	6,108	1,120 S 4,988 G	60,964	80,620	119,933	6,108	-0-	54,856	74,512	113,825
Industrial (self-supplied)	AF	390	G	400	405	425	390	-0-	10	15	35
TOTAL		10,863	1,670 S 9,193 G	66,279	86,970	128,688	10,863	-0-	55,416	76,107	117,825

1/The developed supply for most categories of water use was assumed to equal the base year gross requirement for that use.

2/A positive number indicates a gross requirement (population estimates x per person daily water consumption) which is in excess of the developed water supply (meaning a deficient supply), while a negative number indicates that the developed water supply exceeds the gross requirement (meaning a surplus supply).

3/Other public includes trailer courts, businesses, parks, golf courses, etc. which have their own source of water.

4/Domestic water requirements are expected to decline through 2020 due to the projected decrease in rural and farm population.

5/Demand for rural water in the Missouri Statistical Planning Area (SPA) is expected to remain constant. Most rural water system development in the Missouri SPA is anticipated to be developed after 1990 but before 2000.

6/A farm efficiency factor of 60 percent necessitates the diversion of 1.45 acre-feet of water per acre of land irrigated via ground water sources and 2 acre-feet via surface water. This factor allows for water loss within the farm unit through seepage, evaporation, waste from the distribution system, and deep percolation in the fields.

TABLE III-1-10 SUMMARY OF GROSS REQUIREMENTS, DEVELOPED SUPPLY, AND NET REQUIREMENTS FOR WATER USES - SOURIS RIVER SPA

		GROSS REQUIREMENTS						NET REQUIREMENTS[2/]			
WATER USE CATEGORY	UNITS	BASE YEAR 1980	S-Surface G-Ground	1990	2000	2020	DEVELOPED SUPPLY[1/]	BASE YEAR 1980	1990	2000	2020
	Annual Acre-Feet (AF)										
Municipal	AF	7,825	2,230 S 5,595 G	9,105	12,390	20,045	7,825	-0-	1,280	4,565	12,220
Other Public[3/]	AF	240	G	245	300	230	240	-0-	5	60	-10
Rural Water Supply											
Rural Water Systems (self-supplied)	AF	895	215 S 680 G	1,565	1,760	1,955	895	-0-	670	865	1,060
Domestic[4/]	AF	3,215	G	3,025	2,885	2,595	3,215	-0-	-190	-330	-620
Livestock	AF	2,445	980 S 1,465 G	2,530	2,870	3,050	2,445	-0-	85	425	605
Irrigation											
Land Irrigated	Acres	6,000	5,280 S	16,775	66,217	165,100	6,000	-0-	10,775	60,217	159,100
Water Required[6/]	AF	10,152	4,872 G	27,838	122,858	312,897	10,152	-0-	17,686	112,706	302,745
Industrial (self-supplied)	AF	335	135 S 200 G	345	355	380	335	-0-	10	20	45
Thermoelectric Power (Coal Conversion)	AF	995	G	995	995	995	995	-0-	-0-	-0-	-0-
TOTAL		26,102	8,840 S 17,262 G	45,648	144,413	342,147	26,102	-0-	19,546	118,311	316,045

1/ The developed supply for most categories of water use was assumed to equal the base year gross requirement for that use.

2/ A positive number indicates a gross requirement (population estimates x per person daily water consumption) which is in excess of the developed water supply (meaning a deficient supply), while a negative number indicates that the developed water supply exceeds the gross requirement (meaning a surplus supply).

3/ Other public includes trailer courts, businesses, parks, golf courses, etc. which have their own source of water.

4/ Domestic water requirements are expected to decline through 2020 due to the projected decrease in rural and farm population.

5/ Demand for rural water in the Missouri Statistical Planning Area (SPA) is expected to remain constant. Most rural water system development in the Missouri SPA is anticipated to be developed after 1990 but before 2000.

6/ A farm efficiency factor of 60 percent necessitates the diversion of 1.45 acre-feet of water per acre of land irrigated via ground water sources and 2 acre-feet via surface water. This factor allows for water loss within the farm unit through seepage, evaporation, waste from the distribution system, and deep percolation in the fields.

TABLE III-1-11 TABLE OF GROSS REQUIREMENTS, DEVELOPED SUPPLY, AND NET REQUIREMENTS FOR WATER USES - NORTH DAKOTA

		GROSS REQUIREMENTS						NET REQUIREMENTS 2/			
WATER USE CATEGORY	UNITS	BASE YEAR 1980	S-Surface G-Ground	1990	2000	2020	DEVELOPED SUPPLY 1/	BASE YEAR 1980	1990	2000	2020
	Annual Acre-feet (AF)										
Municipal	AF	58,620	36,175 S 22,445 G	70,190	88,824	134,080	58,620	-0-	11,570	30,204	75,460
Other Public 3/	AF	1,785	152 S 1,633 G	1,900	2,300	1,760	1,785	-0-	115	515	-25
Rural Water Supply											
Rural Water Systems (self-supplied)	AF	5,675	344 S 5,331 G	6,285	8,895	8,375	5,675	-0-	610	3,220	2,700
Domestic 4/	AF	13,440	G	12,660	12,065	10,845	13,440	-0-	-780	-1,375	-2,595
Livestock	AF	23,140	9,265 S 13,875 G	24,220	27,455	28,940	23,140	-0-	1,080	4,315	5,800
Irrigation											
Land Irrigated 6/	Acres	183,000		346,890	479,605	745,034	183,000	-0-	163,890	296,605	562,034
Water Required 6/	AF	315,186	181,220 S 133,966 G	617,197	853,858	1,325,180	315,186	-0-	302,011	538,672	1,009,994
Industrial (self-supplied)	AF	11,195	7,195 S 4,000 G	12,430	12,710	13,295	11,195	-0-	1,235	1,515	2,100
Thermoelectric Power (coal conversion)	AF	1,036,845	1,035,850 S 995 G	1,051,840	1,106,835	1,151,835	1,036,845	-0-	14,995	69,990	114,990
TOTAL		1,465,886	1,270,201 S 195,685 G	1,796,722	2,112,942	2,674,310	1,465,886	-0-	330,836	647,056	1,208,424

1/ The developed supply for most categories of water use was assumed to equal the base year gross requirement for that use.

2/ A positive number indicates a gross requirement (population estimates x per person daily water consumption) which is in excess of the developed water supply (meaning a deficient supply), while a negative number indicates that the developed water supply exceeds the gross requirement (meaning a surplus supply).

3/ Other public includes trailer courts, businesses, parks, golf courses, etc. which have their own source of water.

4/ Domestic water requirements are expected to decline through 2020 due to the projected decrease in rural and farm population.

5/ Demand for rural water in the Missouri Statistical Planning Area (SPA) is expected to remain constant. Most rural water system development in the Missouri SPA is anticipated to be developed after 1990 but before 2000.

6/ A farm efficiency factor of 60 percent necessitates the diversion of 1.45 acre-feet of water per acre of land irrigated via ground water sources and 2 acre-feet via surface water. This factor allows for water loss within the farm unit through seepage, evaporation, waste from the distribution system, and deep percolation in the fields.

AGRICULTURE

North Dakota has been and will continue to be an agricultural state. The economic health of the state is strongly reflective of what is happening in agricultural production and marketing. Although energy development has had a significant impact on overall income in recent years, agriculture will likely remain the economic base well into the future.

Agriculture is dependent on three essential natural elements; air, soil, and water. In North Dakota, air quality is generally well within state standards and the soil has demonstrated its productivity for decades. Water has always been a limiting factor facing the state's agricultural industry. Average annual precipitation ranges from about 15 inches in the west to more than 20 inches in the east. However, average annual precipitation means very little because North Dakota's continental climate is noted for wide variations from average conditions. As a result, the state is vulnerable to cyclic droughts which are devastating to both crop and livestock production. To offset effects of recurring drought, North Dakotans have worked to supplement precipitation through the development of irrigation. Irrigation not only helps to assure production even in dry years, it makes it possible for farmers to diversify their operations, thus becoming less vulnerable to market fluctuations.

An important assumption made for the purposes of the FWO is that North Dakota will continue to produce agricultural products at an increasing rate. Agricultural production is, of course, normally subject to the regulating characteristics of various governmental programs which are typically very difficult to predict from year-to-year. Therefore, the increasing rate of production is based primarily on the anticipated food and fiber needs of a growing world population. Additional irrigation along with technological advancements to stabilize and increase productivity and an improved distribution system will be needed if the projected world demand is to be met.

Figures from the 1978 Census of Agriculture indicate that North Dakota experienced a 100 percent increase in irrigated acres between 1974 and 1978. Although this increase seems dramatic, North Dakota's irrigated cropland accounted for only 0.7 percent of cropland harvested in 1978. This compares to 17 percent in Montana, 63 percent in Wyoming, 2 percent in South Dakota, and 34 percent in Nebraska.

The NDSU Extension Service estimated that approximately 183,000 acres were irrigated in North Dakota in 1980. This is a small percentage of acres of potentially irrigable soil which totals over six million statewide. It is not practical to assume that all irrigable soils can actually be developed as such, but if the state is to approach this potential, it will require development of efficient, effective water distribution systems for surface water distribution and careful management of ground-water appropriations.

The Missouri River has long been recognized as a source of water capable of providing a reliable supply for irrigation and many other uses. Even since the North Dakota Constitutional Convention in 1889, the state has considered a diversion of water from the Missouri River. The Garrison Diversion Unit of the Pick-Sloan Plan approved in the Flood Control Act of 1944 was authorized for construction in 1965. The project is designed to provide water for irrigation, municipal-industrial, rural domestic, livestock, hydroelectric power, wildlife, recreation, and other uses. The planning process recognizes problems that have arisen in regard to implementing the Garrison Diversion Project but assumes for the FWO that Phase I level or approximately 85,000 acres of irrigation will be in place by 1990. The FWO also assumes that Phase II which includes the remaining authorized irrigation areas (164,540 acres), or its equivalent in regards to water requirements, will be in place by the year 2020.

It is important to note that the current direction of federal policy and funding programs will make it increasingly difficult to obtain federal aid for irrigation development beyond completion of the Garrison Diversion Unit.

It was suggested at a Citizens Advisory Board meeting that North Dakota might consider following South Dakota's lead in marketing Missouri River water to help pay for water development projects. This is an alternative that North Dakota may wish to pursue, but no official policy has yet been formulated. Any diversion of water out of the Missouri River Basin would likely require coordination with downstream interests.

Growth in private irrigation development is, again, very difficult to predict because there are so many influencing factors. Factors such as agricultural market fluctuations, rising energy costs, uncertain interest rates for capital, the occurrence of prolonged drought, the availability of water, and water/soil compatibility are each involved in an individual's decision to irrigate. Recent growth in privately developed irrigation has utilized primarily ground-water sources. Many of the State's aquifer systems are rather "fragile" in the sense that they can sustain only so much withdrawal if they are to remain a viable resource. State policy has supported development of ground-water resouces for irrigation, but it strongly opposes "mining" of ground water that would eventually deplete the resource. Water-Use Tables III-1-6 through III-1-11 reflect the anticipated growth in irrigation.

SELF-SUPPLIED INDUSTRIAL WATER

Reference to self-supplied industrial water means water supplies utilized by industry and provided through a system independent of municipal or other public operated systems. In North Dakota, self-supplied industrial water use is dominated by in-state processing of raw agricultural products, sand and gravel processing, and energy development. Increases in self-supplied water demand are largely attributable to rapid growth in the development of the state's energy resources, primarily its lignite reserves. Growth in water use by nonenergy industries has been slow but this is a condition that will change as new agricultural processing plants are built. Three plants that will produce alcohol from agricultural products are expected to be built before 1990. In addition to the alcohol plants, the FWO anticipates a two-to-three percent per year increase in nonenergy self-supplied water use.

As the United States moves to reduce dependency on foreign oil imports, there will be an ever increasing reliance on domestic oil and coal reserves. North Dakota has witnessed the construction of several plants since the early 1970's to convert lignite to electrical energy and, more recently, to synthetic natural gas. Projecting new growth in coal conversion for the FWO is complicated by several unpredictable factors which include, among other things, proposed revisions to Federal air quality standards; the State Department of Health's adoption of a new air quality predictive model; energy conservation and what that will mean in marketing energy; and the rising cost of construction and uncertainty in financing. For the purposes of the FWO, the planning process has assumed the construction of one additional coal conversion plant by 1990, four new plants between 1990 and 2000, and three more plants between 2000 and 2020. Water requirements for each plant is quite variable so the assumption is made that each plant unit will require 15,000 acre-feet of water for its operation each year. The state has no official policy regarding coal-slurry use of North Dakota's water resources, therefore, the possibility exists but it is not actively pursued. Refer to the Water-Use Tables III-1-6 through III-1-11 for current and projected FWO requirements for self-supplied industrial water.

FLOODING

Flooding is a natural and normal phenomenon and it is only when man competes with rivers for the use of floodplain areas that problems begin to arise. It is not unusual for flooding to take place somewhere on North Dakota streams each year. Floods that result from spring snowmelt and summer thunderstorms have been the state's most costly natural disaster. In the time period between 1969 to 1982, ten major presidential disasters were declared in North Dakota; each a result of flooding. Agricultural losses alone in the summer flood of 1975 exceeded $400 million. The following is a general description of flooding in the Missouri River, James River, Red River, Devils Lake, and Souris River drainage basins.

Missouri River Basin

Although flood damages adjacent to the Missouri River have been severe in past years, the potential for future losses has been greatly reduced with construction of the mainstem dams. Unfortunately, flood losses on the Missouri River's many tributary streams remain largely unchecked due primarily to the lack of structural and nonstructural flood protection measures. The Heart River is an exception in that Heart Butte Dam, Dickinson Dam, and dikes in the cities of Mandan and Dickinson all provide important flood protection. Projects that exist in other tributaries are smaller in scope and the protection they provide is limited.

Information presented in the Yellowstone River Basin and Adjacent Coal Area Level B Study report completed in 1978, indicates that average annual flood damages exceeded $2.4 million for the North Dakota Tributaries, an area covering most of the Missouri River Basin in North Dakota. Flood damages experienced in the Missouri River Basin are expected to continue to increase along with the growth in energy development. The area's growing population has turned many small rural communities into "boom" towns which have, in the past, permitted increased development in flood prone areas. The "Yellowstone Report" projects the area's average annual damages to increase to $2.7 million in 1985 and to almost $3.5 million by the year 2000. The planning process estimates that $4.7 million in average annual damages will occur by 2020 if existing trends continue.

The most recent large scale flooding occurred with the spring snowmelt in 1982 which caused approximately $1.3 million in damages to public property in nine counties. This flood resulted in a Presidential Disaster Declaration which qualifies three of the nine affected counties for federal financial aid.

James River Basin

Major floods occurred in the James River Basin in 1881, 1920, 1922, 1942, 1950, and in 1969. By taking into account the major floods and numerous lesser floods, the Basin has incurred flood damages on the average of one out of every four years. The construction of Jamestown Dam in 1953 and Pipestem Dam in 1973 has greatly reduced both urban and rural damages. These two dams combine to provide complete flood protection to the City of Jamestown and over 90 percent reduction in damages along the James River between Jamestown and the South Dakota state line. Damages that still occur within the Basin are related mostly to agricultural lands and to public utilities such as roadway bridges and culverts. The planning process recognizes that there are a number of trouble spots located throughout the James River Basin. Consideration of structural projects like the channel improvements planned for Rocky Run Creek and North Rocky Run Creek watersheds and implementation of nonstructural measures will be required to further minimize future flood losses.

Red River Basin

The Red River Basin has suffered numerous major floods since the first recorded event in 1882. The Red River flows north through what was once the bottom of glacial Lake Agassiz and is now the most productive farmland in North Dakota. The flow of the Red River through this flat topography is extremely sluggish with such intricate meander curves that it takes 397 mile of channel to cover the 187 mile straight line distance between Wahpeton and Pembina. As a result of the region's flat topography, the Red River and its tributaries are bordered by extensive flood plain areas. When a flood occurs, water over flows the banks of the river and its tributaries and moves overland often affecting as many as two million acres. Since nearly 90 percent of the Basin's land is used for agricultural purposes, flood damages take the form of losses from delayed seeding or destruction of growing crops. North Dakota's largest urban center, Fargo, and third largest, Grand Forks, are both located on the Red River and have suffered from the recurring floods. Other flood prone communities in the Basin include Valley City, Wahpeton, West Fargo, Grafton, Mayville, Hillsboro, Harvey, Pembina, and Lisbon. Information derived from the Red River of the North Reconnaissance Report completed in 1980 by the Gulf South Research Institute, indicated current and future average annual flood damages for the North Dakota portion of the Red River Basin to be as follows: approximately $26 million for 1980, $29 million for 1990, $32 million for 2000, and $37 million for 2020.

Many structural flood control projects have been proposed and studied by a variety of governmental agencies in past years with few workable solutions being found. The U.S. Corps of Engineers is currently working on plans for the Lower Sheyenne River and Pembina River flood control projects. It is anticipated that each project will require a combination of structural and nonstructural measures. The current plan for the Sheyenne River would relieve $22.5 million in annual flood damages. Plans for the Pembina River are currently being revised.

In many areas of the Basin, protective diking has been a successful way to limit flood damages although indiscriminate private diking activities have fostered their own set of problems. Farm diking constructed along both sides of the Red River have become a particular problem which is currently being contested in court. Under the present limited flood protection conditions in the Red River Basin, all flood losses now sustained will likely continue into the FWO only on an increased scale due to continuing development in the flood plains and increasing value of existing developments.

In order to find equitable solutions to the Basin's many flood related problems, the various Water Resource Districts, in 1978, pooled their efforts in the form of a Joint Powers Agreement. Improved cooperation and coordination fostered by this agreement should aid the Basin's residents in implementing measures that will mitigate flood losses.

Devils Lake Basin

The Devils Lake Basin is somewhat unique among the state's five major hydrologic basins in that it has no natural outlet and is, therefore, considered a closed drainage system. The Basin's topography plays a large part in the analysis of flood damages experienced by the area's residents. Much of the region's land is rolling, but the general slope is relatively flat. Small streams, shallow lakes, and numerous wetland depressions characterize the Basin's drainage features. Agricultural development is extensive and nearly all flood damages result from delayed crop planting, destruction of growing crops, and delayed or precluded harvest. When runoff exceeds limited channel capacities, it flows out over the land in the form of sheet flooding. There is roughly 56,000 acres of flood plain area that are subject to recurring flood events. Average annual flood damages derived from the Red River of the North Reconnaissance Report written by the Gulf South Research Institute in 1980, show an increasing dollar damage figure. In 1980, average annual damages equalled about $2.8 million; in 1990 they are expected to reach $3.1 million; in 2000 they may reach $3.5 million; and in 2020 they may reach almost $4 million.

A comprehensive, multi-agency study supervised by the Devils Lake Basin Advisory Committee, closely analyzed the Basin's flooding problems and proposed several corrective measures. The 1976 report, coming from this effort, recommended both structural and nonstructural actions. Structural actions include construction of 212 miles of channel improvements, four miles of new channel construction, seven new lake control structures, modification of one existing lake control structure, nine grade stabilization structures, and two control structures on sloughs. Nonstructural actions included restoration and preservation of natural water storage areas under provisions stipulated in the report and acceleration in the application of land treatment measures. Implementation of structural and nonstructural measures would reduce average annual flood damages by about 59 percent.

In order to follow-up on plan recommendations, and to deal with new problems as they develop, the Basin's Water Resource Districts have entered into a Joint Powers Agreement forming the Devils Lake Joint Powers Board. Work on some of the recommendations is either completed, Channel A, or under construction, channel improvements below Hurricane Lake. Flood damage reduction in the Devils Lake Basin's FWO will depend largely on the Joint Powers Board's ability to implement the remaining study recommendations.

Souris River Basin

Both the Souris River and the Des Lacs River, a major tributary, overflow their banks to some extent almost every year. Most of these floods are small and short in duration causing only minor problems. Floods which result in more severe damages originate primarily from snowmelt in the Canadian portion of the Souris River Basin and have occurred seven times since 1969. The one-half to one mile wide valley along the river reach, between the Upper Souris and J. Clark Salyer National Wildlife Refuges, usually sustains the Basin's most significant flood losses. The City of Minot and vicinity are particularly affected with flood damages approaching $11 million in 1969, the second largest flood of record. In most major floods, more than 90 percent of the dollar-damages are incurred in Minot, Other areas affected by primarily agricultural losses are along Stone, Boundary, and Willow Creeks, and Tolley Flats.

Since 1936, Lake Darling Reservoir, owned and operated by the U.S. Fish and Wildlife Service, has done much to reduce flood damages in the Souris River valley by controlling several small floods. The protection provided by the reservoir reduced concern about flooding and numerous residential and commercial developments were constructed at Minot in the river's flood plain. With the severe flood of 1969, which greatly exceeded the reservoir's flood storage capacity, came extensive damages and recognition that some action must be taken to preclude similar future losses. A number of flood control projects have been proposed for the Souris River Basin with the most extensive centering around the construction of a dry dam near Burlington. The Burlington Dam proposal included a diversion tunnel joining the Des Lacs River to the Burlington Reservoir, a four foot raising of Lake Darling, and levee modifications in urban areas between Burlington and Minot and at Sawyer and Velva. The Burlington dry dam proposal met with considerable dissent, due to its impacts, so a compromise plan was devised to provide interim protection until a satisfactory total flood protection plan can be worked out. The Corps of Engineers has received authorization to begin implementation of interim actions which include a four-foot raising of Lake Darling Dam and raising of road and railroad crossing, as well as levee work between Burlington and Minot and at Velva and Sawyer. The construction schedule calls for this work to be completed by 1989. The average annual damages without the interim project are approximately $10.3 million compared to just over two million dollars with the project. The two million dollars in average annual damages is the remaining unmet need which should be addressed in the 1990 to 2000 time frame.

Flood Plain Management in North Dakota

North Dakota has recognized that good flood plain management involves the utilization of a variety of tools to reduce the impact of flood disasters. It is also recognized that a balance must be reached between the three aspects of flood plain management which are: structural works designed to modify the flood itself, regulatory functions which may reduce susceptibility to flooding, and emergency preparedness actions which minimize a flood's effect during a disaster. The Federal Disaster Protection Act of 1973 requires state and local governments to participate in the National Flood Insurance Program (NFIP) as a condition to the receipt of any federal loan or grant for construction projects in flood prone areas. Participation in the NFIP requires communities to adopt flood plain regulations that meet NFIP objectives which are: 1) new buildings must be protected from flood damages that occur as a result of the 100-year flood, and 2) new development must not cause an increase in flood damages to other property. Communities have been provided assistance through passage in 1981 of the state's first Flood Plain Management Act which directs the State Engineer to aid local governments to reduce flood damages through sound flood plain management. As a start, the state legislature provided the State Engineer with an appropriation to be used in assisting communities to obtain base flood (100-year) elevation data. The planning process anticipates the FWO in flooding will see continued reduction in flood damage susceptibility across the state, but it will likely take many years to achieve the established goals.

FISH, WILDLIFE, AND OUTDOOR RECREATION

Fish, wildlife, and outdoor recreation are somewhat unique water uses as each is very dependent upon the availability of water but withdrawals and consumption are relatively minimal. The characteristics of quality and areal extent in terms of surface area and quantity are of major importance.

Sport fishing in North Dakota has experienced a significant increase in recent years due largely to completion of the Missouri River mainstem reservoirs which have more than tripled the state's available fishing waters. The State Game and Fish Department is making considerable progress in managing these waters and has an active fish rearing and stocking program designed to both increase fish numbers and numbers of game-fish species. According to the 1980 State Comprehensive Outdoor Recreation Plan (SCORP), resident fishing licenses for the 1978-1979 season exceeded 97,000 while non-resident license sales grew to more than 28,000 full season and nearly 13,000 short-term.

A viable fishing resource is closely tied to water quality. Although the large Missouri River mainstem reservoirs provide an excellent fishery base, many of the state's smaller reservoirs and natural lakes are progressively eutrophic and are gradually loosing their ability to support a fishery. (Eutrophication is a natural aging process whereby a lake becomes increasingly nutrient rich and deficient in dissolved oxygen). The State Game and Fish Department has been involved in managing, including fish stocking, approximately 236 lakes across North Dakota. Many of these lakes are now marginal fisheries and are stocked only when water conditions are such that a winterkill would not be expected to occur. Under the effect of current trends, fifty percent of these lakes will have very poor to no fishery value within 15 to 20 years due primarily to advanced eutrophic conditions. Man's activities generally accelerate sedimentation and increase levels of nitrates and phosphates which combine to speed the natural aging process. Corrective actions such as the implementation of land treatment measures, improved waste-water treatment, and various lake restoration techniques could improve the situation, but government funded programs to accomplish these tasks are currently not in keeping with the problem.

At the time North Dakota was settled, it was part of a vast prairie grassland region supporting great numbers and diversity of wildlife. As the region developed agriculturally, most of the natural habitat has undergone a change from prairie grasses to production of tilled crops and tame grasses. The shift in land cover has brought about a paralleling change in numbers and make-up of wildlife populations. Diversity has suffered and numbers have been greatly reduced.

A major water related issue that has developed over a number of years concerns the preservation of wetland habitats in the face of increased pressure from agricultural drainage. The most current statewide wetland inventory was completed by the U.S. Fish and Wildlife Service in 1964 and indicated that North Dakota contained approximately 1.7 million acres of Types I, III, IV, V, X, and XI wetlands. However, these survey results are considered to be quite conservative. The Fish and Wildlife Service estimates that in recent years nearly 20,000 acres of wetlands are lost annually through drainage. It is important to note that not every remaining wetland acre is vulnerable to drainage. Topography and other factors make it impractical to drain many of the remaining wetland acres. In addition, the U.S. Fish and Wildlife Service has permanently protected many wetland acres by purchasing approximately 427 thousand acres of land in fee and by the acquisition of perpetual easements on approximately 4.94 million acres of land.

Various government programs such as the Federal and State Water Bank Programs are available to aid in protection of wetlands. The Federal Water Bank Program has been annually funded at $10 million since the program originated in 1972 with North Dakota receiving the lion's share each year. Continued funding of the program is threaten by Presidiential budget cuts at the time of this writing. The State Water Bank Program is newly established and has not as yet been funded.

The determination of wetland values to justify the need for wetland preservation and restoration has, in itself, become a controversial matter. Extensive research by the Fish and Wildlife Service and others has clearly established wetland habitat value in producing and maintaining waterfowl and other wildlife species. Research by North Dakota State University and others has also demonstrated the value gained by draining wetlands to make the land more suitable for tillage and thus, crop production. Most of the current dispute concerns other values that wetlands have such as flood water storage, sediment and pollution retention, and ground-water recharge. Quantification of these values has been attempted but only on limited samples. A much more comprehensive and intensive research effort will be needed to gain reliable results.

Water is an important element in many outdoor recreational activities both directly and indirectly. Activities such as power boating, water skiing, swimming, sailing, cannoeing, and fishing are obviously directly related to water. Camping, hunting, picnicking, hiking, and sightseeing are activities less often associated with water though water often plays an important part in a quality recreational experience. Quantity and quality of water are both important because enough water must be available to meet the demands of the recreationalist and the water must be of adequate quality to assure a safe and enjoyable experience. Poor water quality in many of North Dakota's lakes and streams seriously impacts water-based recreation. Fishing is the second most popular recreational activity among North Dakotans and, as mentioned earlier in this section, the state's fishing waters are in trouble unless existing programs to improve water quality are not adequately funded and aggressively operated.

Many of the existing water-based recreational facilities across the state are not adequate to meet normal demands and are particularly stressed on peak use days such as public holidays. Shortages of camping facilities, boat ramps and docks, marinas, and swimming beachs have become apparent. The influx of people associated with energy development has had a significant impact on existing facilities. As the population of North Dakota continues to increase, the severity of this problem will worsen.

The North Dakota Parks and Recreation Department has indicated that there is a need to preserve scenic river reachs and habitat areas important to rare and unique plants and animals. Setting areas of land or reachs of rivers aside for preservation purposes may conflict with water development for other uses.

PART FOUR

PLAN FORMULATION

FOREWORD

Information portrayed in the following chapters is intended to serve as a guide for decision makers as they consider matters affecting water and related land resource management across North Dakota. As explained in Chapter Three of Part One, the planning process has followed a progression from the identification of water management problems and development opportunities through the review of alternative actions and finally, the selection of elements for the recommended plan. Each major step in this progression included extensive opportunity for public interaction.

The following chapters contain findings pertinent to each of the five major hydrologic basins beginning with the Missouri River Basin. The information is presented primarily in tabular form with tables and figures in each chapter arranged in the following sequence:

<u>Problem Summary</u> - Problems are identified by type, Public Involvement Region, and location. This is followed by a brief description of the problem and its recent status.

<u>Opportunities Summary</u> - Water development opportunities are identified by function, Public Involvement Region or Regions that wish to pursue the opportunity, location, and a description of what the proposal would involve.

<u>Non-Recommended Study Alternatives</u> - When the complete listing of project/program alternatives was reviewed by the Citizens Advisory Boards and the public, some proposals were rejected for a variety of reasons, including poor economic return on investment, adverse environmental impacts or, in some instances, long standing controversy over merits. Listed in this table are those project/program proposals that were dropped from further consideration in the planning process.

<u>Analysis of Alternatives (Three-Account)</u> - This table is preceded by a map depicting the appropriate hydrologic basin and the general geographic locations of project/program proposals within the basin. Contained within the table is a set of brief statements for each project/program regarding the estimated economic, environmental, and other social effects that would likely occur if the proposal were to be implemented.

<u>Recommended Plan Summary</u> - The Recommended Plan Summary table presents an array of water requirements and implementation costs for the alternatives that were recommended by the Citizens Advisory Boards and the public. The information is presented on a functional basis for each of the three time frames addressed in the planning process.

Recommended Plan (Early Action Program) - The recommended alternatives for the early action program, the 1980 to 1990 time frame, are presented in more detail in this table. The names of specific alternatives are listed by function and are followed by a brief description and implementation cost data.

PROBLEMS SUMMARY

TABLE IV-1-1 WATER MANAGEMENT PROBLEMS - MISSOURI RIVER BASIN

Problem Type	Public Involvement Region	Location	General Description
Water Supply	Beaver Creek	Southern Emmons County	There is a shortage of good quality rural-domestic water in southern Emmons County. In 1977, an application was received for a rural water system to supply the needs of rural areas as well as the towns of Strasburg, Westfield, and Hague. Additional funds are needed before the project can proceed.
Water Supply	Cannonball/Grand Heart Knife Little Missouri	Southwestern North Dakota	Many farms and cities in southwestern North Dakota lack a good quality - adequate quantity water supply. The passage of Senate Bill 2338 in the 47th Legislative Assembly (1981 Session) appropriated $983,000 to the State Water Commission to contract for preliminary design of a pipeline delivery system - the Southwest Pipeline Project. The pipeline will supply municipal, rural-domestic, and livestock needs.
Water Supply	Heart	Dickinson, Stark County	Until the late 1940's, ground water was the source of water supply for the City of Dickinson. As this source showed signs of inadequate quantity and quality, the Dickinson Unit was constructed by the Bureau of Reclamation on the Heart River. Dickinson has obtained water from Patterson Lake (part of the Dickinson Unit) since 1952. Since, the City has examined alternatives to provide a supplemental good quality water supply. Most recently, an agreement of intent has been signed for a water purchase contract for water from the Southwest Pipeline.
Water Supply	Lake Sakakawea	Fort Berthold Reservation	Adequate supplies of good quality water are limited for rural-domestic and livestock use on the Fort Berthold Reservation.
Water Supply	Middle Missouri	Eastern Kidder County	In an area south of Pettibone, it is difficult to locate water because of the nature of the aquifer (Kidder County Aquifer Complex). Most aquifers in the area are thin and do not extend very far, making them difficult to locate. If they are located, they may yield only small quantities of water.
Water Supply	Upper Missouri	Mountrail County	There is a shortage of rural-domestic water throughout Mountrail County. There are currently no rural water systems except for one at Ross, a small community which will get a system when funds are available. An application was received for a system in 1976. Project costs ($18 million) are beyond present programs.

Problem Type	Public Involvement Region	Location	General Description
Water Supply	Cannonball/Grand	Cedar Creek and Cannonball River - Morton, Sioux, Grant, Adams, and Slope Counties	Flows in Cedar Creek are extremely low during most of the spring and summer. In 1960, the ND State Water Commission enacted a moratorium on Cedar Creek and the Cannonball River.
Water Quality	Cannonball/Grand	Bowman-Haley Reservoir - Bowman County	The Bowman-Haley Reservoir, located 12 miles southeast of Bowman, is highly eutrophic and suffers severe nutrient loading and heavy siltation. This material is carried by water running off intensively-cropped land within the watershed.
Water Quality	Lake Sakakawea	Lake Audubon - McLean County	Lake Audubon is highly eutrophic and suffers nutrient loading from runoff waters. The lake has extensive shallow water areas which are conducive to algae growth. Studies are underway to determine a plug-removal sequence for McClusky Canal which would improve Lake Audubon's water quality by allowing existing water to flow down the canal to be replaced by fresh water from Lake Sakakawea.
Water Quality	Middle Missouri	Lake Isabel - Kidder County	Lake Isabel, located three miles south of Dawson, is very shallow and highly susceptible to winterkill. In the past, the lake has also suffered water quality problems due to inadequate treatment of domestic wastes from cabins surrounding the lake.
Water Quality	Middle Missouri	Brush Lake - McLean County Cherry Lake - Kidder County	These lakes are rich in nutrients. Algae and aquatic weed growth develop rapidly as the water warms in the spring causing decreased recreation value. Decomposition of aquatic debris over winter depletes the oxygen supply contributing to fish kills.
Water Quality	Knife	Stanton, Mercer County	Possible contamination of the aquifer beneath the City of Stanton is resulting from pollutants in the old Knife River channel of past sewage disposal and feedlot effluent.
Flooding	Beaver Creek	Linton, Emmons County	Flooding is of a severe and continuing nature on Beaver Creek, resulting from rapid snowmelt runoff in early spring or from heavy rainfall in late spring or summer. A project involving a channel clean out and levee system has been proposed by the Corps of Engineers; however, local interests have not provided the necessary assurances to construct the potential project.
Flooding	Beaver Creek	Napoleon, Logan County	Flooding in Napoleon occurs in the spring of the year due to snowmelt runoff and frozen soil conditions. Potential flood areas within the McKenna Coulee Watershed include prime crop and pasture land. A limited number of homes and businesses along the coulee are subject to inundation during a 100-year frequency flood. A flood control project has been proposed by the Soil Conservation Service; however, it was voted down during a special 1981 election.
Flooding	Cannonball/Grand	Mott, Grant County	The floodplain area of the Mott Watershed is entirely within the City of Mott. Numerous short tributaries join north of the city and form a channel which goes through Mott to join with the Cannonball River. Portions of the watershed are inundated about every other year by snowmelt runoff and/or summer rainfall runoff. A flood control project was authorized for Mott as part of the 1958 Flood Control Act; however, the project was placed in an inactive status in 1961. A Corps of Engineers restudy of the project (1978) concluded the authorized project was economically infeasible.

Problem Type	Public Involvement Region	Location	General Description
Flooding	Cannonball/Grand	Louise Creek - Grant and Morton Counties	Louise Creek is a tributary of the Cannonball River. Potential flood areas within the Louise Creek Watershed include primarily agricultural land. A limited number of homes and businesses in Flasher are subject to inundation during a 100-year frequency flood event. Most flooding occurs in the spring from snowmelt runoff. Flood control efforts by the Soil Conservation Service have reached an impasse due to funding difficulties.
Flooding	Cannonball/Grand	Cannonball River and Thirty-mile Creek - Hettinger, Grant, Sioux, and Morton Counties	Flood damages have demonstrated the need for flood control along the Cannonball River and its tributary, Thirty-Mile Creek. High flows have presented a problem in selecting storage sites because of the high cost of providing reservoir space for flood storage. Current investigations include a recreational dam on Thirty-Mile Creek which may have some flood control benefits. Sites proposed in the 1975 State Water Commission West River Study for multi-purpose storage structures on the Cannonball River may be integrated into additional studies to determine their flood prevention capability.
Flooding	Heart	Mandan, Morton County	The City of Mandan sits along the Heart River just above the confluence of that river with the Missouri. Flood hazards from both waterways occasionally threaten. Backup water due to ice jams is common in all areas of West Mandan along Old Highway 10. The Heart River has several flood control and retention devices, the most notable being Heart Butte Dam and the Mandan City dikes. The Corps of Engineers has recently completed the hydrology studies in the re-evaluation of the dikes.
Flooding	Knife	Square Butte Creek - Oliver and Morton Counties	Approximately 6,500 acres of agricultural land, homes, the City Park, and park facilities in Center are subject to flooding from Square Butte Creek. Estimated annual flood damages have been approximated at $13,800. In 1971, a $2 million Soil Conservation Service watershed construction program received approval. This phased project is currently under construction.
Flooding	Knife	Beulah, Mercer County	The City of Beulah is located on the banks of the Knife River. Two coulees break through the hills north of the City, flow through town, and empty into the Knife River. Although normally dry, the coulees have caused flash floods because of the steep channel gradients. Since 1975, the City of Beulah has seen a very rapid growth due to energy development in the area. This growth has resulted in expansion to the north of town. Potential flood losses are greater now due to the increased number of houses in flood prone areas. A flood control dry dam has recently been constructed just northeast of the city.
Flooding	Lake Sakakawea	Underwood McLean County	Approximately 5.5 square miles north and west of Underwood contribute drainage to a large slough just north and adjacent to the City. Part of this slough has been filled and developed into trailer courts. Spring runoff fills the slough and floods the trailer courts as well as some homes. Recently, the City elected to participate in the Coal Lake Coulee Legal Drain to provide an outlet for the floodwater.
Flooding	Middle Missouri	Painted Woods Lake and Creek - McLean County	Excessive runoff has caused flooding and erosion problems in the Painted Woods Lake area. Current action includes investigation of flood control alternatives for the region.

Problem Type	Public Involvement Region	Location	General Description
Flooding	Middle Missouri	Apple Creek - Burleigh County	Areas adjacent to Apple Creek are subject to recurrent floods. Damages to bridges, roads, and water facilities exceeded $1 million in 1979. Neideffer Dam, located about six miles south of Wing, is being constructed as a demonstration project during the first phase of a total flood control program for Apple Creek.
Flooding	Upper Missouri	White Earth - Mountrail County	Flooding in White Earth comes from two areas: 1) the White Earth River and 2) drainage from north of town - Paulsen Creek. Several alternatives have been suggested, including construction of a dam on Paulsen Creek, raising the existing dikes two feet, and several tributary dams.
Flooding	Upper Missouri	Blacktail Dam - Williams County	Blacktail Dam is located about 20 miles north of Williston on Blacktail Creek. Cabin flooding has occurred due to location of the cabins and the level of the dam spillway. The spillway has been lowered once already. Several alternatives have been considered including lowering the emergency spillway and relocating the cabins.
Flooding	All Regions	Cities throughout the Missouri River Statistical Planning Areas	A mechanism is needed to coordinate storm water management between city and surrounding non-city areas.
Erosion	Beaver Creek	Hoskins and Green Lakes - McIntosh County Beaver Lake - Logan County	Lake shore erosion is occurring. Riprapping primarily public lands around the lakes has been suggested.
Erosion	Heart	Dickinson, Stark County	A complex of commercial and agricultural lands in southeast Dickinson has been confronted for several years with an increasingly serious water erosion problem due to high water velocities and highly erodible soil conditions. The principal damage is due to gully erosion, which in turn, causes heavy deposition of sediment into the Heart River. Shaping and seeding of the area and installation of concrete drops will be done as part of a Roosevelt-Custer Resource Conservation and Development Area Plan.
Erosion	Heart Knife Lake Sakakawea Middle Missouri	Missouri River	Since development of the mainstem reservoir system, a new erosion-accretion trend has become evident. Regulated flows of relatively sediment-free water discharged from the mainstem projects account for more river bottom and river bank degradation than there is accretion in the unstabilized reaches of the Missouri River downstream from each project. Construction of streambank erosion control demonstration projects was authorized by the Corps of Engineers at 21 sites on the River between Garrison Dam and Lake Oahe. Due to limited funding, only seven sites have received complete protection. Funding is currently unavailable for either the uncompleted Section 32 projects or additional sites.
Erosion	Heart	Heart River - Morton County	Bank stabilization is needed for at least three sites along the Heart River.
Erosion	Knife	Nelson Lake - Oliver County	Streambank erosion is occurring downstream of Nelson Lake caused by water releases from the lake by the Minnkota Power Company. The dam was built for cooling the Milton R. Young power station, and has little capacity to store floodwaters. The Soil Conservation Service Square Butte Watershed project may alleviate the problems.

Problem Type	Public Involvement Region	Location	General Description
Erosion	Little Missouri	Little Missouri River - Medora and Billings County	Riverbank erosion is occurring along the Little Missouri River particularly causing concern in the area of Medora. Medora is having problems maintaining its sewage lagoon and a county road due to this erosion. The Army Corps of Engineers proposed some erosion control measures; however, a source of funding has not been determined.
Erosion	Lake Sakakawea	Lake Sakakawea	Shoreline erosion is occurring along the shoreline of the Lake.
Erosion	Upper Missouri	Yellowstone River - McKenzie County	Riverbank stabilization is needed for areas of bank erosion. Although two sites have been protected under the Army Corps of Engineers Section 32 Erosion Control Demonstration Program, all funding terminated at the end of fiscal year 1982.
Erosion	All Regions	Missouri River Statistical Planning Area	The installation of land treatment measures is considered essential for protection and preservation of the basic soil resources, for reducing air and water pollution, and for assisting in the sustained production of food and fiber.
Dam Deterioration	Beaver Creek	Jund Dam - McIntosh County	Jund Dam, about four miles east of Zeeland, is an earthfill dam with a rubble masonry spillway built in 1935 by the Work Projects Administration. A 1979 State Water Commission inspection revealed overall and major deterioration of the dam. A new dam site has been proposed just south of the existing site.
Dam Deterioration	Beaver Creek	Welk Dam - Emmons County	Welk Dam was originally constructed by the Work Projects Administration in 1938. It is located on a Beaver Creek tributary eight miles west of Strasburg. The reservoir has filled with silt and repairs are needed. A new structure has been suggested downstream of the existing dam to provide recreation and fish and wildlife habitat.
Dam Deterioration	Beaver Creek	Beaver Lake Dam - Logan County	Beaver Lake Dam was originally constructed by the Civilian Conservation Corps in 1934. The dam has been repaired a number of times in the past; however, these repairs have been superficial. Since the last repair, the spillway has sustained damages which have resulted in the lowering of the lake by approximately two feet. It has been requested that a project be implemented to maintain the lake at its original elevation and to have better control on the release of water from the lake.
Dam Deterioration	Little Missouri	Odland Dam - Golden Valley County	Odland Dam needs two types of improvements. First, there should be a low-level drawdown system installed. Second, repairs should be made to the old spillway.
Outdoor Recreation	Beaver Creek	Southern McIntosh County	In southern McIntosh County, the demand for additional recreation opportunities exceeds the existing facilities.
Outdoor Recreation	Knife	Southern Dunn County	Recreation resources are substantial for certain types of activities in southern Dunn County, but nearly non-existent for others. The almost total absence of substantial water bodies severely limits water-based recreation.

Problem Type	Public Involvement Region	Location	General Description
Lake Restoration	Cannonball/Grand	Hettinger, Adams County	Mirror Lake was originally created by the Milwaukee Railroad to act as a holding pond for use as a water source to power stream-driven locomotives. In 1972, efforts began to restore Mirror Lake for fishing and recreational purposes. Late in 1980, the lake was drained as a first step to restoration. Progress has now been stalled due to a loss of funding from the Environmental Protection Agency. The Hettinger Park Board is exploring alternative sources of funding.
Channel Obstruction	Upper Missouri	Mountrail County	Silt and brush have clogged the channel capacities of the White Earth River, Little Knife River, Shell Creek, and East Fort Shell Creek. These four streams empty into Lake Sakakawea.
Sedimentation	Upper Missouri	Williston, Trenton, and Buford, Williams County	Due to Garrison Dam, excessive sedimentation has built up in the area of Williston at the confluence of the Yellowstone River. One effect is the high water table in the City of Williston, affecting streets and residences. Some units in the Trenton-Buford irrigation districts have also been affected.
Fish and Wildlife Habitat Destruction	All Regions	Missouri River Statistical Planning Area	Serious long-term fish and wildlife problems have occurred due to changes in agricultural land-use practices.
Ground-water Information	Beaver Creek	Emmons, Logan, and McIntosh Counties	More detailed aquifer maps are needed for these areas. Specific information is not currently available.
Saline Seeps	Cannonball/Grand Heart Knife Little Missouri Upper Missouri	Mostly west of the Missouri River	Saline seeps are wet, salty areas in non-irrigated soils on which crop production is reduced or eliminated. The soil surface is intermittently or continuously wet and white salt crusts are often present.
Oil activities	Upper Missouri Little Missouri	Areas of oil-associated activity	Concern has been expressed by area landowners about oil activities that may be allowing seepage of oil-drilling material into ground-water supplies.
Boat Ramps (Wolf Creek)	Lake Sakakawea	Wolf Creek Lake Sakakawea	More boat ramps are needed to serve adequately the large number of boaters using the Wolf Creek recreation area. Funding is limited.

OPPORTUNITIES SUMMARY

TABLE IV-1-2. WATER DEVELOPMENT OPPORTUNITIES - MISSOURI RIVER BASIN

Opportunity	Public Involvement Region	Location	General Description
Multi-purpose storage structure (Beaver Creek Dam)	Beaver Creek	S13,T132,R79; on Beaver Creek about 10 miles west of Linton	This dam would retain flows from Beaver Creek and would back up water approximately 5 miles. Water could be pumped north and south (into Horsehead Flats) for irrigation. The dam would have to be constructed with a pumping plant to maintain the reservoir levels behind the dam with water from the Missouri River and Lake Oahe. A second set of pumps and a piping system would be required for distributing water to irrigable lands.
Multi-purpose storage structure (Unnamed Reservoir)	Knife	S35,T145,R92; one mile southwest of Halliday	It has been proposed to raise Highway 200 so that it would act as a dam on an unnamed creek running south to north through Section 35. The proposed dam would have a normal pool elevation of 2,100 feet msl. The dam would contain a 100-year frequency inflow thereby providing flood damage reduction as well as recreation. The average water depth of 12.5 feet would be adequate to maintain fish life. The maximum depth of water would be 25 feet.

Opportunity	Public Involvement Region	Location	General Description
Multi-purpose storage structure (Beaver Creek Dam)	Little Missouri	Beaver Creek-S34,T143,R105; about 15 miles north of Beach in Golden Valley County	This dam was listed in the 1975 State Water Commission West River Study. The reservoir would store 55,169 acre-feet with 1,920 surface acres - 6,275 acres could be irrigated.
Single-purpose storage structure (Pumpback structure)	Lake Sakakawea	Fort Berthold Reservation	A pumpback or off-stream hydropower project on the reservation could be used to develop a source of low cost power for future major development on the reservation. One such structure (pumpback structure Number 10) was evaluated in the 1975 State Water Commission West River Study.
Water Conveyance System (Rural waterline)	Lake Sakakawea	Fort Berthold Reservation	A rural waterline could be developed to serve reservation residents plus offer a supplemental supply for livestock watering.
Water Conveyance System (Irrigation Project)	Lake Sakakawea	Fort Berthold Reservation	Development of some small-scale irrigation projects from reservation ground-water resources could be put to conjunctive use with projects utilizing Lake Sakakawea water.
Water Conveyance System (Garrison municipal water supply)	Lake Sakakawea	Garrison, McLean County	A Bureau of Reclamation Plan will provide an assured supply of good-quality water by obtaining Garrison Diversion Unit water from Audubon Lake. Proposed facilities include a pumping plant on Lake Audubon, modifying the existing water treatment plant, and a 10-mile pipeline connecting the pumping plant and treatment plant.
Water Conveyance System (McDowell Dam Augmentation)	Middle Missouri	McDowell Dam - about 10 miles east of Bismarck	A possibility exists to freshen the McDowell Dam reservoir with water from the McClusky Canal. The water would be diverted for irrigation in northern Kidder County and central Burleigh County, and freshening purposes for McDowell Dam.
Water Conveyance System (McClusky Canal)	Middle Missouri	McClusky Canal - McLean, Burleigh, and Sheridan Counties	There is a great deal of interest in canal-side irrigation along the McClusky Canal.
Drainage (Agricultural)	Knife	S1,11,&12, T143, R93; about five miles northwest of Marshall	It has been proposed to drain a slough which is about 15.5 square miles in size. The purpose would be to increase agricultural production in slough area. Engineering studies are currently being prepared on this project for the Dunn County Water Resources Board.
Drainage	All Regions	Missouri River Statistical Planning Area	Sound management of an area's surface waters can be enhanced through the use of a watershed or "systems" approach to drainage.
Irrigation (Lakeside)	Lake Sakakawea	Irrigable land adjacent to Lake Sakakawea	Parcels of land around the lake could be developed for lake-side irrigation.
Irrigation (Education)	All Regions	Missouri River Statistical Planning Area	Seminars conducted on a local level by knowledgeable representatives of the State Water Commission, the State Agricultural Department, and other agencies or irrigators could educate landowners on the advantages of irrigation.
Irrigation (Sewage lagoon waters)	All Regions	Missouri River Statistical Planning Area	A possibility exists to utilize community sewage lagoon waters for irrigation of adjacent farmland.
Irrigation (Groundwater Information)	All Regions	Missouri River Statistical Planning Area	Efforts should be made to gain more specific information on groundwater reserves in order to expedite the irrigation permitting process.

Opportunity	Public Involvement Region	Location	General Description
Land Management Practice (Plugging wetlands)	All Regions	Missouri River Statistical Planning Area	The possibility of plugging drained wetlands in the years when the land is summer fallowed should be explored. This practice could decrease erosion and the movement of nutrients, fertilizers, and pesticides from the land.
Land Management Practice (State Water Bank Program)	All Regions	Missouri River Statistical Planning Area	The State Water Bank Program, if funded, would help preserve, restore, and improve inland fresh water and adjacent areas in important migratory waterfowl nesting and breeding areas. Under the program, landowners receive annual payments for conserving and protecting wetlands.
Land Management Practice (Waterfowl production)	All Regions	Missouri River Statistical Planning Area	Waterfowl production could be increased if more attention is paid to developing habitat and managing wetlands now under federal control.
Lake Restoration (Brush Lake)	Middle Missouri	Brush, Blue, Peterson, Pelican, and Williams Lakes in McLean County	A water supply from the McClusky Canal could provide a constant fresh water supply to Brush and Blue Lakes and a consistent source for Pelican, Peterson, and Lake Williams for recreation and fish and wildlife purposes. Additional potential exists for municipal and industrial applications through a central processing plant at Brush Lake.
Fish Hatcheries	All Regions	Missouri River Statistical Planning Area	Fish hatcheries around the State need rejuvenating and/or enlarging. More modern facilities are needed.

NON-RECOMMENDED STUDY ALTERNATIVES

TABLE IV-1-3 NON-RECOMMENDED STUDY ALTERNATIVES - MISSOURI RIVER BASIN

Alternative	Public Involvement Region	Location	General Description
<u>Multi-purpose Reservoirs</u>			
Regent Dam	Cannonball/Grand	S12,T134,R95 Hettinger County	Alt. A: Reservoir size - 40,000 AF storage Use: industrial, municipal, and flood storage. Alt. B 1/: Reservoir size - 80,000 AF storage Use: irrigate 29,727 acres; industrial, and municipal.
Bentley Dam	Cannonball/Grand	S6,T133,R90 Grant County	Reservoir size: 50,000 AF storage Use: irrigate 550 acres; industrial, municipal, and flood storage.
Upper Antelope Dam	Heart	S10,T138,R95 Stark County	1/ Reservoir size - 50,000 AF storage Use: irrigate 13,000 acres; and industrial use.
Manning Dam 2/	Knife	S1,T143,R96 Dunn County	Alt. A: Reservoir size - 11,561 AF storage Use: irrigate 3,200 acres. Alt. B: Reservoir size - 11,561 AF storage Use: irrigate 830 acres; and industrial use.
Broncho Dam 3/	Knife	S8,T142,R90 Mercer County	Alt. A: Reservoir size - 130,000 AF storage Use: irrigate 8,000 acres; industrial, and flood storage. Alt. B: Reservoir size 65,000 AF storage Use: irrigate 5,000 acres; industrial, municipal, and flood storage. Alt. C: Reservoir size - 65,000 AF storage Use: industrial and flood storage. Alt. D 1/: Reservoir size - 130,000 AF storage Use: irrigate 18,500 acres; industrial, municipal, and flood storage.

NON-RECOMMENDED STUDY ALTERNATIVES - MISSOURI RIVER BASIN

Alternative	Public Involvement Region	Location	General Discription
Otter Creek Dam 4/	Knife	S3,T143,R87 Oliver County	Reservoir size - 26,655 AF storage Use: industrial and municipal.
Brush Creek Dam 5/	Knife	S9,T143,R88 Mercer County	Reservoir size: 22,800 AF storage Use: industrial and municipal.
Deep Creek Dam	Little Missouri	S36,T136,R103 Slope County	Alt A: Reservoir size - 24,795 AF storage Use: irrigate 3,700 acres. Alt. B 6/: Reservoir size - 24,795 AF storage Use: irrigate 900 acres; industrial and municipal. Alt. C 1/ 6/: Reservoir size - 48,485 AF storage Use: irrigate 34,000 acres; industrial and municipal.
Single Purpose Reservoirs			
South Coyote Creek Dam	Knife	S19,T143,R88 Mercer County	Alt. A: Reservoir size - 24,800 AF storage Use: water supply for Brush Creek Dam. Alt. B 1/: Reservoir size - 24,800 AF storage Use: industrial and municipal.
Raymond Creek Dam	Knife	S23,T145,R85 Mercer County	Reservoir size - 37,899 AF storage Use: industrial (requires pumpback from the Missouri River).
North Coyote Creek Dam 7/	Knife	S2,T142,R92 Dunn County	Alt. B: Reservoir size - 830 AF storage Use: recreation.
Re-regulation Dam	Lake Sakakawea	Mercer and McLean Counties	Additional hydropower generation at Garrison Dam would require a re-regulation dam downstream from Garrison Dam.
Irrigation Projects			
Horsehead Flats	Beaver Creek	Emmons County	Irrigate 18,000 acres, water conveyed from Lake Oahe.
Flood Control Projects			
Mott Flood Control	Cannonball/Grand	Hettinger County	Two miles of levees and .6 mile of channel improvements.
Blacktail Dam 8/	Upper Missouri	S10,T157,R101 Williams County	Flooding of cabins due to high lake levels. Alt. A: lower the emergency spillway two feet and protect with concrete. Alt. B: lower the emergency spillway two feet and reseed. Alt. C: relocate 27 cabins.
Scenic and Recreational Rivers			
Cannonball River	Cannonball/Grand	Sioux County	Maintain 45 miles of free-flowing stream from Shields to bridge for ND 1806.
Knife River	Knife	Dunn and Mercer Counties	Maintain 76 miles of free-flowing stream from Manning to the Missouri River.
Missouri River	Knife	Mercer, Oliver, Morton, McLean, and Burleigh Counties	Maintain 86 miles of free-flowing river from Garrison Dam to the mouth of the Heart River south of Mandan.
Yellowstone River	Upper Missouri	McKenzie County	Maintain 22 miles of free-flowing stream from the North Dakota-Montana border to the Missouri River.
Instream Flow			
Cannonball River at Breien	Cannonball/Grand	Sioux County	Provide flow of 54,300 AF per year, provided natural conditions permit, to maintain conservation of fish and wildlife resources.
North Fork Grand River at Haley	Cannonball/Grand	Bowman County	Provide a flow of 6,154 AF per year, provided natural conditions permit, to maintain conservation of fish and wildlife resources.

Alternative	Public Involvement Region	Location	General Description
Heart River at Mandan	Heart	Morton County	Provide a flow of 56,038 AF per year, provided natural conditions permit, to maintain conservation of fish and wildlife resources.
Knife River at Hazen	Knife	Mercer County	Provide a flow of 38,662 AF per year, provided natural conditions permit, to maintain conservation of fish and wildlife resources.
Litte Missouri River at Watford City	Litte Missouri	McKenzie County	Provide a flow of 130,320 AF per year, provided natural conditions permit, to maintain conservation of fish and wildlife resources.
<u>Other</u>			
Unique Woodlands Preservation	Little Missouri	Western Slope County	Preservation of woodlands totaling 5,163 acres; protection and management of 4,328 acres of ponderosa pine (1,932 acres federally owned and 3,028 acres privately owned), 735 acres of limber pine (523 acres federally owned and 203 privately owned), and 100 acres of columnar juniper (federally owned).
Weather Modification Programs	Heart and Knife	Statewide	A) The North Dakota Cloud Modification Program B) Drought Management Strategies C) Atmospheric Water Resources Research in conjunction with the North Dakota Cloud Modification Program D) Public Awareness of Weather Modification

1/ Alternative requires diversion of water from Lake Sakakawea.

2/ The construction of Manning Dam would preclude the implementation of both Emerson and Broncho Dams unless a diversion was implemented.

3/ Implementation of this project would preclude the construction of both Manning and Emerson Dams unless a diversion was implemented.

4/ A smaller version utilized for irrigation is included in the Recommended Study Alternatives.

5/ Requires diversion from the Knife River plus an upstream reservoir (Broncho Dam or South Coyote Dam as a water supply).

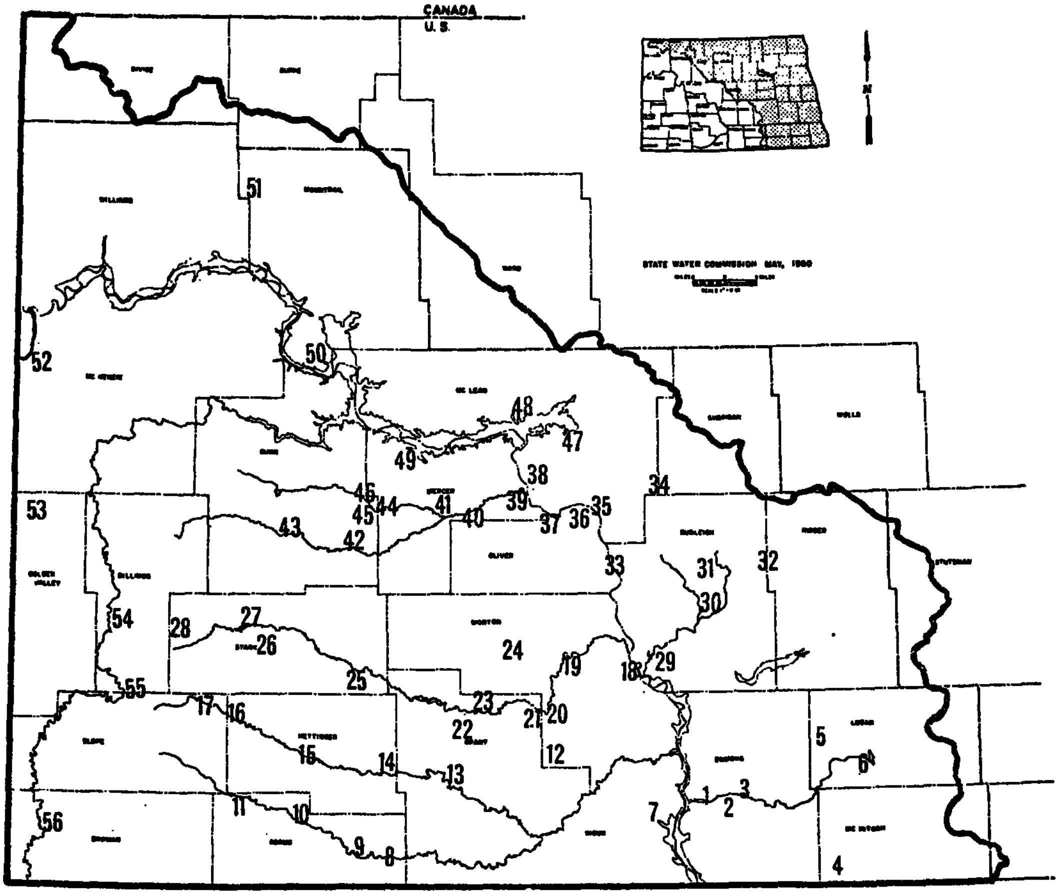
6/ Implementation of this project would require an amendment to the Little Missouri State Scenic River Act.

7/ Alternative A is included in the Recommended Study Alternatives.

8/ An existing reservoir.

FIGURE IV-1-1 MISSOURI RIVER BASIN

LOCATION OF RECOMMENDED STUDY ALTERNATIVES



1. Beaver Creek Dam
2. Welk Dam Repairs
3. Linton Flood Control
4. Jund Dam Repairs
5. Napoleon Flood Control
6. Beaver Lake Dam Repairs
7. Fort Yates Irrigation Unit
8. Thunderhawk Dam
9. Square Butte Dam
10. Hettinger Dam
11. Wolf Butte Dam
12. Flasher Flood Control
13. Cannonball Dam
14. Thirty-Mile Creek Dam
15. Mott Dam
16. Bohlman Dam
17. Philbrick Creek Dam
18. Little Heart Irrigation Unit
19. Heart River - Scenic and Recreation River
20. Heart River Streambank Stabilization
21. Otter Creek Dam
22. Lower Antelope Creek Dam
23. Crown Butte Dam
24. Hailstone Creek Dam
25. Buffalo Creek Dam
26. Upper Antelope Dam
27. North Dickinson Channel Critical Area Treatment
28. Belfield Flood Control
29. Apple Creek Irrigation Unit
30. Series of Flood Control Dry Dams Apple Creek Watershed
31. Schwartz Dry Dam
32. McClusky Canal Diversion to Kidder and Burleigh Counties
33. Missouri River Streambank Stabilization
34. McClusky Canal-side Irrigation
35. Painted Woods Irrigation Unit
36. Oliver-Sanger Irrigation Unit
37. Missouri River - Scenic and Recreation River
38. Knife River Historic Sites Streambank Stabilization
39. Hazen-Stanton Irrigation Unit
40. Otter Creek Dam
41. Beulah Dry Dams
42. North Coyote Creek Dam
43. Emerson Dam
44. Spring Lake Dam
45. Drainage Project - Dunn County
46. Alkali Creek Dam
46. Halliday Flood Control
47. Underwood Flood Control
48. Garrison, ND - Municipal Water Supply
49. Pumpback Reservoir - Hydropower
50. Muskrat Lake Watershed (Watershed Project PL 566)
51. White Earth Flood Control
52. Yellowstone River Streambank Stabilization
53. Beaver Creek Dam
54. Little Missouri Streambank Stabilization
55. Third Creek Dam
56. Marmarth Dam

TABLE IV-1-4 RECOMMENDED STUDY ALTERNATIVES - BENEFICIAL AND ADVERSE EFFECTS OF THE POTENTIAL PROJECTS IN THE MISSOURI RIVER BASIN

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Beaver Creek Dam (Figure IV-1-1; Site #1)
S15, T132, R79
Emmons County

PUBLIC INVOLVEMENT REGION: Beaver Creek

PURPOSE: Multi-purpose storage

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: The implementation of a reservoir that would maintain an elevation of 1,620 feet msl would supply water to irrigate an estimated 18,000 acres of land. A pump-back from Lake Oahe would be necessary to maintain the reservoir level at 1,620 feet msl.

ECONOMIC DEVELOPMENT: Capital Cost NA
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The reservoir would inundate approximately 1,200 acres of land at elevation 1,620 feet msl resulting in a loss of some agricultural land and native riparian vegetation. The land inundated to the 1,620 feet msl is either owned by the Army Corps of Engineers or the Corps has flood easements on the land.

Beaver Creek is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map because of its excellent forage fish production, reproduction of northern pike, and sport fishery on northern pike and channel catfish near the mouth of Beaver Creek. The reservoir will restrict upstream migration of fish species which will reduce the total fish productivity of the Creek.

OTHER SOCIAL EFFECTS:

Irrigation will help stabilize the economy. Employment opportunities would be provided during the construction phase.

STATUS:

Recent Investigation. Further detailed study is required to determine feasibility of the project.

RECOMMENDATION: A detailed study is recommended to determine cost of the project in addition to total acres that could be irrigated.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Philbrick Creek Dam 1/ (Figure IV-1-1; Site #17)
S12, T136, R99
Slope County

PUBLIC INVOLVEMENT REGION: Cannonball/Grand

PURPOSE: Multi-purpose storage

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION:		ECONOMIC DEVELOPMENT
Alt. A:	Reservoir size: 75,000 AF storage; 4,125 surface acres Use: Irrigate 46,650 acres; 81 AF municipal use; 4,520 AF industrial use	Capital Cost $8,935,000 Annual Cost $677,000 Annual Benefit 2/ Benefit/Cost Ratio 1.33
Alt. B:	Reservoir size: 80,000 AF storage; 4,350 surface acres Use: irrigate 63,128 acres; 13,560 AF industrial use; 243 AF municipal use	Capital Cost $9,693,000 Annual Cost $736,000 Annual Benefit 2/ Benefit/Cost Ratio 1.32

ENVIRONMENTAL QUALITY:

With implementation of Alternative A, the reservoir at conservation pool would inundate 4,125 acres of land. Approximately 2,200 acres are native pasture, 1,450 acres are cropland while remaining community types include buffaloberry, wolfberry-rose, sloughgrass, sedge-meadow, and reed-swamp. Alternative B would inundate 4,350 acres of land at conservation pool level. The loss of wildlife habitat may reduce hunting opportunities in the area. The site is located on Philbrick Creek which is not rated on the Game and Fish Stream Evaluation Map. The water drawdowns for industrial and irrigation purposes would cause bankline and structural feature exposure that may be considered by some to be visual intrusions to the area. The power plant would result in increases in aerial contaminants of long-term duration in the area. The success of the reclamation program will be determined by the value of the reclaimed lands. An archaeological site exists in the area which may be adversely affected.

OTHER SOCIAL EFFECTS:

Irrigation will help stabilize the local economy. Industry will result in an increase in population and employment. Alternative A with the associated 400 M.W. plant will have a peak construction work force of approximately 1200 workers of which 600 will be non-locals. There will be a population increase of 1,350 with about 275 of the increase consisting of school aged children. Each unit will have a permanent work force of approximately 125 persons which will come from the construction area or from the construction work force. Alternative B with the associated 1200 M.W. plant will have a peak construction work force of approximately 2,200 workers of which 1,100 will be non-locals. There will be a population increase of 2,475 persons with about 500 of the increase consisting of school aged children. Each unit will have a permanent work force of about 275 persons which will come from the construction area or the construction work force.

STATUS: Inactive

RECOMMENDATION: Continued Study into a diversion from Lake Sakakawea.

1/ Alternative requires diversion of water.
2/ Benefits were not updated. The B/C Ratio is anticipated to be similar to the 1974 ratio.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Mott Dam (Figure IV-1-1; Site #15)
S32, T134, R93
Hettinger County

PUBLIC INVOLVEMENT REGION: Cannonball/Grand

PURPOSE: Multi-purpose storage

LEAD STUDY AGENCY: Bureau of Reclamation/ ND State Water Commission

DESCRIPTION:		ECONOMIC DEVELOPMENT
Alt. A:	Reservoir size: 50,000 AF storage; 3,000 surface acres Use: irrigate 1,400 acres; 40,000 AF flood storage; 4,520 AF industrial use; 81 AF municipal use	Capital Cost $23,080,000 Annual Cost $1,748,000 Annual Benefit 1/ Benefit/Cost Ratio 1.18
Alt. B:	Reservoir size: 50,000 AF storage; 3,000 surface acres Use: irrigate 3,850 acres; 40,000 AF flood storage; 500 AF municipal use	Capital Cost $23,080,000 Annual Cost $1,748,000 Annual Benefit NA 1/ Benefit/Cost Ratio NA
Alt. C:	Reservoir size: 44,700 AF storage; 3,000 surface acres Use: irrigate 5,800 acres; 170,250 AF flood storage	Capital Cost $46,017,000 Annual Cost $3,364,000 Annual Benefit $3,069,000 Benefit/Cost Ratio .91

ENVIRONMENTAL QUALITY:

The reservoir at conservation pool would inundate 3,000 acres of land. Approximately 73 percent or 2,200 acres of the reservoir site is cropland. Four hundred and fifty acres is native pasture; remaining community types include buffaloberry, wolfberry-rose, and elm-boxelder. At flood stage, 5,400 acres of land would be inundated. This reach of the Cannonball River maintains good furbearer, deer, wild turkey, and sharp-tailed grouse populations. The reservoir would destroy riparian habitat and may reduce hunting opportunities in the area. The Cannonball is rated Class II - High Priority on the Game and Fish Stream Evaluation Map because of its moderate forage fish production and moderate sport fishery on northern pike and channel catfish. The reservoir would restrict migration of fish upstream. Seasonally, fishing downstream of reservoir would be slightly improved. The reservoir could also support industry which will result in an increase in aerial contaminants of long-term duration in the area. The value of the reclaimed land will be dependent upon the success of the reclamation program. During drawdown, banklines and structural features will be exposed and may be considered by some to be a visual intrusion to the area. Historical and archaeological impacts were not determined.

OTHER SOCIAL EFFECTS:
The reservoir would provide annual flood control benefits. Irrigation will help stabilize the area's economy. Eighty-one acre feet would be available for municipal use. A power plant would result in an increase in the area's population and employment opportunity. The reservoir would require the relocation of a railroad. Alternative A with the associated 400 M.W. plant will have a peak construction work force of approximately 1,200 workers of which 600 will be non-locals. There will be a population increase of 1,350 with about 275 of the increase consisting of school aged children. Each unit will have a permanent work force of approximately 125 persons which will come from the construction area or from the construction work force.

STATUS: Inactive.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame with continued study into a diversion from Lake Sakakawea.

1/ Benefits were not updated. The B/C ratio is anticipated to be similar to the 1974 ratio.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Cannonball Dam (Figure IV-1-1; Site #13)
S12, T133, R89
Grant County

PUBLIC INVOLVEMENT REGION: Cannonball/Grand

PURPOSE: Multi-purpose storage

LEAD STUDY AGENCY: Bureau of Reclamation/ND State Water Commission

DESCRIPTION:
Alt. A: Reservoir size: 60,000 AF storage; 2,250 surface acres
Use: irrigate 6,875 acres; 48,000 AF flood storage

ECONOMIC DEVELOPMENT
Capital Cost $16,165,000
Annual Cost $1,224,000
Annual Benefit 1/
Benefit/Cost Ratio 1.18

Alt. B: Reservoir size: 60,000 AF storage; 2,250 surface acres Use: irrigate 325 acres; 11,300 AF industrial use; 202 AF municipal use; 48,000 AF flood storage	Capital Cost $15,767,000 Annual Cost $1,195,000 Annual Benefit 1/ Benefit/Cost Ratio 3.58
Alt. C: Reservoir size: 78,000 AF storage; 2,800 surface acres Use: irrigate 5,000 acres; 163,000 AF flood storage; 1,900 AF municipal, industrial, and rural use	Annual Cost $32,031,000 Annual Cost $2,425,000 Annual Benefit $7,508,000 Benefit/Cost Ratio 3.10
Alt. D: Reservoir size: 78,000 AF storage; 2,800 surface acres Use: irrigate 10,000 acres; 163,000 AF flood storage	Capital Cost $39,540,000 Annual Cost $2,961,000 Annual Benefit $4,022,000 Benefit/Cost Ratio 1.36
Alt. E 2/: Reservoir size: 80,000 AF storage; 2,850 surface acres Use: irrigate 29,727 acres; 4,520 AF industrial use; 81 AF municipal use; 48,000 AF flood storage; recreation	Capital Cost $16,050,000 Annual Cost $1,216,000 Annual Benefit 1/ Benefit/Cost Ratio 1.33
Alt. F 2/: Reservoir size: 80,000 AF storage; 2,850 surface acres; Use: irrigate 26,890 acres; 27,130 AF industrial use; 486 AF municipal use; 48,000 AF flood storage	Capital Cost $15,972,000 Annual Cost $1,209,000 Annual Benefit 1/ Benefit/Cost Ratio 1.42

ENVIRONMENTAL QUALITY:

The reservoir at conservation pool with Alternatives A and B would inundate 2,250 acres of land. Approximately 525 acres are cropland, 1,300 acres are native pasture, and 225 acres are elm-boxelder trees. Alternatives C, D, E, and F would inundate 2,850 acres of land. Other community types lost include some aspen, buffaloberry, wolfberry, sedge-meadow, and reed-swamp. The habitat diversity supports excellent furbearer, wild turkey, and deer populations. The loss of this habitat may reduce hunting opportunities in the area.

This reach of the Cannonball River is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map because of its excellent forage fish production and reproduction of sport fishes. The river fishery is a result of seasonal peak flows; therefore, stabilization of flows or restriction to migration could depress the total productivity. Historical and archaeological impacts were not determined. The alternatives associated with industry would have the following effects: areas downwind of the power plant will be subjected to low levels of aerial contaminants over a long period of time, and the value of the reclaimed lands will be determined by the success of the reclamation program.

OTHER SOCIAL EFFECTS:

The reservoir would provide annual flood damage reduction benefits downstream. Irrigation will help stabilize the local economy. The reservoir would inundate four farmsteads and require modification to Sheep Creek Dam and a power line. The area's population and employment opportunity will increase as a result of industry alternatives.

Alternatives B and F with the associated 400 M.W. plant will have a peak construction work force of approximately 1,200 workers of which 600 will be non-locals. There will be a population increase of 1,350 with about 275 of the increase consisting of school aged children. Each unit will have a permanent work force of approximately 125 persons which will come from the construction area or from the construction work force.

Alternative B with the associated 800 M.W. plant will have a peak construction work force of approximately 2,000 workers of which 1,000 will be non-locals. There will be a population increase of 2,250 persons with about 460 of the increase consisting of school aged children. Each unit will have a permanent work force of about 200 persons which will come from the construction area or from the construction work force.

Alternative F with the associated 2,400 M.W. plant will have a peak construction work force of approximately 4,800 workers of which 2,400 will be non-locals. There will be a population increase of 5,400 with about 1,100 of the increase consisting of school aged children. Each unit will have a permanent work force of approximately 500 persons which will come from the construction area or from the construction work force.

STATUS:

Inactive

RECOMMENDATION: Continued study into a diversion from Lake Sakakawea with implementation of Alternative A in the 1990-2000 time frame.

1/ Benefits were not updated. The B/C ratio is anticipated to be similar to the 1974 ratio.

2/ Alternative requires diversion of water.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Hettinger Dam (Figure IV-1-1; Site #10)
S9, T131, R95
Adams County

PUBLIC INVOLVEMENT REGION: Cannonball/Grand

PURPOSE: Multi-purpose storage

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION:	ECONOMIC DEVELOPMENT
Alt. A: Reservoir size: 30,000 AF storage; 2,000 surface acres Use: irrigate 2,500 acres; 8,000 AF flood storage	Capital Cost $8,794,000 Annual Cost $665,000 Annual Benefit 1/ Benefit/Cost Ratio NA
Alt. B 2/: Reservoir size: 30,000 AF stor- 2,000 surface acres Use: irrigate 23,663 acres; 8,000 AF flood storage	Capital Cost $8,794,000 Annual Cost $665,000 Annual Benefit 1/ Benefit/Cost Ratio 1.42 Level II Diversion 1.32 Level II Diversion (multi-purpose)

ENVIRONMENTAL QUALITY:

The reservoir at conservation pool would inundate 2,000 acres of land. Approximately 62 percent or 1,240 acres is native pasture, 460 acres are cropland, while remaining community types are buffaloberry, wolfberry-rose, sloughgrass, reed-swamp, and sedge-meadow. The loss of wildlife habitat may reduce the hunting opportunities in the area. The reservoir would be located on Cedar Creek which is rated Class I - Highest Value on the Stream Evaluation Map because of the excellent forage fish production and excellent sport fishery for northern pike and channel catfish. The reservoir would restrict upstream migration of fish. Seasonally, fishing below the dam would be slightly improved. During drawdown periods structural features and banklines would be exposed that may be considered by some to be visual intrusions to the area. Historical and archaeological impacts were not determined. Cedar Creek has poor water quality. Prior to implementation of Alternative A, a detailed analysis would be required to determine the compatability of the water with intended uses within the area.

OTHER SOCIAL EFFECT:

Irrigation would help stabilize the local economy. The reservoir would provide annual flood damage reduction.

STATUS: Inactive

RECOMMENDATION: Continued study into a diversion system from Lake Sakakawea.

1/ Benefits were not updated. The B/C ratio is anticipated to be similar to the 1974 ratio.

2/ Alternative requires diversion of water.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Thunderhawk Dam (Figure IV-1-1; Site #8)
S29, T130, R91
Adams County

PUBLIC INVOLVEMENT REGION: Cannonball/Grand

LEAD STUDY AGENCY: Bureau of Reclamation/ND State Water Commission

DESCRIPTION:		ECONOMIC DEVELOPMENT
Alt. A:	Reservoir size: 40,000 AF storage; 2,200 surface acres Use: irrigate 290 acres; 4,520 AF industrial use; 48,000 AF flood storage; 81 AF municipal use	Capital Cost $15,074,000 Annual Cost $1,142,000 Annual Benefit [1] Benefit/Cost Ratio 1.47
Alt. B	Reservoir size: 43,400 AF storage; 2,400 surface acres Use: irrigate 4,900 acres; 210,000 AF flood storage	Capital Cost $29,271,000 Annual Cost $2,157,000 Annual Benefit $2,253,000 Benefit/Cost Ratio 1.04
Alt. C:	Reservoir size: 43,400 AF storage; 2,400 surface acres Use: irrigate 2,400 acres; 210,000 AF flood storage	Capital Cost $25,600.00 Annual Cost $1,895,000 Annual Benefit $4,221,000 Benefit/Cost Ratio 2.23
Alt. D [2]:	Reservoir size: 60,000 AF storage; 2,800 surface acres Use: irrigate 24,000 acres; 4,520 to 9,050 AF industrial use; 68,000 AF flood storage; 81 AF municipal use	Capital Cost $19,725,000 Annual Benefit [1] Annual Cost $1,495,000 Benefit/Cost Ratio 1.33 Level I Diversion 1.42 Level II Diversion 1.32 Level II Diversion (multi-purpose)

ENVIRONMENTAL DEVELOPMENT:

The reservoir at conservation pool would inundate 2,200 acres of land. Eighty-eight percent (1,940 acres) is native pasture with 150 acres of cropland. Other community types present include buffaloberry, wolfberry-rose, and sedge-meadow. The riparian habitat supports good populations of furbearers, deer, and upland game birds. The loss of wildlife habitat could result in reduced hunting opportunities. Cedar Creek is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map because of its excellent forage fish production and northern pike and channel catfish fishery. The reservoir would restrict fish migration upstream. Seasonally, fishing in Cedar River below the dam may be slightly improved. Cedar Creek has poor water quality. Prior to implementation of Alternative A, a detailed analysis would be required to determine the compatibility and/or useability of the water for the uses designated.

A power plant would cause an increase in aerial contaminants of low levels and long-term duration. The value of the reclaimed land will be determined by the success of the reclamation program. Historical and archaeological impacts were not determined.

OTHER SOCIAL EFFECTS:

Irrigation will help stabilize the local economy. Annual flood damage will be reduced and industry will cause an increase in the area's population and employment opportunity.

Alternatives A and B with the associated 400 M.W. plant will have a peak construction work force of approximately 1,200 workers of which 600 will be non-locals. There will be a population increase of 1,350 with about 275 of the increase consisting of school aged children. Each unit will have a permanent work force of approximately 125 persons which will come from the construction area or from the construction work force.

Alternative B with a different diversion alternative has an 800 M.W. plant associated with use. A 800 M.W. plant will have a peak construction work force of approximately 2,000 workers of which 1,000 will be non-locals. There will be a population increase of 2,250 persons with about 460 of the increase consisting of school aged children. Each unit will have a permanent work force of about 200 persons which will come from the construction area or from the construction work force.

STATUS: Inactive.

RECOMMENDATION: Continued study into a diversion from Lake Sakakawea with implementation of Alternative C in the 1990-2000 time frame.

1/ Benefits were not updated. The B/C ratio is anticipated to be similar to the 1974 ratio.

2/ Alternative requires diversion of water.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Versippi Dam 1/ (Figure IV-1-1; Site #27)
S26, T140, R95
Stark County

PUBLIC INVOLVEMENT REGION: Heart

PURPOSE: Multi-purpose storage

LEAD STUDY AGENCY: Bureau of Reclamation/ND State Water Commission

DESCRIPTION:		ECONOMIC DEVELOPMENT
Alt. A:	Reservoir size: 15,800 AF storage; 980 surface acres Use: 4,020 AF municipal water and recreation	Capital Cost $33,367,000 Annual Cost $2,456,000 Annual Benefit $2,960,000 Benefit/Cost Ratio 1.21
Alt. B	Reservoir size: 13,400 AF storage; 960 surface acres Use: 3,300 AF municipal use	Capital Cost $5,815,000 Annual Cost $442,000 Annual Benefit 2/ Benefit/Cost Ratio 2.72

Alt. C 3/: Reservoir size: 13,400 AF storage; 960 surface acres
Use: irrigate 10,000 acres; 3,300 AF for municipal use

Capital Cost $5,932,000
Annual Cost $450,000
Annual Benefit 2/
Benefit/Cost Ratio 1.33 Level I Diversion
1.42 Level II Diversion
1.32 Level II Diversion (multi-purpose)

ENVIRONMENTAL QUALITY:

The reservoir would inundate 980 acres of land, approximately 100 acres of cropland, 300 acres of native pasture, and 485 acres of community types including elm-boxelder, wolfberry-rose, buffaloberry, and green ash. Twelve miles of stream and stream habitat would be inundated. The site is considered to possess unique aquatic habitat that would be permanently altered by the reservoir.

The Green River is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map because of its excellent forage fish production and exceptional water quality and high aesthetic value. The reservoir would support a fishery in addition to an improved tailrace fishery for about one mile. Water released during low flows would have a beneficial affect upon the downstream fishery plus improving habitat for native fish.

Five archaeological sites would either be inundated and/or adversely affected.

OTHER SOCIAL EFFECTS:

The reservoir would supply 4,020 AF per year of municipal water to the City of Dickinson. Short-term employment would be available during the construction phase. Water-related recreational activities would be provided in addition to 4,400 annual fisherman days. The reservoir would inundate six farmsteads, two gravel operations, and substantial coal deposits.

STATUS: Inactive.

RECOMMENDATION: Continued study into a diversion from Lake Sakakawea with implementation in the 2000-2020 time frame.

1/ Completion of the Southwest Pipeline Project will preclude the project as a municipal water supply for the City of Dickinson.

2/ Benefits were not updated. The B/C ratio is anticipated to be similar to the 1974 ratio.

3/ Alternative requires diversion of water.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Crown Butte Creek Dam (Figure IV-1-1; Site #23)
S18, T136, R86
Grant County

PUBLIC INVOLVEMENT REGION: Heart

PURPOSE: Industrial

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION:	ECONOMIC DEVELOPMENT
Alt. A: Reservoir size: 34,899 AF storage; 832 surface acres Use: 9,050 AF industrial use; 162 AF municipal use; recreation (requires 9,500 AF diverted from the Heart River)	Capital Cost $13,723,000 Annual Cost $1,106,000 Annual Benefit [1] Benefit/Cost Ratio 3.00
Alt. B: Reservoir size: 34,899 AF storage; 832 surface acres Use: 15,000 AF industrial use; 1,018 AF municipal (requires 17,000 AF diverted from the Heart River)	Capital Cost $14,348,000 Annual Cost $1,190,000 Annual Benefit [1] Benefit/Cost Ratio 6.41
Alt. C [2]: Reservoir size: 34,899 AF storage; 832 surface acres Use: 9,040 AF industrial use (requires diversion from the Heart River)	Capital Cost $14,568,000 Annual Cost $1,165,000 Annual Benefit [1] Benefit/Cost Ratio 1.33
Alt. D [2]: Reservoir size: 34,899 AF storage; 832 surface acres Use: 15,000 AF industrial use; 1,018 AF municipal use (requires diversion from the Heart River)	Capital Cost $14,348,000 Annual Cost $1,189,000 Annual Benefit [1] Benefit/Cost Ratio 1.42 Level II Diversion 1.32 Level II Diversion (multi-purpose)

ENVIRONMENTAL QUALITY:

At conservation pool approximately 72 percent (600 acres) of the reservoir site is native pasture while 100 acres are cropland. Remaining community types include aspen stands, green ash, buffaloberry, elm-boxelder, sedge-meadow, and bur oak which is rather unique to the area. At flood storage, 900 acres would be inundated.

The creek is not rated on Game and Fish Stream Evaluation Map; however, water would be diverted from the Heart River to augment flows in the creek to support the industry. The reduced flows in the Heart River may have a negative effect upon biological elements of the stream. The reservoir would inundate highly diverse woodland habitat, adversely affecting wildlife which may reduce hunting opportunities in the area.

The areas downwind of the industrial plant would be subjected to low levels of aerial contaminants over a long period of time. The value of the reclaimed lands will be dependent on the success of the reclamation program. Historical and archaeological impacts were not determined.

OTHER SOCIAL EFFECTS:

The industry will result in an increase in the area's population and employment opportunities. A peak construction work force of approximately

2,000 workers of which 1,000 will be non-locals. There will be a population increase of 2,250 persons with about 460 of the increase consisting of school aged children. Each unit will have a permanent work force of about 200 persons which will come from the construction area of from the construction work force.

STATUS: Inactive.

RECOMMENDATION: Continued study into diversion from Lake Sakakawea with implementation in the 2000-2020 time frame.

1/ Benefits were not updated. The B/C ratio is anticipated to be similar to the 1974 ratio.

2/ Alternative requires diversion.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Spring Lake Dam (Figure IV-1-1: Site #44)
S19, T144, R90
Mercer County

PUBLIC INVOLVEMENT REGION: Knife

PURPOSE: Multi-purpose storage

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION:		ECONOMIC DEVELOPMENT
Alt. A:	Reservoir size: 18,000 AF storage; 950 surface acres Use: irrigate 2,200 acres; 6,000 AF flood storage	Capital Cost $5,403,000 Annual Cost $410,000 Annual Benefit 1/ NA Benefit/Cost Ratio 1.06
Alt. B 2/:	Reservoir size: 18,000 AF storage; 950 surface acres Use: irrigate 4,500 acres; 6,000 AF flood storage	Capital Cost $5,617,000 Annual Cost $426,000 Annual Benefit 1/ Benefit/Cost Ratio 1.42

ENVIRONMENTAL QUALITY:

The reservoir at conservation pool would inundate 950 acres of land, consisting of approximately 750 acres of cropland and 150 acres of native pasture. The remaining acreage is comprised of such community types as green ash, buffaloberry, elm-boxelder, wolfberry-rose, sedge-meadow, and reed-swamp which reflects high habitat diversity with undisturbed vegetation present. At flood storage, 1,400 acres would be inundated. The area supports good populations of furbearers, pheasants, sharp-tailed grouse, Hungarian partridge, and deer. The reservoir would inundate riparian habitat and reduce hunting opportunites in the vicinity altering the current ecosystem to a permanent aquatic environment.

Spring Creek is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map because of its forage production and reproduction of several species of sport fish. The Creek is vital to over wintering of sport and forage fish in the creek and portions of the Knife River. The reservoir would restrict fish migration upstream reducing the total fish productivity of the creek.

Structural features and exposed banklines during drawdown period could cause visual intrusions to the area. Historical and archaeological impacts were not determined.

OTHER SOCIAL EFFECTS:

The reservoir will provide downstream flood control benefits. Irrigation will help to stabilize the local economy. Short-term employment opportunity would be available during the construction phase.

STATUS: Inactive.

RECOMMENDATION: Continued study into a diversion from Lake Sakakawea with implementation in the 1990-2000 time frame.

1/ Benefits were not updated. The B/C ratio is anticipated to be similar to the 1974 ratio.

2/ Alternative requires diversion of water.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Emerson Dam (Figure IV-1-1; Site #43)
S22, T143, R94
Dunn County

PUBLIC INVOLVEMENT REGION: Knife

PURPOSE: Multi-purpose storage

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION:		ECONOMIC DEVELOPMENT
Alt. A:	Reservoir size: 43,200 AF storage; 2,640 surface acres Use: irrigate 5,500 acres; 28,000 AF flood storage	Capital Cost $9,235,000 Annual Cost $700,000 Annual Benefit 1/ Benefit/Cost Ratio 1.52
Alt. B:	Reservoir size: 43,200 AF storage; 2,640 surface acres Use: irrigate 750 acres; 9,050 AF industrial use; 28,000 AF flood storage	Capital Cost $9,235,000 Annual Cost $700,000 Annual Benefit 1/ Benefit/Cost Ratio 4.85

Alt. C [2]: Reservoir size: 57,500 AF storage; 3,000 surface acres
Use: irrigate 27,068 acres; 12,204 AF industrial use; 34,000 AF flood storage; 219 AF municipal use

Capital Cost $10,715,000
Annual Cost $813,000
Annual Benefit [1]
Benefit/Cost Ratio 1.42 Level II Diversion
1.32 Level II Diversion (multi-purpose)

ENVIRONMENTAL QUALITY:

The reservoir at conservation pool would inundate approximately 2,640 acres of land. Ninety-two percent or 2,430 acres is cropland, the remaining is composed of pasture land, wolfberry-rose, buffaloberry, and sedge-meadow. At flood storage approximately 3,500 acres of land will be inundated. The loss of habitat will adversely affect wildlife and may reduce hunting opportunities in the area.

The Knife River is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map because of the highly valued fishery, the forage fish production, and the reproduction of several sport species. The reservoir would destroy several miles of free flowing stream habitat, inhibit fish migration, and may reduce the total fish productivity of the river.

Structural features and exposed banklines during drawdown periods would be visual intrusion to the area. The industrial alternative will result in an increase in low levels of aerial contaminants in the area. Archaeological and historical impacts were not determined.

OTHER SOCIAL EFFECTS:

Irrigation will help stabilize the local economy and short-term employment would be available during the construction phase. Four farms would be inundated. The industrial alternative will result in an increase in the area's population and also employment opportunities.

A 800 M.W. plant will have a peak construction work force of approximately 2,000 workers of which 1,000 will be non-locals. There will be a population increase of 2,250 persons with about 460 of the increase consisting of school aged children. Each unit will have a permanent work force of about 200 persons which will come from the construction area or from the construction work force.

STATUS: Inactive.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame with continued study into a diversion from Lake Sakakawea.

[1] Benefits were not updated. The B/C ratio is anticipated to be similar to the 1974 ratio.

[2] Alternative requires diversion of water.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Alkali Creek Dam (Figure IV-1-1; Site #46)
S35, T145, R92
Dunn County

PUBLIC INVOLVEMENT REGION: Knife

PURPOSE: Multi-purpose

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 1,545 AF storage; 124 surface acres, maximum depth 35 feet; average depth 12.5 feet.
Use: recreation and flood control.

ECONOMIC DEVELOPMENT: Capital Cost $602,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The reservoir at conservation pool would inundate 124 acres of land and 240 acres at flood storage. The loss of wildlife habitat will adversely affect terrestrial species resulting in a displacement of those species affected. This tributary of the Knife River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The reservoir would supply a sport fishery and additional water-based recreation to area residents. The reservoir would contain a 100 year inflow from Alkali Creek, therefore, providing some flood damage reduction benefits to the City of Halliday.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Third Creek Dam 1/ (Figure IV-1-1; Site #55)
S32, T137, R101
Billings County

PUBLIC INVOLVEMENT REGION: Little Missouri

PURPOSE: Irrigation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION:

		ECONOMIC DEVELOPMENT
Alt. A 2/:	Reservoir size: 46,415 AF storage; 1,163 surface acres Use: irrigate 39,000 acres; 4,520 AF industrial use; 81 AF municipal use	Capital Cost $12,497,000 Annual Cost $946,000 Annual Benefit 3/ Benefit/Cost Ratio 1.33
Alt. B 2/:	Reservoir size: 46,415 AF storage; 1,163 surface acres Use: irrigate 27,070 acres; 4,520 AF industrial use; 81 AF municipal use	Capital Cost $11,777,000 Annual Cost $892,000 Annual Benefit 3/ Benefit/Cost Ratio 1.32

ENVIRONMENTAL QUALITY:

The implementation of the project would require diversion from Lake Sakakawea to the Little Missouri River. The reservoir at conservation pool would inundate 1,163 acres of land. Seventy-nine percent or 920 acres of the reservoir site is native pasture used for grazing. Other community types include approximately 70 acres of salt-desert shrub, 60 acres of green ash, 43 acres of wolfberry-rose, 31 acres of buffaloberry, and 24 acres of elm-boxelder, plus some juniper, willow-cottonwood, and sedge-meadow. At flood storage, 1,325 acres would be inundated. The reservoir would result in a loss of agricultural land and wildlife habitat changing the ecosystem to a permanent aquatic environment.

The good habitat diversity and undisturbed climax community types present indicate that good wildlife population exist in the area. Species of interest include wild turkey, sharp-tailed grouse, deer, and furbearers. The inundation may reduce hunting opportunities in the area. The area has a high aesthetic value which could never be reclaimed. The potential exists for the area to have significant historical and/or archaeological value.

OTHER SOCIAL EFFECTS:

Irrigation of 39,080 acres will help stabilize the local economy. Short-term employment opportunity would increase for the duration of the construction phase. The reservoir would inundate three farmsteads.

Alternative B and associated industry will result in a peak construction work force of approximately 1,200 workers of which 600 will be non-locals. There will be a population increase of 1,350 with about 275 of the increase consisting of school aged children. Each unit will have a permanent work force of approximately 125 persons which will come from the construction area or from the construction work force.

STATUS: Inactive.

RECOMMENDATION: Continue study into a diversion from Lake Sakakawea. The energy development associated with the project would require amendment to the Little Missouri State Scenic River Act. Implementation in the 2000-2020 time frame.

1/ Alternative requires diversion of water.

2/ Implementation of this project would require an amendment to the Little Missouri State Scenic River Act.

3/ Benefits were not updated. The B/C ratio is anticipated to be similar to the 1974 ratio.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Bohlman Dam (Figure IV-1-1; Site #16)
S27, T136, R97
Hettinger County

PUBLIC INVOLVEMENT REGION: Cannonball/Grand

PURPOSE: Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 2,070 AF storage; 185 surface acres

ECONOMIC DEVELOPMENT: Capital Cost $822,000
Annual Cost NA
Annual Benefit NA
Beneift/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The reservoir at conservation pool would inundate 185 acres of land. Approximately 145 acres of the reservoir site are native pasture, 25 acres are cropland while remaining community types include some wolfberry-rose, sedge-meadow, and reed-swamp. At flood stage, 275 acres would be inundated. The reservoir would change the existing ecoystem to a permanent aquatic environment that would support a fishery. The reservoir site is located on an unnamed creek of the Cannonball River a few miles north of New England. The creek is not rated on the Game and Fish Stream Evaluation Map. Terrestrial wildlife would be displaced as a result of inundation of habitat. Archaeological and historical impacts were not determined.

OTHER SOCIAL EFFECTS:

The reservoir would provide additional water-based recreation and a fishery to area residents.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Square Butte Dam (Figure IV-1-1; Site #9)
S2, T130, R93
Adams County

PUBLIC INVOLVEMENT REGION: Cannonball/Grand

PURPOSE: Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 1,360 AF storage; 136 surface acres

ECONOMIC DEVELOPMENT: Capital Cost $511,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The reservoir at conservation pool would inundate 136 acres of land. Approximately 100 acres are native pasture, ten acres are cropland while remaining community types are composed of wolfberry-rose, sloughgrass, sedge-meadow, and reed-swamp. At flood storage of 204 acres would be inundated. The reservoir would be located on an unnamed tributary of Cedar Creek that is not rated on the Game and Fish Stream Evaluation Map. The reservoir would change the existing ecosystem to a permanent aquatic environment that would support a fishery. As a result of lost habitat, terrestrial wildlife will be displaced. Historical and archaeological impacts were not determined.

OTHER SOCIAL EFFECTS:
The reservoir would provide additional water-based recreation and a fishery to area residents.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Thirty Mile Creek Dam (Figure IV-1-1; Site #14)
S36, T134, R91
Hettinger County

PUBLIC INVOLVEMENT REGION: Cannonball/Grand

PURPOSE: Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 6,000 AF storage; 520 surface acres

ECONOMIC DEVELOPMENT: Capital Cost $2,040,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The reservoir at conservation pool would inundate 520 acres of land. Two hundred acres are cropland while remaining acreage consists of native pasture, elm-boxelder, buffaloberry, wolfberry-rose, and sand dunes. The re-

servoir site is located on Thirty Mile Creek, a tributary of the Cannonball River. The Creek is not rated on the Game and Fish Stream Evaluation Map. The loss of habitat will have an adverse effect upon the wildlife in the area. The reservoir would change the existing ecosystem to a permanent aquatic environment that would support a fishery. Archaeological and historical impacts were not determined.

OTHER SOCIAL EFFECTS:

The reservoir would provide additional water-based recreation and a fishery to area residents. The reservoir will reduce downstream agricultural flood damages.

STATUS: Currently being investigated by the Hettinger County Water Resource Board and the ND State Water Commission.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Wolf Butte Dam (Figure IV-1-1; Site #11)
S1, T131, R97
Adams County

PUBLIC INVOLVEMENT REGION: Cannonball/Grand

PURPOSE: Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 1,100 AF storage; 130 surface acres

ECONOMIC DEVELOPMENT: Capital Cost $675,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The reservoir at conservation pool would inundate 130 acres of land. Eighty-three percent of the reservoir site is native pasture. The remaining community type is wolfberry-rose and wetland. At flood storage, 195 acres would be inundated. The loss of habitat will adversely affect wildlife resulting in a displacement of terrestrial species.

The reservoir is located on unnamed tributary of Cedar Creek and is not rated on the Game and Fish Stream Evaluation Map. The reservoir would change the existing ecosystem to a permanent aquatic environment that would support a fishery. Historical and archaeological impacts were not determined.

OTHER SOCIAL EFFECTS:

The reservoir would supply additional water-related recreation and a fishery to area residents.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Lower Antelope Creek Dam (Figure IV-1-1; Site #22)
S28, T135, R87
Grant County

PUBLIC INVOLVEMENT REGION: Heart

PURPOSE: Irrigation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 13,400 AF storage; 595 surface acres
Use: irrigate 1,563 acres; (4,000 AF flood storage possible)

ECONOMIC DEVELOPMENT: Capital Cost $3,670,000
Annual Cost $279,000
Annual Benefit 1/
Benefit/Cost Ratio 1.08

ENVIRONMENTAL QUALITY:
The reservoir at conservation pool would inundate 595 acres. The community types in the reservoir site are as follows: 300 acres native pasture, 140 acres cropland, 65 acres green ash, in addition to some wolfberry-rose, buffaloberry, aspen, and bur oak which is unique to the area. At flood storage, 900 acres would be inundated. The reservoir would result in a permanent change from the present ecosystem to an aquatic environment. The creek is rated Class II - High Priority on the Game and Fish Stream Evaluation Map because of the forage fish production for the Heart River fishery. The reservoir will restrict fish migration upstream. The area has good furbearers, deer, and upland game populations. The loss of wildlife habitat will have an adverse effect upon the area's wildlife. Historical and archaeological impacts were not determined.

OTHER SOCIAL EFFECTS:
Irrigation will help stabilize local economy. Short-term employment opportunity will be available during the construction phase.

STATUS: Inactive

RECOMMENDATION: Implementation in the 1980-1990 time frame.

1/ Benefits were not updated. The B/C ratio is anticipated to be similar to the 1974 ratio.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Hailstone Creek Dam (Figure IV-1-1; Site #24)
S9, T138, R86
Morton County

PUBLIC INVOLVEMENT REGION: Heart

PURPOSE: Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 800 AF storage; 72 surface acres

ECONOMIC DEVELOPMENT: Capital Cost $551,000
Annual Cost $42,000
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The reservoir at conservation pool would inundate 72 acres of land. Seventy-six per cent or 55 acres of the site is cropland and 12 acres are native pasture, while remaining communities include elm-boxelder, wolfberry-rose, buffaloberry, some green ash, and sedge-meadow. At flood storage, 125 acres would be inundated. The reservoir would alter the current ecosystem to a permanent aquatic environment capable of supporting a fishery. The loss of habitat will have an adverse effect on wildlife in the area, resulting in a displacement of terrestrial wildlife.

The creek is rated Class III - Substantial Value on the Game and Fish Stream Evaluation Map because of its moderate fish reproduction and forage production. The reduced flows caused by the reservoir may affect the fish population that are maintained in pool areas because of the streams intermittent flows. Historical and archaeological impacts were not determined.

OTHER SOCIAL EFFECTS:

The reservoir would provide additional recreation days by providing added water-based recreational opportunities and fishing.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Otter Creek Dam (Figure IV-1-1; Site #21)
S25, T136, R85
Grant County

PUBLIC INVOLVEMENT REGION: Heart

PURPOSE: Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 880 AF storage; 73 surface acres

ECONOMIC DEVELOPMENT: Capital Cost $591,000
Annual Cost $45,000
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The reservoir at conservation pool would inundate 73 acres of land, of which approximately 42 acres are native pasture. Other community types present include green ash, buffaloberry, sage, wolfberry-rose, elm-boxelder, and sedge-meadow. At flood storage, 125 acres would be inundated. The permanent loss of habitat will adversely affect wildlife, resulting in displacement of terrestrial wildlife species. The creek is not rated on the Game and Fish Stream Evaluation Map. Historical and archaeological impacts were not determined.

OTHER SOCIAL EFFECTS:

The reservoir would provide additional water-related recreational opportunities and fishing to the area.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Upper Antelope Dam (Figure IV-1-1; Site #26)
S10, T138, R95
Stark County

PUBLIC INVOLVEMENT REGION: Heart

PURPOSE: Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 3,000 AF storage; 280 surface acres
Use: recreation

ECONOMIC DEVELOPMENT: Capital Cost $2,833,000
Annual Cost $216,000
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The reservoir at conservation pool would inundate 280 acres. Approximately 84 acres of the site are cropland and 128 acres are native pasture. Other community types inundated include green ash and buffaloberry. The loss of wildlife habitat will adversely affect the wildlife resource. The creek is not rated on the Game and Fish Stream Evaluation Map. Historical and archaeological impacts were not determined.

OTHER SOCIAL EFFECTS:
The reservoir will inundate two farmsteads. Water-related recreation and fishing would be provided by the reservoir.

STATUS: Recent Investigation.

RECOMMENDATION: Continued study with possible implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Buffalo Creek Dam (Figure IV-1-1; Site #25)
S12, T137, R92
Stark County

PUBLIC INVOLVEMENT REGION: Heart

PURPOSE: Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 2,180 AF storage; 170 surface acres

ECONOMIC DEVELOPMENT: Capital Cost $1,020,000
Annual Cost $78,000
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The reservoir at conservation pool would inundate 170 acres of land. Approximately 120 acres are native pasture plus a few acres of cropland. The remaining community types include green ash, wolfberry-rose, and sedge-meadow. Habitat will be lost which will have an adverse effect upon the wildlife resource. The reservoir would permanently alter the ecosystem, changing it to an aquatic environmental capable of supporting a fishery. The creek is not rated on the Game and Fish Stream Evaluation Map. Historical and archaeological impacts were not determined.

OTHER SOCIAL EFFECTS:
The reservoir would provide water-related recreational opportunities and fishing to the area.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: North Coyote Creek Dam (Figure IV-1-1; Site #42)
S2, T142, R92
Dunn County

PUBLIC INVOLVEMENT REGION: Knife

PURPOSE: Irrigation or Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION:
Alt. A: Reservoir size: 4,100 AF storage; 250 surface acres
Use: irrigate 800 acres

ECONOMIC DEVELOPMENT
Capital Cost $1,700,000
Annual Cost $130,000
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The reservoir at conservation pool level will inundate 250 acres of land. Ninety-eight percent of the reservoir site is native pasture. Other community types present include green ash and buffaloberry. Loss of wildlife habitat will have an adverse effect upon wildife, resulting in a displacement of terrestrial wildlife. The tributary is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The reservoir will provide water for 800 acres of irrigation which will help stabilize the local economy. Short-term employment would be available during the construction phase.

STATUS: Inactive.

RECOMMENDATION: Continue study with implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Otter Creek Dam (Figure IV-1-1; Site #40)
S3, T143, R87
Oliver County

PUBLIC INVOLVEMENT REGION: Knife

PURPOSE: Irrigation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 7,500 AF storage; 360 surface acres
Use: irrigate 1,400 acres

ECONOMIC DEVELOPMENT: Capital Cost $2,635,000
Annual Cost $201,000
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The reservoir at conservation pool would inundate 360 acres of land. Approximately 95 percent of the site is native pasture utilized for grazing. Some green ash and buffaloberry would also be inundated. The loss of habitat will have an adverse effect upon wildlife.

The creek is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map because of the creek's extremely high forage fish production which is very important to the Knife River sport fishery.

OTHER SOCIAL EFFECTS:

Irrigation of 1,400 acres will help stabilize the local economy. Short-term employment will be available during the construction phase. Implementation would require relocation of a power plant.

STATUS: Recent Investigation

RECOMMENDATION: Continue study with implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Beulah Dry Dams (North and West) (Figure IV-1-1; Site #41)
Mercer County

PUBLIC INVOLVEMENT REGION: Knife

PURPOSE: Flood Control

LEAD STUDY AGENCY: City of Beulah/ND State Water Commission

DESCRIPTION: Two dry dams on the north tributary and one dry dam on the west tributary. The dry dams are anticipated to have an estimated 1,440 AF maximum-flood storage capacity.

ECONOMIC DEVELOPMENT: North Dry Dams Capital Cost $346,800 (estimate)
West Dry Dam Capital Cost 236,400 (estimate)
Total Cost $583,200 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

No significant environmental impacts are anticipated.

OTHER SOCIAL EFFECTS:

The dry dams will reduce flood damages to the City of Beulah.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Beaver Creek Dam [1/] (Figure IV-1-1; Site #53)
S34, T143, R105
Golden Valley County

PUBLIC INVOLVEMENT REGION: Little Missouri

PURPOSE: Irrigation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 55,169 AF storage; 1,920 surface acres
Use: irrigate 6,275 acres

ECONOMIC DEVELOPMENT: Capital Cost $12,791,000
Annual Cost $970,000
Annual Benefit [2/]
Benefit/Cost Ratio 1.25

ENVIRONMENTAL QUALITY:

The reservoir at conservation pool would inundate 1,920 acres of land of which 1,400 acres of the site is cropland. The remaining community types include 240 acres native pasture, 220 acres elm-boxelder and green ash, in addition to buffaloberry, wolfberry-rose, sedge-meadow, and reed swamp. At flood storage, 2,700 acres of land would be inundated. The reservoir would result in a loss of agricultural land and wildlife habitat changing the current ecosystem to that of an aquatic environment. The area has high habitat diversity indicating the presence of good wildlife populations including furbearers, deer, and upland game birds. The loss of wildlife habitat could reduce hunting opportunities in the area.

The creek is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map because of the excellent furbearer population and also because of its value for forage fish production and reproduction of northern pike, channel catfish, and sauger. The reservoir would restrict upstream migration of fish.

Historical and archaeological impacts were not determined. Field surveys are recommended prior to implementation of this project since artifacts of historical or archaeological value may exist in the area.

The drawdown during peak water use would result in exposure of shoreline and structural features while irrigation return flows would increase the annual total dissolved solids. The areas high aesthetic value would be reduced by the implementation of the project.

OTHER SOCIAL EFFECTS:

Implementation of the project would result in short-term employment for the duration of the construction phase. Irrigation would stablize the local economy. The reservoir would inundate three Montana farmsteads. Another site has been proposed in Montana for industrial purposes; both sites can not be built, thus raising an issue of North Dakota-Montana water rights.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 2000-2020 time frame.

1/ Tenneco is considering building a dam on Beaver Creek in Montana. This would preclude development of the North Dakota site.

2/ Benefits were not updated. The B/C ratio is anticipated to be similar to the 1974 ratio.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Marmarth Dam 1/ (Figure IV-1-1: Site #56)
S23, T132, R106
Bowman County

PUBLIC INVOLVEMENT REGION: Little Missouri

PURPOSE: Irrigation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 240,000 AF storage; 7,500 surface acres
Use: irrigate 33,500 acres

ECONOMIC DEVELOPMENT: Capital Cost $35,711,000
Annual Cost $2,705,000
Annual Benefit 2/
Benefit/Cost Ratio 2.38

ENVIRONMENTAL QUALITY:
The Little Missouri River is a State Scenic River and water development on the mainstem is prohibited under state law. An amendment to the law would be required to allow implementation of this project.

The River is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map because of its forage fish production and sport fishery of northern pike, channel catfish, and sauger. The river is inhabited with the flathead catfish which is considered threatened in North Dakota. A reservoir would restrict the upstream migration of the channel catfish and forage fish, in addition to depressing the total productivity of the river fishery because of reduced diversity of habitat caused by the alteration of flows. Peak flows are essential to the maximum productivity of the Little Missouri River.

The reservoir at conservation pool would inundate 7,500 acres of land. Fifty-two percent or 3,900 acres is native prairie while approximately eleven percent (825 acres) is cropland. Remaining community types include about 1,575 acres of sage, 650 acres of willow cottonwood, and 260 acres of buffaloberry, also present are green ash, juniper, elm-boxelder, and sedge-meadow. At flood storage, 12,000 acres would be inundated. The site is very significant because of its sage community since the sage grouse is completely dependent upon this community type. The area also supports good populations of wild turkey, sharp-tailed grouse, deer, and furbearers.

The area has the potential of having high historical and/or archaeology value, impacts were not determined. The area is also valued highly for its aesthetic value.

OTHER SOCIAL EFFECTS:

Irrigation will help stabilize the local economy. Short-term employment opportunity during the construction phase.

STATUS: Inactive.

RECOMMENDATION: Continue study recognizing the fact that implementation of the project would require amendment to the Little Missouri State Scenic River Act. The project is envisioned for implementation in the 2000-2020 time frame.

1/ Implementation of this project would require an amendment to the Little Missouri State Scenic River Act.

2/ Benefits were not updated. The B/C ratio is anticipated to be similar to the 1974 ratio.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Schwartz Dry Dam (Figure IV-1-1; Site #31)
S22, T142, R77
Burleigh County

PUBLIC INVOLVEMENT REGION: Middle Missouri

PURPOSE: Flood Control

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Dry dam with 2,000 AF storage capacity

ECONOMIC DEVELOPMENT 1/ Capital Cost $250,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Inundation of vegetation for an extended period of time will reduce plant diversity. Wildlife will be displaced to similar available habitat. This tributary of Apple Creek is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The structure would provide downstream flood control benefits.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

1/ Benefit/Cost Ratio is anticipated to be similar to the Neideffer Dam, a demonstration project sponsored by the State Water Commission and Burleigh County Water Resource Board. The Benefit/Cost Ratio of Neideffer was 0.35.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Series of Flood-Control Dams (Figure IV-1-1; Site #30)
Apple Creek Watershed
Burleigh County

PUBLIC INVOLVEMENT REGION: Middle Missouri

PURPOSE: Flood Control

LEAD STUDY AGENCY: ND State Water Commission/Burleigh County Water Resource District

DESCRIPTION: Dry Dams.

ECONOMIC DEVELOPMENT 1/: Capital Cost $100,000-$200,000 (estimate per dam)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
Inundation of vegetation for an extended period of time will reduce plant diversity. Wildlife will be displaced to similar available habitat. Apple Creek is rated Class I and II - Highest Value and High Priority on the Game and Fish Stream Evaluation Map because of the excellent forage fish production and moderate reproduction of northern pike. The East Branch of Apple Creek is rated Class III - Substantial Value because of the moderate forage fish production. All other tributaries are not rated on the Game and Fish Stream Evaluation Map. The dams will reduce upstream migration of fish.

OTHER SOCIAL EFFECTS:
The structure would provide downstream flood control benefits.

STATUS: Inactive.

RECOMMENDATION: Implementation of the projects should be delayed until full analysis of benefits from Neideffer and Schwartz Dams can be fully determined.

1/ Benefit/Cost Ratio is anticipated to be similar to the Neideffer Dam, a demonstration project sponsored by the State Water Commission and Burleigh County Water Resource District. The Benefit/Cost Ratio of Neideffer Dam was 0.35.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: White Earth Flood-Control (Figure IV-1-1; Site #51)
Mountrail County

PUBLIC INVOLVEMENT REGION: Upper Missouri

PURPOSE: Flood Control

LEAD STUDY AGENCY: ND State Water Commission/Mountrail County Water Resource Board.

DESCRIPTION	ECONOMIC DEVELOPMENT
Alt. A: Raise existing dike two feet at the City of White Earth	Capital Cost $20,000 (1981 estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Alt. B: Flood control dam on Paulsen Creek	Capital Cost $145,000 (1981 estimate) Annual Cost NA Annual Benefit NA Benefit/Cost NA
Alt. C: Several tributary dry dams	Capital Cost $24,000 per dry dam Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Alternative A would have no significant environmental impacts. Alternatives B and C would inundate vegetation for an extended period of time reducing plant diversity due to the loss of vegetation intolerant to excessive water. Terrestrial wildlife will be displaced.

OTHER SOCIAL EFFECTS:

Both Alternatives A and B would reduce flood damages to the city of White Earth and improve the health and safety of the 98 residents. Short-term employment opportunity would be available during the construction phase.

STATUS: Mountrail County Water Resource Board is investigating Alternative C.

RECOMMENDATION: Continued study of Alternative C.

HYDROPOWER PROJECT

NAME/LOCATION: Pumpback Reservoir (Figure IV-1-1; Site #49)
S10, T146, R89
Mercer County

PUBLIC INVOLVEMENT REGION: Lake Sakakawea

PURPOSE: Hydropower

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Pump-back from Lake Sakakawea.
Reservoir size: 26,135 AF storage; 839 surface acres
Use: hydropower

ECONOMIC DEVELOPMENT: Capital Cost $8,354,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The reservoir would inundate 839 acres of land. Vegetation inundated includes approximately 246 acres of cropland, 398 acres of native pasture, 18 acres of green ash, and 310 acres of buffaloberry and wolfberry-rose. Loss of habitat will adversely affect wildlife; terrestrial species will be displaced. The tributary is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The project would provide a source of power for future development on the Fort Berthold Reservation.

STATUS: Current investigation.

RECOMMENDATION: Continued study to determine the feasibility of the project.

IRRIGATION PROJECT

NAME/LOCATION: Fort Yates Unit (Figure IV-1-1; Site #7)
Sioux County

PUBLIC INVOLVEMENT REGION: Cannonball/Grand

PURPOSE: Irrigation

LEAD STUDY AGENCY: Bureau of Reclamation

DESCRIPTION: Irrigate 4,260 acres, located on a terrace 10 to 40 feet above Lake Oahe in an 8 mile strip near Fort Yates. A lift station is required from Lake Oahe.

ECONOMIC DEVELOPMENT: Capital Cost $9,694,000
Annual Cost $823,000
Annual Benefit $1,360,000
Benefit/Cost Ratio 1.65

ENVIRONMENTAL QUALITY:

Irrigation return flows will cause an increase in the annual total dissolved solids. Upland game birds and furbearers will have additional habitat. Wind erosion will be reduced. The unit is estimated to take 21 miles of canals and 17 miles of drains.

OTHER SOCIAL EFFECTS:

The project will help stabilize local economy. Construction will bring additional people into the area for a three year period.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

IRRIGATION PROJECT

NAME/LOCATION: Little Heart Unit (Figure IV-1-1; Site #18)
Morton County

PUBLIC INVOLVEMENT REGION: Heart

PURPOSE: Irrigation

LEAD STUDY AGENCY: Bureau of Reclamation

DESCRIPTION: Irrigate 3,100 acres beginning five miles south of Mandan, along a terrace 40 to 75 feet above the Missouri River.

ECONOMIC DEVELOPMENT: Capital Cost $6,956,000
Annual Cost $569,000
Annual Benefit $980,000
Benefit/Cost Ratio 1.72

ENVIRONMENTAL QUALITY:

Upland game birds and furbearers will have additional habitat because of a 12 mile canal. Wind erosion should be reduced. Irrigation return flow will result in additional total dissolved solids.

OTHER SOCIAL EFFECTS:

The project will help in stabilizing the local economy. Employment opportunities will be available during the construction phase.

STATUS: Inactive

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

IRRIGATION PROJECT

NAME/LOCATION: Hazen-Stanton Unit [1] (Figure IV-1-1; Site #39)
Mercer County

PUBLIC INVOLVEMENT REGION: Knife

PURPOSE: Irrigation

LEAD STUDY AGENCY: Bureau of Reclamation

DESCRIPTION: This project would irrigate 12,650 acres of land located at the confluence of the Knife and Missouri Rivers on the south bank of the Knife River between Hazen and Stanton. Irrigation water would be supplied from the Missouri River by a 253 cfs pumping plant and four relift plants.

ECONOMIC DEVELOPMENT: Capital Cost $39,129,000
Annual Cost $3,072,000
Annual Benefit $4,241,000
Benefit/Cost Ratio 1.38

ENVIRONMENTAL QUALITY:
Upland game birds and furbearers will have additional habitat because of 51 miles of canals. Wind erosion should be reduced. Irrigation return flow will result in additional total dissolved solids.

OTHER SOCIAL EFFECTS:
The project will help in stabilizing the local economy. Employment opportunities will be available during the construction phase.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

[1] Some irrigation is currently ongoing on land within the identified project area.

IRRIGATION PROJECT

NAME/LOCATION: Oliver-Sanger Unit [1] (Figure IV-1-1; Site #36)
Oliver County

PUBLIC INVOLVEMENT REGION: Knife

PURPOSE: Irrigation

LEAD STUDY AGENCY: Bureau of Reclamation

DESCRIPTION: The project would irrigate 8,000 acres of land in an 11-mile strip along the west bank of the Missouri River opposite the city of Washburn. Irrigation water would be supplied from the Missouri River by a 159 cfs pumping plant and six relift plants.

ECONOMIC DEVELOPMENT: Capital Cost $24,383,000
Annual Cost $1,962,000
Annual Benefit $2,656,000
Benefit/Cost Ratio 1.35

ENVIRONMENTAL QUALITY:
Upland game birds and furbearers will have additional habitat because of 44 miles of canals. Wind erosion should be reduced. Irrigation return flow will result in additional total dissolved solids.

OTHER SOCIAL EFFECTS:
The project will help stabilize the local economy. Employment opportunities will be available during the construction phase.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

1/ Some irrigation is currently ongoing on land within the identified project area.

IRRIGATION PROJECT

NAME/LOCATION: Apple Creek Unit (Figure IV-1-1; Site #29)
Burleigh County

PUBLIC INVOLVEMENT REGION: Middle Missouri

PURPOSE: Irrigation

LEAD STUDY AGENCY: Bureau of Reclamation

DESCRIPTION: Irrigate 20,386 acres; also a recreation and wildlife plan.

ECONOMIC DEVELOPMENT: Capital Cost $92,322,000
Annual Cost $7,042,000
Annual Benefit $10,902,000
Benefit/Cost Ratio 1.55

ENVIRONMENTAL QUALITY:

Annual mean monthly total dissolved solids (TDS) in Apple Creek will be reduced. There may be an increase in occurrence of algal blooms in low flow areas due to increased nitrates. The fishery will benefit from increased flows except during low flow periods when localized fish kills may occur. Approximately 6,380 acres of native grassland and 2,430 acres of tame grassland will be converted to irrigated cropland. Restoration and management of 4,130 acres of grassland at McKenzie Slough (3,884 acres for mitigation). Three hundred thirty acres of grassland established in Glencoe Channel, 195 acres of shrub planting, and 4,460 acres of agriculturally distrubed land will be restored for mitigation. One thousand forty-two acres of wetland will be lost; 1,352 wetlands affected. Restoration and management of 4,035 acres of drained wetlands at McKenzie Slough, 100 acres of wetland established by six low-head impoundments in the Glencoe Channel. Three hundred eighty-six acres of trees will be lost; 361 acres will be established for mitigation purposes; 100 acres will be established in McKenzie Slough area for enhancement. Six acres of Lake Oahe Game Management Area will be lost to pumping facilities. Four hundred three acres of wetlands under Fish and Wildlife Service (FWS) easement will be lost or affected. Control structure will be constructed on FWS easement in S32, T178, R78 to preserve a wetland. Recreational development includes: ten miles of bicycling and hiking trails along Apple Creek; two parks (Apple Valley, Lincoln); recreation facilities in a currently unaccessible portion of Lake Oahe including developed overlook, boat ramp, fishing dock, camper hookups, shelters, and picnic area.

OTHER SOCIAL EFFECTS:

The project will help stabilize the local economy. Nine thousand three hundred fifty-six acres of farmland will become public land affecting nine farming operations in the McKenzie Slough Area. Construction employment will average 135 laborers during the five year construction period, with population increases reaching a peak of 570 people during the period. A peak of 160 additional students would have to be accommodated.

Total annual regional earnings would increase by $2,360,000 as a result of the completed project.

STATUS: The Bureau of Reclamation is re-evaluating the project.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

IRRIGATION PROJECT

NAME/LOCATION: McClusky Canal-Side Irrigation (Figure IV-1-1; Site #34)
McLean, Burleigh, and
Sheridan Counties

PUBLIC INVOLVEMENT REGION: Middle Missouri

PURPOSE: Irrigation

LEAD STUDY AGENCY: Bureau of Reclamation

DESCRIPTION: Canal-side irrigation of 14,000 acres

ECONOMIC DEVELOPMENT:

Ten dollars per acre (subject to change) for federal costs associated with the project. Facilities to divert the water from the canal and metering devices shall be installed at the expense of the contractor, and the contractor shall be responsible for all other costs associated with putting the water to a beneficial use. The 1976 cost of pumping plant turnouts range from $6,600 to $12,800, not including the cost of the pump and motor or the irrigation system beyond the right-of-way. Portable pumping facilities are being investigated.

ENVIRONMENTAL QUALITY:

No significant environmental effects are anticipated.

OTHER SOCIAL EFFECTS:

Irrigation will help in stabilizing the local economy. Irrigation will also result in a need for additional goods and services in the area.

STATUS:

Temporary or short-term irrigation water service can be made available from McClusky Canal beginning in 1982 in McLean County. Temporary contracts can cover up to 10,000 AF of water per contract with a term of two years or less.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

IRRIGATION PROJECT

NAME/LOCATION: McClusky Canal Diversion to Kidder and Burleigh Counties (Figure IV-1-1; Site #32)
Burleigh and Kidder Counties

PUBLIC INVOLVEMENT REGION: Middle Missouri

PURPOSE: Irrigation

LEAD STUDY AGENCY: Bureau of Reclamation

DESCRIPTION: Divert water from McClusky Canal for irrigation purposes in Northern Kidder County and Central Burleigh County, plus water to augment McDowell Reservoir. Exact acreage of irrigation in Kidder County is uncertain, possible limits range from 50,000 to 120,000 acres.

ECONOMIC DEVELOPMENT:

A.) Conveyance System to Kidder County

Capital Cost $77,300,000 to $147,890,000 (1982 estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

B.) Conveyance System to Burleigh County to irrigate an estimated 12,000 acres and water to augment McDowell Reservoir (would probably not be feasible without Kidder County acreage)

Capital Cost NA
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
Information is not available at the present time.

OTHER SOCIAL EFFECTS:
Information is not available at the present time.

STATUS: Inactive.

RECOMMENDATION: Continued studies with implementation of half the project in the 1990-2000 time frame and the remaining half in the 2000-2020 time frame.

IRRIGATION PROJECT

NAME/LOCATION: Painted Woods Unit (Figure IV-1-1; Site #35)
Washburn, ND
McLean County

PUBLIC INVOLVEMENT REGION: Middle Missouri

PURPOSE: Irrigation

LEAD STUDY AGENCY: Bureau of Reclamation

DESCRIPTION: Irrigate 610 acres, located south of the City of Washburn on an upper bench of glacial river origin above Highway 83.

ECONOMIC DEVELOPMENT: Capital Cost $2,099,000
Annual Cost $150,000
Annual Benefit $217,000
Benefit/Cost Ratio 1.45

ENVIRONMENTAL QUALITY:
Upland game birds and furbearers will benefit from additional habitat. Irrigation return flow will cause an increase in the annual total dissolved solids. It is estimated that the unit will require two miles of canals and two miles of drains.

OTHER SOCIAL EFFECTS:
The project will help stabilize the local economy. Short-term employment will be available during the construction phase.

STATUS: Inactive.

RECOMMENDATION: Continued study with investigation into the possibility of including additional acres for irrigation.

FLOOD CONTROL PROJECT

NAME/LOCATION: Napoleon Flood Control (Figure IV-1-1; Site #5)
Logan County

PUBLIC INVOLVEMENT REGION: Beaver Creek

PURPOSE: Flood Control

LEAD STUDY AGENCY: City of Napoleon/Logan County Soil Conservation District/ Logan County Water Resource Board/ ND State Water Commission

DESCRIPTION: Floodway

ECONOMIC DEVELOPMENT: Capital Cost $201,000
Annual Cost $15,855
Annual Benefit $16,886
Benefit/Cost Ratio 1.07

ENVIRONMENTAL QUALITY:
No significant environmental effects anticipated.

OTHER SOCIAL EFFECTS:
The project will provide one percent (100-year) flood protection to the City and enhance the life, health, and safety of the City's 1,103 residents. Annual income benefit distribution of $16,886 will be created in the region and annual local costs of $2,777 will be borne by the region.

STATUS:
The project has been approved for construction; to date funding has not been appropriated.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Linton Flood Control (Figure IV-1-1; Site #3)
Emmons County

PUBLIC INVOLVEMENT REGION: Beaver Creek

PURPOSE: Flood Control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Levees and channel improvements

ECONOMIC DEVELOPMENT: Capital Cost $1,124,200
Annual Cost $140,375
Annual Benefit $82,350
Benefit/Cost Ratio 0.59

ENVIRONMENTAL QUALITY:
Construction of three miles of channel improvement will result in a loss of vegetation and wildlife habitat. No significant long-term envoronmental impacts are anticipated.

OTHER SOCIAL EFFECTS:
The project will provide one percent (100-year) flood protection to the City and enhance life, health, and safety of the City's 1,561 residents.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Flasher Flood Control (Figure IV-1-1; Site #12)
Morton County

PUBLIC INVOLVEMENT REGION: Cannonball/Grand

PURPOSE: Flood Control

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Dike

ECONOMIC DEVELOPMENT: Capital Cost $40,000 (estimate)
Average Annual Cost $3,000 (estimate)
Average Annual Benefit $3,015 (estimate)
Benefit/Cost Ratio 1.01

ENVIRONMENTAL QUALITY:
No significant environmental effects anticipated.

OTHER SOCIAL EFFECTS:
The project will create an annual income benefit distribution of $3,015; and local costs totaling an estimated $300 annually will be borne by the region. Flood protection against the one percent (100-year) frequency flood will be provided to the City of Flasher; protecting health, life, and safety of the residents.

STATUS:

Preliminary Measure Plan to date currently in the planning stage.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Belfield Flood Control (Figure IV-1-1; Site #28)
Stark County

PUBLIC INVOLVEMENT REGION: Heart

PURPOSE: Flood Control

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Dam and floodway - Watershed (PL-566) project.

ECONOMIC DEVELOPMENT: Capital Cost $510,000 (1980 estimate)
Average Annual Cost $15,710 (1969 preliminary)
Average Annual Benefit $16,894 (1969 preliminary)
Benefit/Cost Ratio 1.08

ENVIRONMENTAL QUALITY:

No significant wildlife effects addressed to date. Significant effects on the human environment; reduced flooding, erosion, sediment damages.

OTHER SOCIAL EFFECTS:

The project will create an annual income benefit distribution of $16,984 (1969 dollars), and local costs estimated at $5,000 (1980 dollars) annually will be borne by the region. The project will result in short-term multi-year effect of federal dollars to adjacent communities.

STATUS:

This project is currently in the pre-planning stage, to date it has not been authorized for planning.

RECOMMENDATION: The project should be authorized for detailed study with implementation in the 1990-2000 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Halliday Flood Control (Figure IV-1-1; Site #46)
Dunn County

PUBLIC INVOLVEMENT REGION: Knife

PURPOSE: Flood Control - Spring Creek and Alkali Creek

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Dike and diversion channel

ECONOMIC DEVELOPMENT: Capital Cost $104,000 Preliminary estimates
Average Annual Cost $8,000
Average Annual Benefit $10,000
Benefit/Cost Ratio 1.25

ENVIRONMENTAL QUALITY:
No significant environmental impacts anticipated.

OTHER SOCIAL EFFECTS:
The program creates regional annual income benefit distribution of $10,000. Local costs to be borne by the region total an estimated $500 annually. The project provides flood protection against the one-percent (100-year) frequency flood for the City of Halliday, protecting health, life, and safety of the 355 residents.

STATUS:
Preliminary Measure Plan currently in the planning stage.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Underwood Flood Control (Figure IV-1-1; Site #47)
McLean County

PUBLIC INVOLVEMENT REGION: Lake Sakakawea

PURPOSE: Flood Control

LEAD STUDY AGENCY: City of Underwood/McLean County Water Resource Board/
ND State Water Commission

DESCRIPTION	ECONOMIC DEVELOPMENT
Alt. A: Lift station and force main installation flow capabilities of approximately 4 cfs	Capital Cost $83,770 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Alt. B: Gravity 36-inch arch pipe flow capabilities of approximately 12 cfs	Capital Cost $534,482 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Alt. C: Lift station and force main flow capacity of approximately 8 cfs	Capital Cost $197,340 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
No significant environmental effects are anticipated.

OTHER SOCIAL EFFECTS:
Operation cost of Plan B and C would cost the city $300 annually. Each alternative would prevent flood damages to the city.

STATUS: Currently under study.

RECOMMENDATION: Continued study with implementation in the 1990-2000 time frame.

FLOOD CONTROL PROJECT

NAMELOCATION: Muskrat Lake Watershed (Figure IV-1-1; Site #50)
Mountrail County

PUBLIC INVOLVEMENT REGION: Lake Sakakawea

PURPOSE: Flood Control

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Land Treatment Measures - Watershed (PL-566) project

ECONOMIC DEVELOPMENT: Capital Cost $1,273,000 (Estimates)
Average Annual Cost $97,965
Average Annual Benefit $154,856
Benefit/Cost Ratio 1.58

ENVIRONMENTAL QUALITY:
No significant wildlife effects addressed to date. Significant effects on the human environment (reduced flooding, erosion, sediment damages).

OTHER SOCIAL EFFECTS:
The project will create an annual income benefit distribution of $54,856; and local costs estimated at $1,000 annually will be borne by the region. The project will help stabilize the local economy and short-term multi-year effect of federal dollars will occur to adjacent communities.

STATUS:
This project is currently in the pre-planning stage, to date it has not been authorized for planning.

RECOMMENDATION: The study should be authorized for planning.

WATER SUPPLY PROJECT

NAME/LOCATION: Garrison, ND (Figure IV-1-1; Site #48)
McLean County

PUBLIC INVOLVEMENT REGION: Lake Sakakawea

PURPOSE: Water Supply

LEAD STUDY AGENCY: Bureau of Reclamation

DESCRIPTION: The City of Garrison would be provided with a better quality of water supplied by a ten-mile pipeline from Lake Audubon, including a pumping plant, regulating structure, and modifications to existing treatment facilties.

ECONOMIC DEVELOPMENT: Capital Cost $2,461,000 (1981 dollars)
Annual Cost $208,000
Annual Benefit $375,000
Benefit/Cost Ratio 1.80

ENVIRONMENTAL QUALITY:
No significant environmental impacts.

OTHER SOCIAL EFFECTS:
There would be a peak increase of nine people during the construction period; four additional students would have to be accommodated. An increased mill levy will be needed after construction to amortize project costs. The quality of life will be enhanced by an improved water supply and increased income during the construction phase.

STATUS: Feasibility study has been completed and it has been submitted to the City of Garrison.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

DRAINAGE PROJECT

NAME/LOCATION: Drainage Project (Figure IV-1-1; Site #45)
S1,11, and
12, T143, R92
Dunn County

PUBLIC INVOLVEMENT REGION: Knife

PURPOSE: Drainage

LEAD STUDY AGENCY: Dunn County Water Resource Board/ND State Water Commission

DESCRIPTION: Drainage of a 975 acre wetland. Preliminary engineering report indicates the length of drain is 6,000 feet with a maximum cut of 28 feet.

ECONOMIC DEVELOPMENT: Capital Cost $275,000 to $300,000 (preliminary estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The loss of wetland habitat would have a significant adverse effect on wildlife in the area, since wetlands are not common west of the Missouri River.

OTHER SOCIAL EFFECTS:

Approximately 975 acres of land will go into permanent agricultural production. At the present time much of this acreage is lost to production because of present water levels. Short-term employment will be available during the construction phase.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

STREAMBANK STABILIZATION PROJECT

NAME/LOCATION: Missouri River (Figure IV-1-1; Site #33)
Morton County

PUBLIC INVOLVEMENT REGION: Heart, Knife, Lake Sakakawea, and Middle Missouri

PURPOSE: Streambank Stabilization

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION:	ECONOMIC DEVELOPMENT
HEART PUBLIC INVOLVEMENT REGION	
Site A [1/]: S24 & 25, T138, R80 Morton County	Capital Cost $200,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site B [1/] [2/]: S31, T138, R80 Morton County	Capital Cost $400,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

Site C 3/:	S33, T140, R81 S4, T139, R81 Morton County	Capital Cost $180,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site D 3/:	S5, T138, R80 Morton County	Capital Cost $350,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

KNIFE PUBLIC INVOLVEMENT REGION

Site A 1/:	S5, T142, R81 Oliver County	Capital Cost $240,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site B 1/:	S9, 16, 21, & 28, T142, R81 Oliver County	Capital Cost $490,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site C 1/:	S16 & 22, T145, R84 Mercer County	Capital Cost $120,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site D 1/:	S12 & 13, T141, R81 Oliver County	Capital Cost $330,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site E 3/:	S15 & 23, T144, R82 Oliver County	Capital Cost $700,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site F 3/:	S24, T141, R81 Oliver County	Capital Cost $110,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site G 3/:	S24, T141, R81 Oliver County	Capital Cost $160,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site H 3/:	S22 & 23, T144, R84 Mercer County	Capital Cost $110,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

LAKE SAKAKAWEA PUBLIC INVOLVEMENT REGION

Site A 1/:	S8 & 17, T144, R84 McLean County	Capital Cost $80,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site B 1/:	S30, T146, R84 Mercer County	Capital Cost $90,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site C 3/:	S9 & 15, T145, R84 McLean County	Capital Cost $490,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

MIDDLE MISSOURI PUBLIC INVOLVEMENT REGION

Site A 1/:	S32 & 29, T143, R81 McLean County	Capital Cost $200,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site B 1/:	S27 & 34, T142, R81 Burleigh County	Capital Cost $90,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site C 1/:	S1 & 2, T141, R81 Burleigh County	Capital Cost $550,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site D 1/:	S9, T140, R81 Burleigh County	Capital Cost $120,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site E 1/:	S24 & 25, T139, R81 Burleigh County	Capital Cost $240,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site F 3/:	S15, T144, R82 McLean County	Capital Cost $90,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Site G 3/:	S30, T144, R81 McLean County	Capital Cost $280,000 Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Water turbidity will be reduced by eliminating the source of sediment, improving water quality. Biological elements will be adversely affected due to physical changes to the riverine ecosystem during the construction phase.

OTHER SOCIAL EFFECTS:

The project will protect the livelihood of landowners affected by stream erosion. Short-term employment will be available during the construction phase.

STATUS:

Funding is currently not available for either the uncompleted Section 32 projects (Demonstration Act of 1974) or the other sites.

RECOMMENDATION: Congressional authorization and funding for uncompleted S Section 32 (Demonstration Act of 1974) sites as well as any new sites that have been identified. Implementation in the 1980-1990 time frame.

1/ Demonstration Act of 1974, Section 32 - uncompleted sites.

2/ Landowners indicate that they do not want the project built.

3/ Other erosion sites identified.

STREAMBANK STABILIZATION PROJECT

NAME/LOCATION: Heart River (Figure IV-1-1; Site #20)
S29,20,&9,
T136, R84
Morton County

PUBLIC INVOLVEMENT REGION: Heart

PURPOSE: Prevent streambank erosion at three sites along the Heart River

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Three sites have been identified as requiring stabilization to prevent serious soil erosion. The erosion problem at one of the sites may result in the washout of a county bridge.

ECONOMIC DEVELOPMENT: Capital Cost $220,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Water turbidity will be reduced by eliminating the source of sediment, improving water quality. Biological elements will be adversely affected during the construction phase due to physical changes to the riverine ecosystem.

OTHER SOCIAL EFFECTS:

The project will protect the livelihood of landowners affected by streambank erosion. It will also maintain and protect the structural soundness of the county bridge thus assuring the health and safety of those persons utilizing the bridge. Short-term employment will be available during the construction phase.

STATUS: Inactive

RECOMMENDATION: Implementation in the 1980-1990 time frame.

STREAMBANK STABILIZATION PROJECT

NAME/LOCATION: Knife River Historic Sites (Figure IV-1-1; Site #38)
Mercer County

PUBLIC INVOLVEMENT REGION: Knife

PURPOSE: Prevent erosion at four archeological sites

LEAD STUDY AGENCY: National Park Service/Army Corps of Engineers

DESCRIPTION Berm and rock protection to the following sites: Taylor Bluff Site, Elbee Site, Mad Mans Bluff Site, and the Hadu Nowassa Site

ECONOMIC DEVELOPMENT: Capital Cost $200,000-$300,000 per site (1982 estimate)
Annual Cost $12,000
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The berm and rock would preserve an irreplaceable archeological resource and restore the natural setting of an area of historic importance.

OTHER SOCIAL EFFECTS:

Short-term employment would be available during the construction phase.

STATUS: Currently under investigation.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

STREAMBANK STABILIZATION PROJECT

NAME/LOCATION: Little Missouri River (Figure IV-1-1; Site #54)
S27,T140, R102
Medora,
Billings County

PUBLIC INVOLVEMENT REGION: Little Missouri

PURPOSE: Prevent streambank erosion of the Medora sewage lagoon.

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Two sites have been identified as requiring stabilization to prevent erosion of the city lagoon. Measures include: a composite revetment, a bankline revetment, and two windrow refusals.

ECONOMIC DEVELOPMENT: Capital Cost $70,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The streambank erosion control measures would protect the Little Missouri River from being polluted by sewage from the city lagoon. Pollution from the lagoon would adversely affect aquatic biota. Water turbidity will be reduced by eliminating the source of sediment and improving water quality.

OTHER SOCIAL EFFECTS:
The erosion control measures would protect the lagoon and a county road; therefore, the city would not have to repair or construct another lagoon. Short-term employment will be available during the construction phase.

STATUS:
Inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

STREAMBANK STABILIZATION PROJECT

NAME/LOCATION: Yellowstone River (Figure IV-1-1; Site #52)
S21, T150, R104
McKenzie County

PUBLIC INVOLVEMENT REGION: Upper Missouri

PURPOSE: Streambank Stabilization and Erosion Control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Horse Creek Site and a site upstream from the Cheney Creek Site

ECONOMIC DEVELOPMENT: Capital Cost $400,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
Water turbidity will be reduced by eliminating the source of sediment, improving water quality. Biological elements will be adversely affected during the construction phase due to physical changes to the riverine ecosystem.

OTHER SOCIAL EFFECTS:
The project will protect the livelihood of landowners affected by stream erosion. Short-term employment will be available during the construction phase.

STATUS:
Inactive. Funding is currently not available for Section 32 Streambank Erosion Control Demonstration Project.

RECOMMENDATION: Congressional authorization and funding for identified sites. Implementation in the 1980-1990 time frame.

STREAMBANK STABILIZATION PROJECT

NAME/LOCATION: North Dickinson Channel Critical Area Treatment (Figure IV-1-1; Site #27)
S11, T139, R96
Stark County

PUBLIC INVOLVEMENT REGION: Heart

PURPOSE: Prevent soil erosion of side channel of the Heart River

LEAD STUDY AGENCY: Soil Conservation Service/City of Dickinson/ Stark County Water Resource District

DESCRIPTION: The project involves three concrete drop structures and riprap consisting of four acres of road and ditch and four acres of channel located on the southeast part of the City of Dickinson.

ECONOMIC DEVELOPMENT: Capital Cost $463,600
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The project would control soil erosion, reduce sedimentation, and improve water quality in the Heart River downstream of Dickinson.

OTHER SOCIAL EFFECTS:
The project will protect the livelihood of landowners affected by the stream erosion. Short-term employment will be available during the construction phase.

STATUS:
Currently under investigation.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SCENIC AND RECREATION RIVER

NAME/LOCATION: Missouri River (Figure IV-1-1; Site #37)
Mercer, Oliver, Morton,
McLean, and Burleigh Counties

PUBLIC INVOLVEMENT REGION: Heart, Knife, Lake Sakakawea, and the Middle Missouri

PURPOSE: Scenic and Recreation River

LEAD STUDY AGENCY: ND Parks and Recreation Department

DESCRIPTION: Maintain 86 miles of free flowing river.

ECONOMIC DEVELOPMENT: 1/ Capital Cost $23,238,000
Annual Cost $2,175,000
Annual Benefit $2,171,000
Benefit/Cost Ratio 1.00

ENVIRONMENTAL QUALITY:

This alternative would preserve and maintain 86 miles of the Missouri River from Garrison Dam to the mouth of the Heart River south of Mandan for scenic, recreation, and wildlife purposes. This will assure preservation of riparian habitat for plant diversity, wildlife habitat, and recreational and aesthetic value of the river.

The Missouri River segment that flows through North Dakota is one of the last undeveloped areas left on the Missouri River system. Large stands of native cottonwoods continue to thrive along Missouri River banks with heavy streamside vegetation. Numerous wildlife forms thrive here including deer, wild turkeys, various species of birds, grouse, and pheasant. Rolling hills and agricultural land also characterize the shoreline appearance. Natural areas, grasslands, woodlands, and prairie continually provide interpretive and educational resources. The Missouri River from Garrison downstream to Fort Lincoln State Park is considered a priority in river conservation and preservation.

OTHER SOCIAL EFFECTS:

Land ownership and control would be regulated by purchase of 16 acres fee title and 16,500 acres easement. The Missouri River provides major historical and cultural information for North Dakota. This history should be protected from development. Recreationally, this segment of the Missouri provides opportunities to explore history and unspoiled, native natural resources.

STATUS:

Segments of this river are on the final list of rivers to be considered for inclusion into the Nationwide Inventory of Wild and Scenic Rivers.

RECOMMENDATION: Further study to be completed in the 1980-1990 time frame of the program with the following changes: Lake Sakakawea and Middle Missouri Citizens Advisory Boards recommends program exclusive of easement and fee title purchase; and the Heart Citizens Advisory Board recommends no additional dams on the mainstem.

1/ Costs were developed from the Yellowstone Basin and Adjacent Coal Area Level B Study - Missouri River Basin Commission.

SCENIC AND RECREATION RIVER

NAME/LOCATION: Heart River (Figure IV-1-1; Site #19)
Grant and Morton Counties

PUBLIC INVOLVEMENT REGION: Heart

PURPOSE: Scenic and Recreation River

LEAD STUDY AGENCY: ND Parks and Recreation

DESCRIPTION: Maintain 106 miles of free flowing river from Heart Butte Dam to Missouri River.

ECONOMIC DEVELOPMENT: 1/ Capital Cost $28,901,000
Annual Cost $2,440,000
Annual Benefit $811,000
Benefit/Cost Ratio 0.33

ENVIRONMENTAL QUALITY:

This alternative would preserve and maintain 106 miles of the Heart River for scenic, recreation, and wildlife purposes. This will assure preservation of riparian habitat for plant diversity, wildlife habitat, and recreational and aesthetic value of the Heart River.

The Heart River begins flowing through rugged badlands down through level bench land and rolling to gently sloping prairies. Hardwood stands with brush understory are still existing in some areas while others have been depleted through development. The Heart flows through coal and oil impacted areas which have had profound effects. Dams have been constructed and developed along the Heart furnishing recreational opportunities. Fishing is an important resource with the lower Heart River Basin serving as the most important fish area in southwestern North Dakota. At one time, segments of this river had been initially listed for inclusion into the Nationwide Inventory of Wild and Scenic Rivers.

OTHER SOCIAL EFFECTS:

Land ownership and control will be regulated by purchase of 76 acres of fee title and 23,320 acres of easements. Historical aspects along the Heart

River include archaeological finds relating to early Indian tribes inhabiting the area of confluence with the Missouri.

STATUS:

Inactive. Potential inclusion to the Nationwide Inventory of Wild and Scenic Rivers.

RECOMMENDATION: Implementation of program exclusive of easement and fee title purchase.

1/ Costs are for purchase of easements and fee titles and were developed from the Yellowstone Basin and Adjacent Coal Area Level B Study - Missouri River Basin Commission.

LAKE RESTORATION/STRUCTURE REPAIR PROJECT

NAME/LOCATION: Beaver Lake Dam Repair 1/ (Figure IV-1-1; Site #6)
S33, T134, R71
Logan County

PUBLIC INVOLVEMENT REGION: Beaver Creek

PURPOSE: Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Repairs to existing structure

ECONOMIC DEVELOPMENT: Capital Cost $72,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

No significant adverse environmental effects are anticipated.

OTHER SOCIAL EFFECTS:

The repairs will enhance and assure the water-based recreation opportunity in the area.

STATUS:

Currently under investigation

RECOMMENDATION: Implementation in the 1980-1990 time frame.

1/ An existing reservoir.

LAKE RESTORATION/STRUCTURE REPAIR PROJECT

NAME/LOCATION: Jund Dam Repairs 1/ (Figure IV-1-1; Site #4)
S18 & 19, T129, R72
McIntosh County

PUBLIC INVOLVEMENT REGION: Beaver Creek

PURPOSE: Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Repairs and dredging to existing reservoir or a new reservoir constructed downstream with repairs to the existing reservoir.

ECONOMIC DEVELOPMENT:

Alt. A:	Repairs to existing reservoir and dredging	Capital Cost $26,500 (for repairs and $2,000 per AF for dredging estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Alt B:	New reservoir constructed downstream from existing reservoir and repairs to existing reservoir. New Reservoir size: 221 AF storage and 27.5 surface acres	Capital Cost $276,500 (estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Alternative A will enhance the reservoir fishery. Alternative B will result in the loss of 27.5 acres of land and wildlife riparian habitat due to inundation, resulting in a displacement of terrestrial wildlife. The old Jund Dam would act as a nutrient and sediment trap enhancing the water quality in the lower lake.

OTHER SOCIAL EFFECTS:

Both alternatives would enhance the water-based recreation opportunity in the area.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame of Alternative A repairs only.

1/ Existing reservoir.

LAKE RESTORATION/STRUCTURE REPAIR PROJECT

NAME/LOCATION: Welk Dam Repairs 1/ (Figure IV-1-1; Site #2)
S33, T131, R77
Emmons County

PUBLIC INVOLVEMENT REGION: Beaver Creek

PURPOSE: Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Repairs to existing reservoir and/or construction of a new reservoir downstream.

ECONOMIC DEVELOPMENT:

Alt A:	Repairs to existing dam including the filling and compaction of soil in the scour area, reseeding the embankment, tree removal in the problem area, and some increased riprap protection.	Capital Cost $2,000-$7,000 (for repairs and $2,000 per AF for dredging.) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Alt. B:	Construct new dam downstream and repairs to existing dam. New reservoir size: 1,750 AF storage; 87 surface acres	Capital Cost $809,000 (estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Alternative A is anticipated to have no significant environmental impacts. Alternative B will result in the loss of 87 acres of land and riparian habitat due to inundation. Terrestrial wildlife will be displaced.

OTHER SOCIAL EFFECTS:

Both alternatives will enhance the water-based recreational opportunity in the area.

STATUS: Inactive.

RECOMMENDATION: Implementation of Alternative A in the 1980-1990 time frame.

1/ Existing reservoir.

REGIONWIDE PROGRAM FOR THE
MISSOURI RIVER STATISTICAL PLANNING AREA

NAME: Land Treatment Measures

PUBLIC INVOLVEMENT REGION: All Regions in the Missouri River SPA

PURPOSE: Control soil erosion and flooding

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Land treatment measures are those practices used to reduce soil erosion and control flooding, and include such features as grassed water ways, shelter belts, and strip cropping.

ECONOMIC DEVELOPMENT:

Land treatment measures on a total of 6,856,000 acres	Capital Cost	$57,998,000
	Annual Cost	NA
	Annual Benefit	NA
	Benefit/Cost Ratio	NA

ENVIRONMENTAL QUALITY

Soil erosion by wind and water will be reduced. Water quality and wildlife habitat will be enhanced.

OTHER SOCIAL EFFECTS:

Damages to agricultural lands caused by wind and water erosion of soil will be reduced.

STATUS:

An ongoing program dependent upon voluntary participation by individual landowners and the availability of cost-share monies from the Soil Conservation Service.

RECOMMENDATION: Implementation as indicated in Table IV-1-5.

NAME: Municipal Waste Treatment Facilities

PUBLIC INVOLVEMENT REGION: All Regions in the Missouri River SPA

PURPOSE: Enhance the capability for treating municipal wastewater

LEAD STUDY AGENCY: ND State Health Department

DESCRIPTION: New facilities are required and existing facilities need to be improved before the year 2000 in 45 communities serving 35,869 people, in addition to Fort Lincoln, Lewis and Clark and Lake Sakakawea State Parks, and Fort Berthold Reservation. Incorporated communities and certain other public entities are eligible for financial assistance through the Construction Grant Program of the Environmental Protection Agency. This program is administered in North Dakota by the State Health Department. Under this program, 75 percent of the planning and construction costs for new collection and treatment facilities and for upgrading existing wastewater treatment plants are reimbursible. Congress appropriates the money for the Program. The State Health Department disperses North Dakota's share according to a priority list it has developed.

ECONOMIC DEVELOPMENT: Capital Cost $6,458,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The wastewater treatment facilities will improve the water quality of the receiving watercourses. Additional solid waste resulting from the treatment process will need disposal.

OTHER SOCIAL EFFECTS:
The communities will have to furnish 25 percent of the total cost of any new or improved facility.

STATUS:
Ongoing program. Other sources of funding will have to furnish 25 percent of the total cost of new or improved facilities.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

NAME: Municipal Water Supply Treatment Facilities

PUBLIC INVOLVEMENT REGION: All Regions in the Missouri River SPA

PURPOSE: Enhance municipal water supply treatment capability

LEAD STUDY AGENCY: ND State Health Department

DESCRIPTION: Additional or improved treatment facilities are needed in 12 communities serving 97,000 people in order to meet the recommended Standards for Safe Drinking Water Supplies set by the Environmental Protection Agency.

ECONOMIC DEVELOPMENT: Capital Cost $11,501,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The additional or improved water supply treatment facilities will enhance the quality of municipal water supplies. Additional solid wastes generated by the treatment processes will require disposal.

OTHER SOCIAL EFFECTS:
Municipal water supplies will be improved, enhancing the safety, health and well-being, and quality of life for community residents. The only funding available is currently derived from the tax base of the community. No State or Federal funds are currently available.

STATUS:

Facilities are constructed on an individual basis as community funding allows.

RECOMMENDATION:

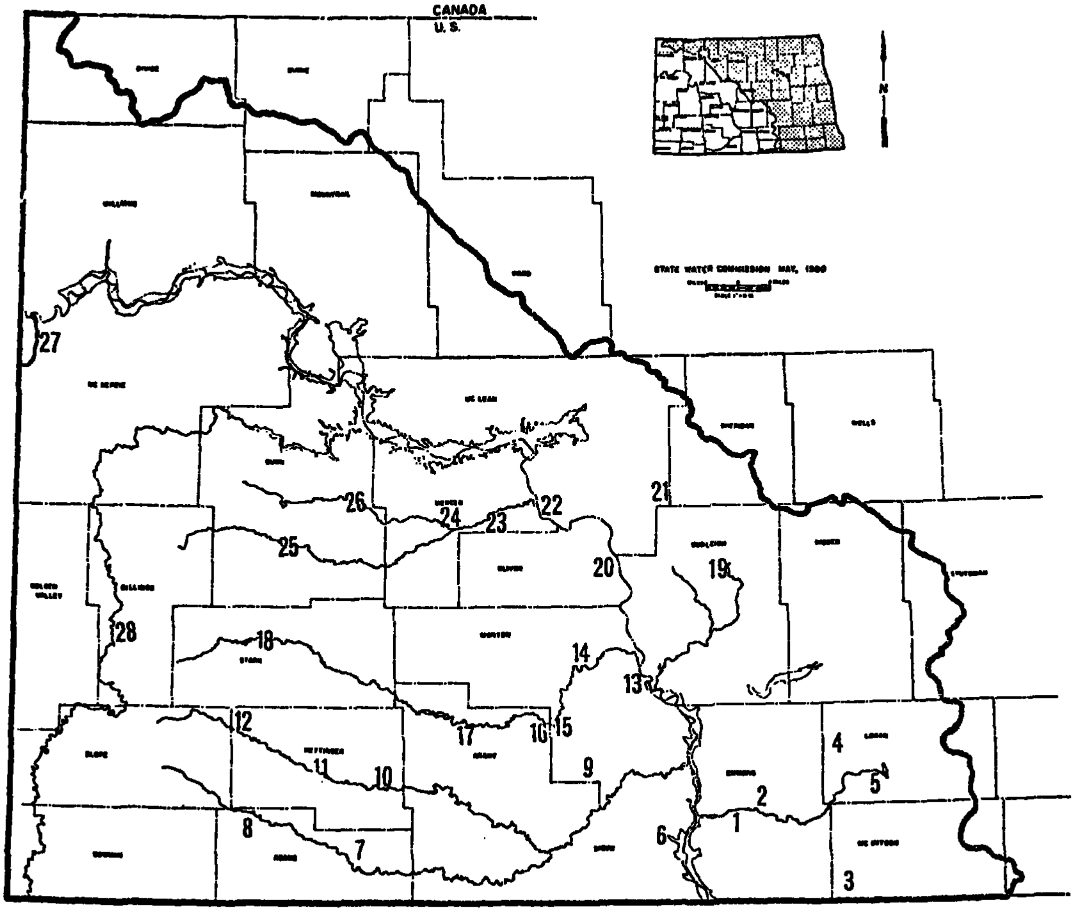
Implementation in the 1980-1990 time frame except the City of Garrison for which implementation is in the 1990-2000 time frame.

TABLE IV-1-5 RECOMMENDED PLAN AND ESTIMATED INVESTMENTS IN 1980 DOLLARS MISSOURI RIVER BASIN

Water and Related Land Resources Category	Units	Composition and Estimated Investments (All Values are Incremental) 1980-1990 (Early Action Program) Quantity	1980-1990 Initial Investment Federal ($1000)	1980-1990 Initial Investment State/Local ($1000)	1980-1990 Annual O.M.&R. Federal ($1000)	1980-1990 Annual O.M.&R. State/Local ($1000)	1990-2000 Quantity	1990-2000 Initial Investment Federal ($1000)	1990-2000 Initial Investment State/Local ($1000)	1990-2000 Annual O.M.&R. Federal ($1000)	1990-2000 Annual O.M.&R. State/Local ($1000)	2000-2020 Quantity	2000-2020 Initial Investment Federal ($1000)	2000-2020 Initial Investment State/Local ($1000)	2000-2020 Annual O.M.&R. Federal ($1000)	2000-2020 Annual O.M.&R. State/Local ($1000)
SURFACE WATER CONTROL																
Multi-purpose Reservoir																
Total Storage	1000AF	161.2 2/	--	32,315	--	323	371.5	20,992	26,778	--	477.7	94.7 1/	--	32,997	--	330
Flood Control	1000AF	(68)					(248.5)									
Other Purpose 3/	1000AF	(93.2)					(123)					(94.7)				
Single Purpose Reservoir																
Flood Control	1000AF	3.4	--	833	--	8.3										
Irrigation	1000AF	17.4	--	3,670	--	36.7	11.6	--	4,335	--	43.4	295.2	--	48,502	--	465
Municipal	1000AF															
Recreation	1000AF	11.4	--	4,639	--	46.4	6	--	4,404	--	44					
Instream Control																
Channel Improvement	Miles	0.5	343	120	--	0.5										
Levees, Floodwalls, etc.	Each	2	213	28	--	3.1										
Streambank Stabilization	Each	33	7,290	220	24	126.2 4/										
Diversion																
Irrigation	1000AF	68	45,739	31,040	--	696	168.6	156,378 5/	34,327 5/	--	1,421	120	60,680	13,320	--	740
Municipal	1000AF						0.4	2,461	-- 6/	194	-- 6/					
Multi-feature Project 7/	Each	2	94	1,134	--	23	1	459	51	--	5					
RELATED LAND PROGRAMS																
Drainage	Each						2	--	384	--	5.8					
Irrigation																
Private 8/	1000Ac	14														
Public 9/	1000Ac	31.1					102.1					256.1 10/				
ENVIRONMENTAL AND RESOURCE ENHANCEMENT 11/																
Protection and Management 12/																
Cropland	1000Ac	1,374	11,336	3,778	NA	NA	937	7,730	2,577	NA	NA	936	7,722	2,574	NA	NA
Pasture	1000Ac	214	883	294	NA	NA	143	590	197	NA	NA	114	470	157	NA	NA
Range	1000Ac	1,332	5,495	1,831	NA	NA	884	3,647	1,215	NA	NA	884	3,647	1,215	NA	NA
Forest	1000Ac	22	908	302	NA	NA	13	536	179	NA	NA	13	536	179	NA	NA
Outdoor Recreation																
Stream Preservation 13/	Miles	106	--	--	--	--										
Facilities	Each															
Waste Water Management 14/																
Municipal	1000PS 15/	35.9 16/	4,843	1,615	--	646 17/										
Water Supply Treatment																
Municipal	1000PS	95	--	11,214	--	556.5	2	--	287	--	0.3					
ADDITIONS AND MODIFICATIONS TO EXISTING PROJECTS																
Reservoir Storage	Each	3	--	104	--	1										
TOTAL COST			77,144	93,137	24	2,466.7		192,793	74,734	194	1,997.2		73,055	98,944	--	1,555

1/ Only reservoir capacity has been listed; in addition, approximately 368,000 AF would be diverted from Lake Sakakawea to meet the potential demand. Cost of the diversion system has not been determined.
2/ Figures in parentheses are non-additive.
3/ Storage included for municipal and industrial water supply, water quality control, sedimentation, fish and wildlife, and recreation.
4/ The current policy requiring local entities to bear the OM & R Cost of streambank stabilization projects on the Missouri and Yellowstone Rivers is a matter of dispute between the State of North Dakota and the Federal Government.
5/ Cost includes a Fish and Wildlife and Recreation Development Plan as part of the 20,400 acre Apple Creek Unit Irrigation Project located in southwestern Burleigh County (North Dakota Pumping Division, Pick-Sloan Missouri Basin Program).
6/ The City of Garrison must pay the initial cost of the treatment plant and annual OM & R Costs. The costs have been added to the Water Supply Treatment Category.
7/ Multi-feature projects are defined as those projects which consist of more than one element, including structural and non-structural measures. Example: a dam and diversion floodway.
8/ Costs are shown under Surface Water Control-Diversion (Irrigation) totaling 21 million dollars.
9/ Acres irrigated reflect reservoir and diversion development. Costs are shown under Surface Water Control (Multi-purpose Reservoirs, Single Purpose Reservoirs, and Diversion). Cost under Reservoirs does not include distribution cost.
10/ The total includes 156,500 acres of land that could be irrigated with water diverted from Lake Sakakawea, including 7,375 acres and 9,100 acres of land which would be irrigated with water stored in Lake Patterson and Lake Tschida, respectively. Also associated with the diversion system will be 56,100 acre-feet for industrial use. Cost of the diversion system has not been determinud.
11/ The data used to compute the figures displayed in this Category are useable on a county basis; therefore the figures are for the Missouri River Statistical Planning Area (Figure I-1-2) rather than the Basin.
12/ Land treatment measures have been accelerated from the Future Without Plan Projections (Table III-1-1) as follows: 1980-1990 figures by 1.5 percent, 1990-2000 figures by 1.0 percent, and 2000-2020 figures by 0.5 percent.
13/ The Heart River from Heart Butte Dam to the Missouri River should remain free-flowing and designated as a State Scenic River.
14/ Some of the projects will be constructed in the 1990-2000 time frame. However, since the construction date of each specific project could not be determined, all costs have been placed in the 1980-1990 time frame.
15/ P.S. represents population served based upon the highest projection.
16/ The population served does not include the Fort Lincoln, Lake Sakakawea, and Lewis and Clark State Parks facilities nor the Fort Berthold Reservation.
17/ The annual OM & R Cost does not include the Fort Lincoln, Lake Sakakawea, and Lewis and Clark State Parks facilities nor the Fort Berthold Reservation.

FIGURE IV-1-2 MISSOURI RIVER BASIN
LOCATION OF RECOMMENDED PLAN - EARLY ACTION PROGRAM



1. Welk Dam Repairs
2. Linton Flood Control
3. Jund Dam Repairs
4. Napoleon Flood Control
5. Beaver Lake Dam Repairs
6. Fort Yates Irrigation Unit
7. Square Butte Dam
8. Wolf Butte Dam
9. Flasher Flood Control
10. Thirty-Mile Creek Dam
11. Mott Dam
12. Bohlman Dam
13. Little Heart Irrigation Unit
14. Heart River - Scenic and Recreation River
15. Heart River Streambank Stabilization
16. Otter Creek Dam
17. Lower Antelope Creek Dam
18. North Dickinson Channel Critical Area Treatment
19. Schwartz Dry Dam
20. Missouri River Streambank Stabilization
21. McClusky Canal-side Irrigation
22. Knife River Historic Sites Streambank Stabilization
23. Hazen-Stanton Irrigation Unit
24. Beulah Dry Dams
25. Emerson Dam
26. Halliday Flood Control
27. Yellowstone River Streambank Stabilization
28. Little Missouri River Streambank Stabilization

TABLE IV-1-6 MISSOURI RIVER BASIN RECOMMENDED PLAN - EARLY ACTION PROGRAM

Program Feature	Description	Initial Costs "1980 Dollars" Federal	State/Local	Total	Annual Operation, Maintenance, and Replacement Costs "1980 Dollars" Federal	State/Local	Total
SURFACE WATER CONTROL							
Multi-purpose Reservoirs	Mott- Dam - This 50,000 acre-foot (AF) reservoir would be located three miles west of Mott in Hettinger County; utilized for flood control and irrigation of 3,850 acres.	-	$23,080,000	$23,080,000	-	$230,800	$230,800
	Emerson Dam - This 43,200 AF reservoir would be located three miles south and nine miles east of Manning in Dunn County; utilized for irrigating 5,500 acres and flood control.	-	$9,235,000	$9,235,000	-	$92,350	$92,350
Single purpose Reservoirs	Bohlman Dam - This 2,070 AF recreation reservoir would be located two miles north of New England in Hettinger County.	-	$822,000	$822,000	-	$8,220	$8,220
	Square Butte Dam - This project, a 1,360 AF recreation reservoir, would be located nine miles east and ten miles north of Haynes in Adams County.	-	$511,000	$511,000	-	$5,110	$5,110
	Thirty-Mile Creek Dam - This 6,000 AF reservoir would be utilized for recreation and could also have some flood control benefits. The reservoir site is located three miles north of Bentley in Hettinger County.	-	$2,040,000	$2,040,000	-	$20,400	$20,400
	Lower Antelope Creek Dam - This 13,400 AF reservoir would be utilized to irrigate 1,563 acres. This site is located five miles north and two miles west of Carson in Grant County.	-	$3,670,000	$3,670,000	-	36,700	$36,700
	Otter Creek Dam - This 880 AF recreation reservoir would be located ten miles north and 13 miles east of Carson in Grant County.	-	$591,000	$591,000	-	$5,910	$5,910
	Wolf Butte Dam - This 1,100 AF recreation reservoir would be located nine miles north of Bucyrus in Adams County.	-	$675,000	$675,000	-	$6,800	$6,800
	Beulah Dry Dams - A total of three dry dams are to be constructed. Two dams are north and one dam is west of the City of Beulah. Maximum flood storage capacity of the three dams is an estimated 1,440 AF.	-	$583,200	$583,200	-	$5,832	$5,832
	Schwartz Dry Dam - This 2,000 AF dry dam would be located three miles south and seven miles west of Wing in Burleigh County.	-	$250,000	$250,000	-	$2,500	$2,500

Program Feature	Description	Initial Costs "1980 Dollars Federal	State/Local	Total	Annual Operation, Maintenance, and Replacement Costs "1980 Dollars" Federal	State/Local	Total
Instream Control Channel Improvement	North Dickinson Channel Critical Area Treatment- This project involves three concrete drop structures and rip-rap consisting of four acres of road and ditch and four acres of channel. The project is southeast of Dickinson on the City's outskirts.	$342,800	$120,800	$463,600	-	$500	$500
Levees, Floodwall, etc.	Napoleon Flood Control - A diversion floodway which would provide protection against the one percent (100-year) frequency flood event for the town of Napoleon in Logan County.	$177,000	$24,000	$201,000	-	$2,777	$2,777
	Flasher Flood Control - This dike would provide protection against the one percent (100-year) frequency flood event for the town of Flasher in Morton County.	$36,000	$4,000	$40,000	-	$300	$300
Streambank Stabilization	Missouri River Streambank Stabilization - Streambank stabilization is proposed for 22 sites along the river.	$5,620,000	-	$5,620,000	-	$112,400 1/	$112,400
	Heart River Streambank Stabilization - Three sites in Morton County need protection along the river.	$70,000	$150,000	$220,000	-	$4,400	$4,400
	Knife River Historic Sites Streambank Stabilization - Four historical sites on the bank of the river need protection.	$1,200,000	-	$1,200,000	$24,000	-	$24,000
	Little Missouri River Streambank Stabilization - Two sites near Medora, in Billings County need protection.		$70,000	$70,000	-	$1.400	$1.400
	Yellowstone River Streambank Stabilization - Two sites require bank stabilization along the river.	$400,000	-	$400,000	-	$8,000 1/	$8,000
Diversion Irrigation	Fort Yates Unit - Irrigation of 4,260 acres is proposed along Lake Oahe near Fort Yates in Sioux County.	$7,949,000	$1,745,000	$9,694,000	-	$132,000	$132,000
	Little Heart Irrigation Unit - Irrigation is proposed for 3,100 acres located along a terrace above the Missouri River beginning five miles south of Mandan in Morton County.	$5,704,000	$1,252,000	$6,956,000	-	$73,000	$73,000

Program Feature	Description	Initial Costs "1980 Dollars" Federal	State/Local	Total	Annual Operation, Maintenance, and Replacement Costs "1980 Dollars" Federal	State/Local	Total
	Hazen-Stanton Irrigation Unit - Irrigation is proposed for 12,650 acres of land located at the confluence of the Knife and Missouri Rivers on the south side of the Knife River between Hazen and Stanton in Mercer County.	$32,086,000	$7,043,000	$39,129,000	-	$281,000	$281,000
	McClusky Canal-side Irrigation - Irrigation is proposed for 14,000 acres of land along the McClusky Canal in McLean, Burleigh, and Sheridan Counties.	-	$21,000,000	$21,000,000	-	$210,000	$210,000
Multi-feature Project	Linton Flood Control - Flood control measures would include a levee and channel improvements to provide protection against the one percent (100-year) frequency flood event for Linton in Emmons County.	-	$1,124,200	$1,124,200	-	$22,500	$22,500
	Halliday Flood Control - Flood control measures would include a dike and di- diversion channel to provide protection against the one percernt (100-year) frequency flood event for Halliday in Dunn County.	$94,000	$10,000	$104,000	-	$500	$500
ENVIRONMENTAL AND RESOURCE ENHANCEMENT Protection and Management	Land Treatment Measures - These measures would be applied to 2,942,000 acres of land to reduce soil erosion in the Missouri River SPA.	$18,620,250	$6,206,750	$24,827,000	NA	NA	NA
Outdoor Recreation Stream Preservation	Heart River - Scenic and Recreation River - One hundred and six miles of the Heart River would be maintained free-flowing from the Heart Butte Dam to the Missouri River.	-	-	-	-	-	-
Waste Water Management Municipal 2/	New and/or improved existing municipal waste treatment facilities would be developed for 45 communities serving 35,869 people, in addition to Fort Lincoln, Lake Sakakawea, and Lewis and Clark State Parks, plus the Fort Berthold Reservation.	$4,843,500	$1,614,500	$6,458,000	-	$645,642 3/	$645,642 3/
Water Supply Treatment Municipal 4/	Additional or improved treatment facilities would be developed to meet recommended limits for domestic water supply purposes in 11 communities serving 95,000 people.	-	$11,214,000	$11,214,000	-	$556,500	$556,500

Program Feature	Description	Initial Costs "1980 Dollars Federal	State/Local	Total	Annual Operation, Maintenance, and Replacement Costs "1980 Dollars" Federal	State/Local	Total
ADDITIONS AND MODI-FICATIONS TO EXIST-ING PROJECT							
Reservoir Storage	Beaver Lake Dam Repairs - Repairs are needed for the existing structure in Logan County.	-	$72,000	$72,000	-	$720	$720
	Jund Dam Repairs - Repair is needed for the existing reservoir structure in McIntosh County.	-	$26,500	$26,500	-	$265	$255
	Welk Dam Repairs - Repair is needed for the existing reservoir structure in Emmons County.	-	$5,000	$5,000	-	$50	$50

1/ The current policy requiring local entities to bear the OM&R cost of streambank stabilization on the Missouri and Yellowstone Rivers is a matter of dispute between the State of North Dakota and the Federal Government.

2/ As identified by the ND State Health Department, some of the projects will be constructed in the 1990-2000 time frame. However, since the construction date of each specific project could not be determined, all costs have been placed in the 1980-1990 time frame. The communities in the Missouri River Statistical Planning Area (SPA) include: Braddock, Wishek, Napoleon, Linton, Lincoln, Gackle, Scranton, Solen, Bucyrus, Reeder, Elgin, Flasher, Hettinger, New Leipzig, Selfridge, South Heart, Carson, Taylor, Golden Valley, Stanton, Halliday, Hazen, Dodge, Parshall, Pick City, Benedict, Underwood, Garrison, Washburn, Beach, Golva, Sentinel Butte, Medora, Pettibone, Regan, Mercer, McClusky, Steele, Dawson, Tioga, White Earth, Palermo, Alamo, Grenora, and Ross, in addition to Fort Berthold Reservation and Lewis and Cla[rk] Lake Sakakawea, and Fort Lincoln State Park facilities.

3/ Does not include the State Park treatment facilities nor Fort Berthold Reservation OM&R Costs.

4/ As identified by the ND State Health Department, the communities in the Missouri River SPA include: Linton, Wishek, Elgin, Hettinger, Mott Belfield, Glen Ullin, Richardton, Hebron, Bismarck, and Stanley.

ADDITIONAL SPECIAL STUDIES AND PROGRAMS -

1) A detailed study should be initiated to determine the economic feasibility of a water supply system from Lake Sakakawea to all the major tributaries of the Missouri River. The following multi-purpose retention structures, in addition to existing reservoirs, should be considered in the diversion system:

   A) Philbrick Dam - a 75,000 acre-foot (AF) reservoir located 10 miles west and four miles north of New England in Slope County.

   B) Cannonball Dam - a 60,000 AF reservoir located seven miles east and one mile south of New Leipzig in Grant County.

   C) Mott Dam - a 50,000 AF reservoir located three miles west of Mott in Hettinger County.

   D) Thunderhawk Dam - a 43,300 AF reservoir located four miles north and 26 miles east of Hettinger in Adams County.

   E) Versippi Dam - a 13,400 AF reservoir located seven miles east and one mile north of Dickinson in Stark County.

   F) Crown Butte Dam - a 34,899 AF reservoir located 12 miles north of Carson in Grant County.

   G) Spring Lake Dam - a 18,000 AF reservoir located three miles west of Golden Valley in Mercer County.

   H) Emerson Dam - a 43,200 AF reservoir located three miles south and nine miles east of Manning in Dunn County. This project would require an amendment to the Little Missouri State Scenic River Act.

   I) Third Creek Dam - a 46,415 AF reservoir located 19 miles south and three miles east of Medora in Billings County.

   J) Beaver Creek Dam - a detailed study to investigate the feasibility of irrigating lands in Emmons County by constructing a dam near the mouth of Beaver Creek. The project would help irrigate about 18 thousand acres in the Horsehead Flats area and would require construction of a pumpback facility.

2) Single purpose reservoirs requiring additional study include:

   A) Wolf Butte Dam - a 1,100 AF recreation reservoir located nine miles north of Bucyrus in Adams County.

   B) Hailstone Creek Dam - an 800 AF recreation reservoir located three miles north and one mile west of Almont in Morton County.

   C) Upper Antelope Creek Dam - a 3,000 AF recreation reservoir located six miles south and six miles east of Dickinson in Stark County.

D) Buffalo Creek Dam - a 2,180 AF recreation reservoir located 15 miles south and four miles east of Richardton in Stark County.

E) North Coyote Creek Dam - a 4,100 AF irrigation reservoir located one mile northeast of Marshall in Dunn County.

F) Otter Creek Dam - a 7,500 AF irrigation reservoir located four miles east and two miles south of Beulah in Oliver County.

G) Beaver Creek Dam - a 55,169 AF irrigation reservoir located 16 miles north of Beach in Golden Valley County.

H) Marmarth Dam - a 240,000 AF irrigation reservoir located 11 miles west of Rhame in Bowman County. This project would require an amendment to the Little Missouri State Scenic River Act.

I) Schwartz Dry Dam - a 2,000 AF dry dam located three miles south and seven miles west of Wing in Burleigh County.

J) Series of dry dams for flood control purposes in Apple Creek Watershed - dry dams which could be constructed for flood control purposes after Neideffer and Schwartz Dam have been evaluated for their effectiveness and economic feasibility.

K) White Earth Tributary Dams - dry dams located near the City of White Earth in Mountrail County.

L) Hydropower Pumpback Reservoir - a 26,135 AF reservoir utilizing pumpback from Lake Sakakawea to produce hydroelectric power, located on the Fort Berthold Reservation in northern Mercer County.

3) The following irrigation projects utilizing water from the Missouri River or Lake Oahe should be studied in detail and implementation beginning in the 1990 time frame:

A) Oliver-Sanger Unit - irrigation of 8,000 acres of land on an 11-mile strip along the west bank of the Missouri River in Oliver County (opposite the City of Washburn).

B) Apple Creek Unit - irrigation of 20,386 acres located south and west of the City of Bismarck in Burleigh County.

C) McClusky Canal diversion to Kidder and Burleigh Counties - irrigation of an undetermined amount of acreage in Kidder County ranging from 50,000 to 120,000 acres.

D) Painted Woods Unit - irrigation of 610 acres of land located south of the City of Washburn in McLean County; additional study to determine the feasibility of increasing the total irrigable acres should be initiated.

4) All alternatives to the use of a re-regulation dam for increasing hydropower generation at Garrison Dam should be investigated in detail; this possibility is currently being studied by the Army Corps of Engineers.

5) Belfield Flood Prevention (PL-566 Watershed Study) is recommended to be authorized for planning. This project includes a dam and floodway project for Belfield in Stark County.

6) Muskrat Lake Watershed Protection (PL-566 Watershed Study) is recommended to be authorized for planning. This project includes land treatment measures located in Mountrail County.

7) Alternatives for flood control in Underwood, McLean County should be studied further to determine the best solution.

8) Continued investigation into an improved water supply for the City of Garrison is recommended utilizing Lake Audubon as a water supply.

9) Continued study is recommended for a drainage project in Dunn County. This project would drain a 975-acre wetland located eight miles south and four miles west of Halliday in Dunn County.

10) Congressional authorization and funding is recommended for streambank stabilization sites on the Missouri and Yellowstone Rivers, including all uncompleted Section 32 sites and new erosion sites that have been identified. The annual OM & R Cost of these sites should be the responsibility of the Federal Government and not the local entities as is the current policy.

11) Further investigation into the Little Missouri River streambank stabilization problem at Medora is recommended.

12) Continued study is recommended for Knife River Historic Site streambank stabilization; four historical sites require protection from streambank erosion.

13) Consensus was not reached among the Missouri River SPA Public Involvement Regions regarding designation of the Missouri River between Garrison Dam and the upper reaches of Lake Oahe as a State Scenic River; therefore, further study should be completed in the 1980-1990 time frame.

14) It is recommended that study be continued into the restoration of Jund Dam in McIntosh County and Welk Dam in Emmons County with repairs completed in the 1980-1990 time frame. Possible construction of new downstream reservoirs should be considered.

15) Consensus was not reached among the Public Involvement Regions of the Missouri River SPA to support the Weather Modification Program. The regions supporting the program include: Beaver Creek, Cannonball/Grand, Lake Sakakawea, Little Missouri, Middle Missouri, and Upper Missouri.

16) Implementation of rural water supply systems is recommended for south Emmons and McIntosh Counties; all possible funding alternatives should be investigated.

17) A comprehensive study, to be completed in the 1980-1990 time frame, is recommended for areas experiencing water supply problems (examples: Turtle Lake and Mercer in McLean County, Pettibone area in Kidder County, and McClusky and Denhoff in Sheridan County) to determine the most feasible method (including rural water) to meet the supply needs.

18) An exploration of alternatives is recommended to assure a supply of good quality rural-domestic water in Mountrail County.

19) Acceleration of land management practices is recommended (through coordination with the Soil Conservation Service - SCS) in order to reduce severe nutrient loading and sediment deposits in the Bowman - Haley Reservoir.

20) Studies, involving a multi-agency approach, with the State Health Department as the lead agency, should be undertaken to determine sources and solutions for pollution in Lake Audubon in McLean County and Lake Isabel and Cherry Lake in Kidder County, as well as several other lakes in the area.

21) Comprehensive water management studies with the ND State Water Commission as lead agency are recommended for the Painted Woods Creek Watershed. (Apple, Burnt, Hay, Buffalo, and Merry's Creeks should undergo similar studies).

22) A study should be undertaken to develop a mechanism to coordinate urban and rural storm water management. The study should determine the need for now or revised legislation to accomplish improved coordination particularly in the area of project cost sharing. Currently, cities may not expend funds for projects outside their boundaries.

23) Studies are recommended to determine the need for, and feasibility of, lakeshore riprapping to protect recreational values of primarily public lands around these lakes. (Hoskins Lake and Green Lake - McIntosh County and Beaver Lake - Logan County).

24) Acceleration of the installation of land treatment measures is recommended to protect and preserve basic soil resources, reduce air and water pollution, and to assist in the sustained production of food and fiber.

25) It is suggested that the State Water Commission work closely with the Corps of Engineers in their ongoing studies to alleviate the sedimentation problems occurring in the area of Williston in Williams County.

26) It is recommended that the State Water Commission's "second generation" ground-water studies be accelerated.

27) Continued study on saline seeps is recommended with emphasis on implementing corrective programs and practices.

28) More stringent enforcement of regulations regarding seismic activities and drilling pit disposal practices is recommended due to the threat of ground-water contamination.

29) It is recommended that the State Water Bank Program be utilized to the fullest extent possible in future habitat preservation activities.

30) A study is recommended to determine the potential of developing irrigation on large blocks of land adjacent to Lake Sakakawea and Lake Audubon. Studies should determine feasibility and funding sources.

31) Seminars are recommended, conducted on a local level by knowledgeable representatives of the State Water Commission, the State Agricultural Department, and other agencies or irrigators, to educate landowners on the advantages and current methods of irrigation.

32) Studies should be conducted to determine the need for boat ramp facilities around Lake Sakakawea.

33) A feasibility study for a potential water supply from McClusky Canal to provide recreation and fish and wildlife habitat for Brush, Blue, Pelican and Peterson Lakes, as well as Lake Williams in McLean County, is recommended to be completed by the 1990 time frame. The Bureau of Reclamation is the identified lead agency for this study.

34) The Heart River (106 miles) from Heart Butte Dam to the Missouri River should remain free flowing and be designated a State Scenic River.

35) The Lake Sakakawea Board recommends that Congressional authorization and funding be made available to riprap the entire Missouri River channel from Garrison Dam to Lake Oahe.

36) A study is recommended to investigate the potential for irrigation in the upper portion of Beaver Creek watershed in Emmons and Logan Counties.

37) In future years, when State lands are sold, consideration should be given to allowing water management entities to enter into the bidding process when such lands have an obvious high potential for water-related outdoor recreation.

38) A study is needed to accelerate research on revising and changing outdated, Federal irrigability criteria/standards.

39) It is recommended that an inventory of all small dams be completed to determine necessary dam repairs or replacement. A multi-agency approach should be undertaken to investigate the feasibility of restoration and/or repair of the dams.

40) There exists a need to clarify which agency or agencies have the authority to enforce existing laws regarding seismic activities and drilling disposal practices. Stricter enforcement of the existing laws is also needed.

41) Studies should be undertaken to identify solutions to lake shore erosion problems on Lake Sakakawea.

42) An investigation is recommended to identify ground-water sources of supply for rural domestic and irrigation water on the Fort Berthold Reservation.

43) A study should be initiated to delineate sources of possible ground-water contamination at the City of Stanton in Mercer County resulting from pollutants from the old Knife River channel.

44) It is recommended that the State aggressively explore the possibility of early mining by the Tenneco Company on the North Dakota side of the Montana-North Dakota border. Current plans do not call for the mining of North Dakota coal for several years. Mining activities on the Montana side would, however, impact in numerous ways on Beach and the surrounding area; yet, impacts would have to be dealt with without benefit of assistance from the Impact Funds generated by North Dakota's Coal Severance Tax. In addition, in the event Tenneco should decide to mine in North Dakota, careful consideration should be given to reclaiming mined land in a manner that would permit irrigation of those lands.

45) The South Heart Watershed Project (PL-566 Watershed Study) in Stark County is recommended to be authorized for planning and detailed study. The project includes the construction of three dams on tributaries of the Heart River near South Heart. The purpose of the dams is to reduce the bentonite entering the Heart River and Lake Patterson, thereby enhancing water quality and reducing the water supply treatment at Dickinson.

PROBLEMS SUMMARY

TABLE IV-2-1 WATER MANAGEMENT PROBLEMS - JAMES RIVER BASIN

Problem	Public Involvement Region	Location	General Description
Flooding	James	Rocky Run Creek - Wells, Eddy, and Foster Counties	Overbank flooding onto agricultural lands has reduced productivity. Three projects have been planned to correct this problem: The Emrick Drain, Oak Creek Drain, and North Branch Rocky Run improvements.
Flooding	James	A slough area west of Fessenden, Wells County	High water levels in a large slough have caused problems for the City of Fessenden. Floodwaters encroach upon the Fessenden sewage lagoon and create operational problems. Floodwaters also result in the isolation of farmsteads and in crop damage. Several improvements, including a legal drain, have been proposed.
Flooding	James	S11, 13, 14, 15, 23, and 24, T149, R71 approximately four miles southwest of Heimdal in Wells County.	Substantial cropland, hayland, and pasture losses have occurred from inadequate drainage. The Heimdal Drain Project has been proposed, but litigation has stalled the project.
Flooding	James	Unnamed watercourse that begins west of Carrington in the northern half of S23, T146, R67 which eventually discharges into Kelly Creek approximately 10 miles east Carrington.	The City of Carrington discharges water from its storm drains and sewage lagoons into this channel. This discharge, coupled with natural runoff, causes some flooding of residences and agricultural land. Homeowners have complained about the odor of standing water in the area and farmers have stated that saline deposits are occurring due to the high water table. The Foster County Water Resource Board and the landowners along this watercourse are contemplating a project to correct the situation, possibly a legal drain.
Flooding	James	James River Statistical Planning Area	A mechanism is needed to coordinate stormwater management between city and surrounding non-city areas.
Flooding	James	Forbes, Dickey County	The floodplain of an unnamed tributary of the Elm River is occupied by the City of Forbes. The tributary is ephemeral and flows south past the west side of the City and then southeast to its confluence with the Elm River. Forbes is subject to periodic overland flooding.
Drainage	James	Drainage areas above Jamestown and Pipestem Dams	There is concern that drainage projects intended to relieve flooding in areas above the dams might cause problems in the operation and maintenance of the two dams.
Drainage	James	James River Statistical Planning Area	Sound management of an area's surface water can be enhanced through the use of a watershed or "systems" approach to drainage.
Dam discharges	James	James River - Pipestem and Jamestown Dams	Erratic fluctuations in James River streamflow have, at times, been attributed to water discharges from the Pipestem and Jamestown Dams.
Rising water table	James	Ladish Malting Plant S22, T140, R62 about 10 miles east of Jamestown in Stutsman County	There is a possibility that the Ladish Company waste water disposal system has created the potential for larger than normal amounts of water to be percolating through the root zone to the water table. The actual amount of water entering the ground-water system and the resultant rise in the water table are unknown.

Problem	Public Involvement Region	Location	General Description
Erosion	James	James River Statistical Planning Area	The installation of land treatment practices is considered essential for the protection and preservation of the basic soil resources and for assisting in the sustained production of food and fiber.
Channel Obstruction	James	James River - Wells, Eddy, Foster, Stutsman, LaMoure, and Dickey Counties	The James River channel through Jamestown and on down through Stutsman and LaMoure County is in need of snagging and clearing.

OPPORTUNITIES SUMMARY

TABLE IV-?-? WATER DEVELOPMENT OPPORTUNITIES - JAMES RIVER BASIN

Opportunity	Public Involvement Region	Location	General Description
Multi-purpose Storage Structure (Edinger Dam)	James	S24, T149, R69 in Wells County about 10 miles northeast of Fessenden	Edinger Dam, a potential water-related recreation and fishing project on the upper James River, was first proposed in 1969 by the Bureau of Reclamation. The dam would be located on the James River. Flows to maintain the conservation pool would be augmented with Garrison Diversion water from the New Rockford Canal.
Irrigation (Education)	James	James River Statistical Planning Area	Seminars conducted on a local level by knowledgeable representatives of the State Water Commission, the State Agricultural Department, and other agencies or irrigators could educate landowners on the advantages of irrigation.
Irrigation (Groundwater information)	James	James River Statistical Planning Area	Efforts should be made to gain more specific information on groundwater reserves in order to expedite the irrigation permitting process.
Irrigation (Sewage lagoon waters)	James	James River Statistical Planning Area	A possibility exists to utilize community sewage lagoon waters for irrigation of adjacent farmland.
Land Management Practice (Plugging Wetlands)	James	James River Statistical Planning Area	The possibility of plugging drained wetlands in the years when the land is summer fallowed should be explored. This practice could decrease erosion and the movement of nutrients, fertilizers, and pesticides from the land.
Drainage	James	James River Statistical Planning Area	Sound management of an area's surface water can be enhanced through the use of a watershed or "systems" approach to drainage.
Fish Hatcheries	James	James River Statistical Planning Area	Fish hatcheries around the State need rejuvenating and/or enlarging. More modern facilities are needed.

TABLE IV-2-3 NON-RECOMMENDED STUDY ALTERNATIVES - JAMES RIVER BASIN

Alternative	Puolic Involvement Region	Location	General Description
Forbes Flood Control Project	James	Dickey County	Dike
James River - Scenic and Recreation River	James	Stutsman, LaMoure, and Dickey Counties	Maintain 115 miles of James River as a free-flowing stream from Jamestown to the South Dakota border

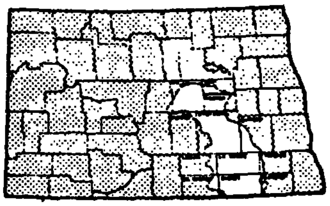


FIGURE IV-2-1 JAMES RIVER BASIN
LOCATION OF RECOMMENDED STUDY ALTERNATIVES

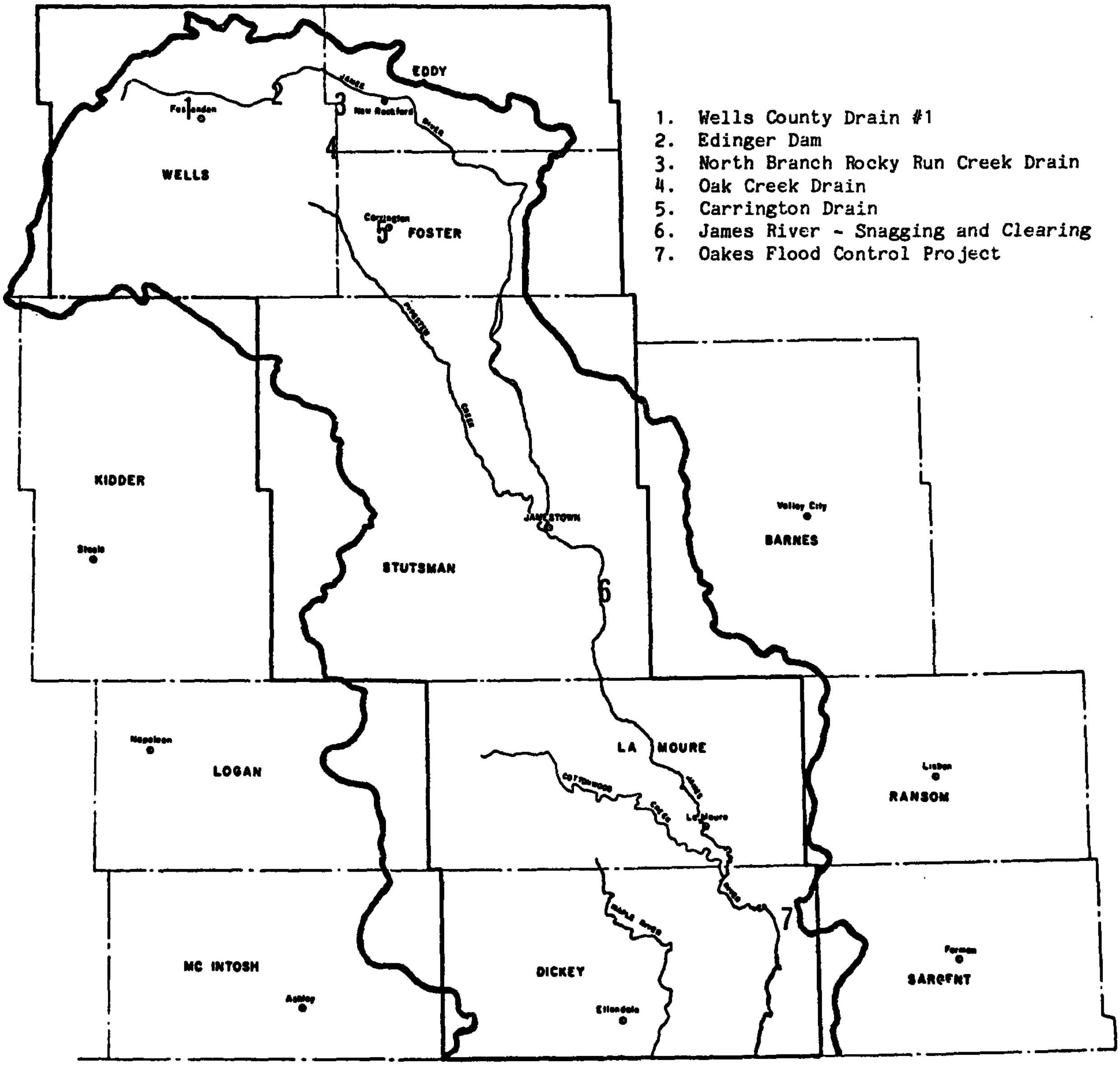


TABLE IV-2-4 RECOMMENDED STUDY ALTERNATIVES - BENEFICIAL AND ADVERSE EFFECTS OF THE POTENTIAL PROJECTS IN THE JAMES RIVER BASIN

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Edinger Dam (Figure IV-2-1; Site #2)
S24, T149, R69
Wells County

PUBLIC INVOLVEMENT REGION: James

PURPOSE: Recreation

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 5,766 AF storage; 462 surface acres; maximum depth of 20 feet; average depth of 8.08 feet; 14.8 miles of shoreline.

ECONOMIC DEVELOPMENT: Capital Cost $684,461 1/ (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio 2/

ENVIRONMENTAL QUALITY:

Edinger Dam would be located on the James River. Flows to maintain the conservation pool would be augmented with Garrison Diversion water from the New Rockford Canal. The reservoir would inundate 462 acres of land, much of this is either cropland or native pasture. Wildlife habitat would be inundated; terrestrial wildlife would be adversely affected and displaced. This reach of the James River is rated Class II - High Priority on the Game and Fish Stream Evaluation Map because of the moderate forage fish production and moderate sport fishery on northern pike, yellow perch, and bullheads. The reservoir would inundate Sellie Dam, a WPA dam, located three miles upstream from the construction site.

OTHER SOCIAL EFFECTS:

The 462 surface acre reservoir would provide additional water-based recreation and sport fishery to the region. Short-term employment opportunity will be available during the construction phase. Two bridges would have to be replaced.

STATUS: Inactive.

RECOMMENDATION: Continue study into a different location for the recreation dam.

1/ The estimate does not include costs of land, recreation facilities, or replacing the two bridges. The combined cost of the two proposed recreation areas is $89,301.

2/ Benefits are assumed to exceed costs.

FLOOD CONTROL PROJECT

NAME/LOCATION: Oakes Flood Control (Figure IV-2-1; Site #7)
Dickey County

PUBLIC INVOLVEMENT REGION: James

PURPOSE: Flood Control

LEAD STUDY AGENCY: Soil Conservation Service

DESCRPTION: Floodway improvements

ECONOMIC DEVELOPMENT: Capital Cost $260,000 (Preliminary estimates)
Average Annual Cost $20,000 (estimates)
Average Annual Benefit $22,900 (estimates)
Benefit/Cost Ratio 1.15

ENVIRONMENTAL QUALITY:
No significant environmental effects anticipated.

OTHER SOCIAL EFFECTS:
The project will create an annual income benefit distribution of $22,900; and local costs totaling $2,000 annually will be borne by the region. Flood protection against the one percent (100-year) frequency flood will be provided to the City of Oakes, protecting health, life, and safety of the residents.

STATUS: Preliminary Measure Plan currently in the planning stage.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

DRAINAGE PROJECT

NAME/LOCATION: Oak Creek Drain (Figure IV-2-1; Site #4)
T148, R68
Eddy and Wells County

PUBLIC INVOLVEMENT REGION: James

PURPOSE: Alleviate overland flooding.

LEAD STUDY AGENCY: Rocky Run Joint Flood Control Board consisting of Wells, Eddy, and Foster County Water Resource Boards/ ND State Water Commission.

DESCRIPTION: The project consists of main channel diversion and mainstem channel improvements to Oak Creek, in addition to improvements to Rocky Run Creek mainstem downstream of the Oak Creek channel.

ECONOMIC DEVELOPMENT: Capital Cost $321,600 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio 1/

ENVIRONMENTAL QUALITY:

Wildlife will be adversely affected due to the loss of seasonal wetlands and plant diversity will be reduced.

OTHER SOCIAL EFFECTS:

Agricultural flood damages will be reduced. Short-term employment opportunity will be available during the construction phase.

STATUS:

Current investigation. The Oak Creek Preliminary Design and Cost Estimate has been presented to the Wells County Water Resource Board (WRB). It has been recommended to the WRB that some additional information be collected before the assessment vote. This information is currently being compiled.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

1/ Benefits are assumed to exceed costs.

DRAINAGE PROJECT

NAME/LOCATION: North Branch Rocky Run Creek (Figure IV-2-1; Site #3)
T147, R69
Eddy and Wells County

PUBLIC INVOLVEMENT REGION: James

PURPOSE: Alleviate overland flooding

LEAD STUDY AGENCY: Rocky Run Joint Flood Control Board consisting of Wells, Eddy, and Foster County Water Resource Boards/ND State Water Commission.

DESCRIPTION: The project consists of channel improvement to increase the capacity of the existing channel.

ECONOMIC DEVELOPMENT: Capital Cost $71,868 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio 1/

ENVIRONMENTAL QUALITY:

Construction activities will result in a loss of vegetation and wildlife habitat adversely affecting wildlife. Wildlife species would be temporarily displaced.

OTHER SOCIAL EFFECTS:

Flood damages to agricultural lands resulting in crop losses and late spring planting will be reduced. Short-term employment opportunity will be available during the construction phase.

STATUS:

Current Investigation. The project is still in the preliminary design stages. The preliminary plans will be presented to the Wells and Eddy County Water Resource Boards.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

1/ Benefits are assumed to exceed costs.

NOTE: A majority of landowners with acreage assessed in the project area voted against this project in November, 1982. However, interest in the project per se remains.

DRAINAGE PROJECT

NAME/LOCATION: Carrington Drain (Figure IV-2-1; Site #5)
S23, T146, R47
Foster County

PUBLIC INVOLVEMENT REGION: James

PURPOSE: Flood Control

LEAD STUDY AGENCY: Foster County Water Resource Board/ND State Water Commission

DESCRIPTION: Channel Improvements. The City of Carrington discharges excess water from its storm drains and sewage lagoon into an unnamed watercourse that begins west of Carrington and eventually discharges into Kelly Creek approximately 10 miles east of Carrington. This discharge, in addition to natural runoff, causes some flooding of residences and agricultural land.

ECONOMIC DEVELOPMENT: Capital Cost $170,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio 1/

ENVIRONMENTAL QUALITY:

Construction activities will disturb vegetation and displace wildlife. Channel improvement will reduce the incidence of saline deposit on agricultural land because of the higher water table.

OTHER SOCIAL EFFECTS:

Residential and agricultural flood damages will be reduced. Income lost as a result of crop damage will be reduced.

STATUS:

Current Investigation. The Foster County Water Resource Board and the landowners along the watercourse are contemplating a legal drain.

RECOMMENDATION: Continued study.

1/ Benefits are assumed to exceed cost.

DRAINAGE PROJECT

NAME/LOCATION: Wells County Drain #1 (Figure IV-2-1; Site #1)
S3&10,T148,R71;
S26&35,T149,R71;
Wells County

PUBLIC INVOLVEMENT REGION: James

PURPOSE: To alleviate high water levels in a large slough west of Fessenden.

LEAD STUDY AGENCY: ND State Water Commission/Wells County Water Resource District.

DESCRIPTION: The project involves increasing the capacity of the channel outlet and the construction of two lateral drains. High water levels encroach upon Fessenden sewage lagoons and create operation problems. High water also results in the isolation of farmsteads and in crop damage. The existing outlet channel has been shown to be ineffective in handling spring runoff.

ECONOMIC DEVELOPMENT: A) Channel outlet improvements:
Capital Cost $190,394 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio 1/

B) Two lateral drains:
Capital Cost $401,404 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio 1/

ENVIRONMENTAL QUALITY:
Wildlife will be adversely affected due to loss of habitat.

OTHER SOCIAL EFFECTS:
Fessenden sewage lagoon operation problems that are caused by flood water encroachment will be eliminated. Flood damages to agricultural lands and roads will be reduced. Roads that were inundated in the 1975 spring runoff will be accessible and farmsteads will not be isolated. Short-term employment will be available during the construction phase. The loss of income from crop damaged by late spring plantings will be reduced.

STATUS:
Recent Investigation.

RECOMMENDATION: Continued Study

1/ Benefits are assumed to exceed costs.

SNAGGING AND CLEARING PROJECT

NAME/LOCATION: James River (Figure IV-2-1; Site #6)
Jamestown through
LaMoure County.

PUBLIC INVOLVEMENT REGION: James

PURPOSE: Snagging and clearing of James River channel

LEAD STUDY AGENCY: ND State Water Commission/Stutsman County Commission

DESCRIPTION: Snagging and clearing a total of about 85 miles of the James River channel from the Jamestown Dam through LaMoure County.

ECONOMIC DEVELOPMENT: Capital Cost $190,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio [1/]

ENVIRONMENTAL QUALITY:
Riparian habitat will be eliminated. The fishery value of the river may be reduced due to the loss of protective cover and resting areas for fish.

OTHER SOCIAL EFFECTS:
Snagging and clearing will increase channel capacity, lessening the threat and/or incidence of downstream flooding. Short-term employment opportunity will be available.

STATUS:
Recent Investigation. Stutsman County Commission is responsible to annually maintain the channel and improve the bank on the James River downstream of its confluence with Pipestem Creek.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

[1/] Benefits are assumed to exceed costs.

REGIONWIDE PROGRAMS FOR THE JAMES RIVER STATISTICAL PLANNING AREA

NAME: Land Treatment Measures

PUBLIC INVOLVEMENT REGION: All Regions in the James River SPA

PURPOSE: Control soil erosion and flooding

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Land treatment measures are those practices used to reduce soil erosion and control flooding, and include such features as grassed waterways, shelter belts, and strip cropping.

ECONOMIC DEVELOPMENT:

Land treatment measures on a total of 1,293,000 acres

Capital Cost $12,293,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Soil erosion by wind and water will be reduced. Water quality and wildlife habitat will be enhanced.

OTHER SOCIAL EFFECTS:

Damages to agricultural lands caused by wind and water erosion of soil will be reduced.

STATUS:

An ongoing program dependent upon voluntary participation by individual landowners and the availability of cost-share monies from the Soil Conservation Service.

RECOMMENDATION: Implementation as indicated in Table IV-2-5.

NAME: Municipal Waste Treatment Facilities

PUBLIC INVOLVEMENT REGION: All Regions in the James River SPA

PURPOSE: Enhance the capability for treating muncipal wastewater

LEAD STUDY AGENCY: ND State Health Department

DESCRIPTION: New facilities are required and existing facilities need to be improved before the year 2000 in 15 communities serving 6,200 people. Incorporated communities and certain other public entities are eligible for financial assistance through the Construction Grant Program of the Environmental Protection Agency. This program is administered in North Dakota by the State Health Department. Under this program, 75 percent of the planning and construction costs for new collection and treatment facilities and for upgrading existing wastewater treatment plants are reimbursible. Congress appropriates the money for the Program. The State Health Department disperses North Dakota's share according to a priority list it has developed.

ECONOMIC DEVELOPMENT: Capital Cost $2,851,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The wastewater treatment facilities will improve the water quality of the receiving watercourses. Additional solid waste resulting from the treatment process will need disposal.

OTHER SOCIAL EFFECTS:

The communities will have to furnish 25 percent of the total cost of any new or improved facility.

STATUS:

Ongoing program. Other sources of funding will have to furnish 25 percent of the total cost of new or improved facilities.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

NAME: Municipal Water Supply Treatment Facilities

PUBLIC INVOLVEMENT REGION: All Regions in the James River SPA

PURPOSE: Enhance municipal water supply treatment capability

LEAD STUDY AGENCY: ND State Health Department

DESCRIPTION: Additional or improved treatment facilities are needed in two communities serving 1,361 people in order to meet the recommended Standards for Safe Drinking Water Supplies set by the Environmental Protection Agency.

ECONOMIC DEVELOPMENT: Capital Cost $930,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The additional or improved water supply treatment facilities will enhance the quality of municipal water supplies. Additional solid wastes generated by the treatment processes will require disposal.

OTHER SOCIAL EFFECTS:

Municipal water supplies will be improved, enhancing the safety, health and well-being, and quality of life for community residents. The only funding available is currently derived from the tax base of the community. No State or Federal funds are currently available.

STATUS:

Facilities are constructed on an individual basis as community funding allows.

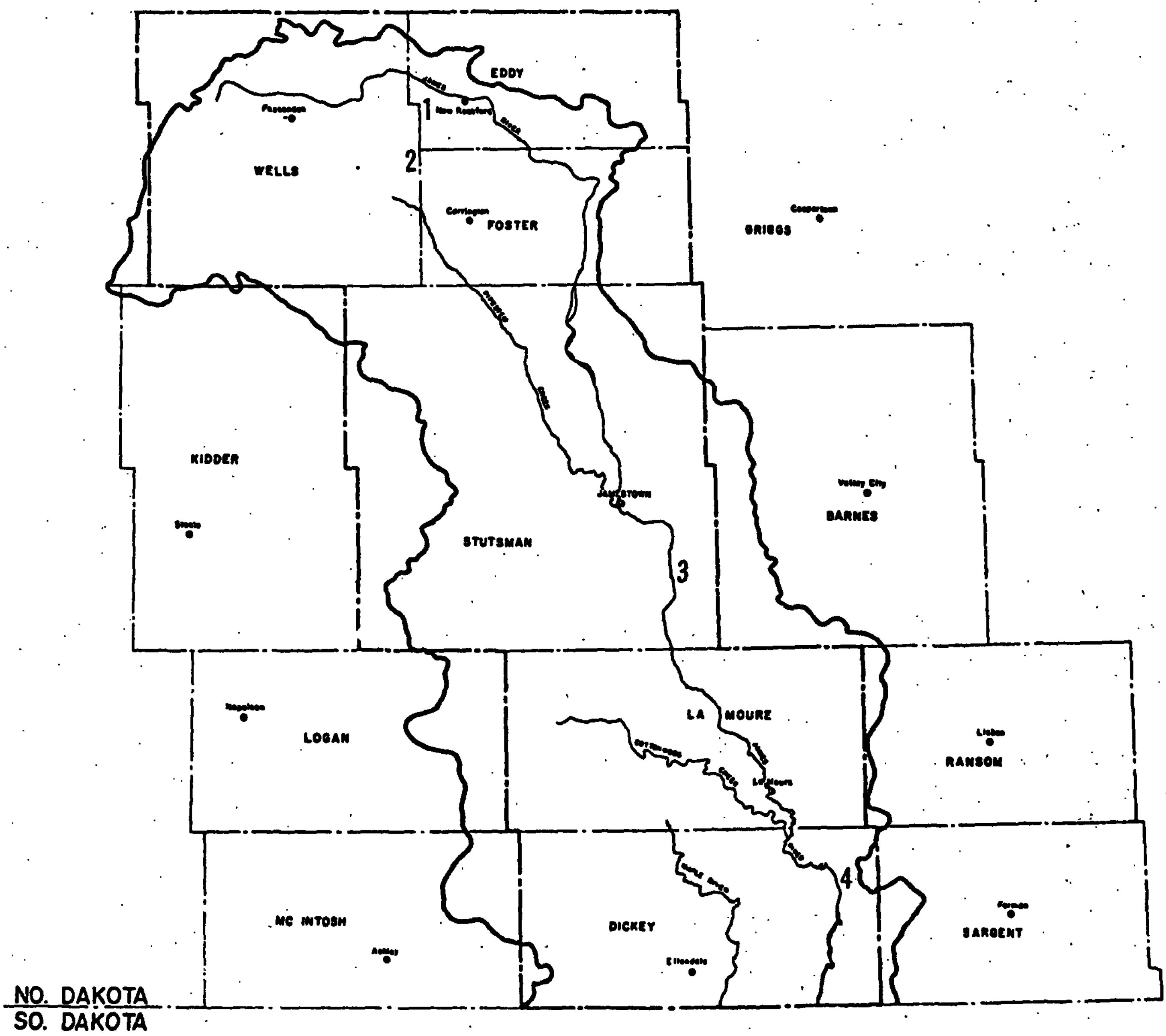
RECOMMENDATION: Implementation in the 1980-1990 time frame.

TABLE IV-2-5 RECOMMENDED PLAN AND ESTIMATED INVESTMENTS IN 1980 DOLLARS
JAMES RIVER BASIN

Water and Related Land Resources Category	Units	Composition and Estimated Investments (All Values are Incremental)														
		1980-1990 (Early Action Program)					1990-2000					2000-2020				
			Initial Investment		Annual O.M.&R.			Initial Investment		Annual O.M.&R.			Initial Investment		Annual O.M.&R.	
		Quantity	Federal ($1000)	State/Local ($1000)	Federal ($1000)	State/Local ($1000)	Quantity	Federal ($1000)	State/Local ($1000)	Federal ($1000)	State/Local ($1000)	Quantity	Federal ($1000)	State/Local ($1000)	Federal ($1000)	State Local ($1000)
SURFACE WATER CONTROL																
Multi-purpose Reservoir																
Total Storage	1000AF															
Flood Control	1000AF															
Other Purpose	1000AF															
Single Purpose Reservoir																
Flood Control	1000AF															
Irrigation	1000AF															
Municipal	1000AF															
Recreation	1000AF															
Instream Control																
Channel Improvement	Miles	85	--	190	--	10										
Levees, Floodwalls, etc.	Each	1	234	26	--	2										
Streambank Stabilization	Each															
Diversion																
Irrigation	1000AF															
Municipal	1000AF															
Multi-feature Project 1/	Each															
RELATED LAND PROGRAMS																
Drainage	Each	2	--	393	--	6										
Irrigation																
Private	1000Ac															
Public	1000Ac															
ENVIRONMENTAL AND RESOURCE ENHANCEMENT 2/																
Protection and Management 3/																
Cropland	1000Ac	448	3,696	1,232	NA	NA	299	2,467	822	NA	NA	132	1,089	362	NA	NA
Pasture	1000Ac	92	380	126	NA	NA	61	252	84	NA	NA	51	211	70	NA	NA
Range	1000Ac	87	359	120	NA	NA	58	239	80	NA	NA	58	239	80	NA	NA
Forest	1000Ac	3	124	41	NA	NA	2	83	27	NA	NA	2	83	27	NA	NA
Outdoor Recreation																
Stream Preservation	Miles															
Facilities	Each															
Waste Water Management 4/																
Municipal	1000PS 5/	6.2	2,138	713	--	112										
Water Supply Treatment																
Municipal	1000PS	1.4	--	930	--	47										
ADDITIONS AND MODIFICATIONS TO EXISTING PROJECTS																
Reservoir Storage	Each															
TOTAL COST			6,931	3,771	--	177		3,041	1,013	NA	NA		1,622	539	NA	NA

1/ Multi-feature projects are defined as those projects which consist of more than one element, including structural and non-structural measures. Example: a dam and diversion floodway.
2/ The data used to compute the figures displayed in this Category are useable on a County basis; therefore the figures are for the James River Statistical Planning Area (Figure I-1-2) rather than the Basin.
3/ Land treatment measures have been accelerated from the Future Without Plan Projections (Table III-1-2) as follows: 1980-1990 figures by 1.5 percent, 1990-2000 figures by 1.0 percent, and 2000-2020 figures by 0.5 percent.
4/ Some of the projects will be constructed in the 1990-2000 time frame. However, since the construction date of each specific project could not be determined, all costs have been placed in the 1980-1990 time frame.
5/ P.S. represents population served based upon the highest projection.

FIGURE IV-2-2 JAMES RIVER BASIN
LOCATION OF RECOMMENDED PLAN -EARLY ACTION PROGRAM



1. North Branch Rocky Run Creek Drain
2. Oak Creek Drain
3. James River Snagging and Clearing
4. Oakes Flood Control Project

TABLE IV-2-6 JAMES RIVER BASIN RECOMMENDED PLAN - EARLY ACTION PROGRAM

Program Feature	Description & Purpose	Initial Costs "1980 Dollars" Federal	State/Local	Total	Annual Operation, Maintenance, and Replacement Costs "1980 Dollars" Federal	State/Local	Total
SURFACE WATER CONTROL							
Instream Control							
Channel Improvements	James River Snagging and Clearing - Eighty-five miles of river channel, from Jamestown Dam to the Dickey County line, needs snagging and clearing.	-	$190,000	$190,000	-	$9,500	$9,500
Levees, Floodwall, etc.	Oakes Flood Control - A floodway is proposed to protect Oakes, Dickey County, from the one-percent (100 year) frequency flood event.	$234,000	$26,000	$260,000	-	$2,000	$2,000
RELATED LAND PROGRAMS							
Drainage	Oak Creek Drain - This project involves construction of a main channel diversion and mainstem channel improvements to Oak Creek, in addition to improvements to the Rocky Run Creek mainstem downstream of the Oak Creek Channel located in Eddy and Wells Counties.	-	$321,600	$321,600	-	$4,824	$4,824
	North Branch Rocky Run Creek Drain - This project involves channel improvements to increase the capacity of the existing channel in Eddy and Wells Counties.	-	$71,868	$71,868	-	$1,078	$1,078
ENVIRONMENTAL AND RESOURCE ENHANCEMENT							
Protection and Management	Land Treatment Measures - Soil erosion protection is needed for 630,000 acres of land in the James River SPA.	$4,558,500	$1,519,500	$6,078,000	NA	NA	NA
Waste Water Management Municipal 1/	Development of new and/or improvement of existing municipal waste treatment facilities is needed for 15 communities serving 6,200 people.	$2,137,500	$712,500	$2,850,000	-	$111,600	$111,600
Water Supply Treatment Municipal 2/	Development of additional or improvement of existing treatment facilities is needed to meet the recommended limits for a domestic water supply in two communities serving 1,361 people.	-	$930,000	$930,000	-	$46,500	$46,500

1/ As identified by the ND State Health Department, some of the projects will be constructed in the 1990-2000 time frame. However, since the construction date of each specific project could not be determined, all costs have been placed in the 1980-1990 time frame. The communities in the James River Statistical Planning Area (SPA) include: LaMoure, Edgeley, McHenry, Montpelier, Cleveland, Jud, Forbes, Monango, Ellendale, Spiritwood Lake, Fullerton, Fessenden, Pingree, Medina, and Streeter.

2/ As identified by the ND State Health Department, the communities in the James River SPA include Fessenden and Kulm.

ADDITIONAL SPECIAL STUDIES AND PROGRAMS -

1) Continued study is recommended in order to locate an alternate site to Edinger Dam - a recreation dam originally proposed on the James River in Wells County 10 miles east and five miles north of Fessenden.

2) Continued study of a drainage project at Carrington is recommended. Channel improvements are necessary to correct the problem of flooding of residences and agricultural lands. The flooding is caused both from agricultural runoff and the City of Carrington discharging excess water from the storm drains and sewage lagoon into an unnamed watercourse northeast of Carrington.

3) Continued study of a flooding problem near Fessenden is approved. Channel outlet improvements or lateral drains are necessary to alleviate high water levels in a large slough west of Fessenden which has caused operation problems with the city sewage lagoons, in addition to agricultural flood damages.

4) Continuation of the Weather Modification Programs is supported including: the North Dakota Cloud Modification Program, Drought Management Strategies, Atmospheric Water Resources Research in conjunction with the North Dakota Cloud Modification Program (NDCMP), and Public Awareness of Weather Modification.

5) A review of the Pipestem and Jamestown Dams discharge operations is recommended to determine if refinements could be made to stabilize flow downstream.

6) A rising water table problem near the Ladish Malting Plant east of Jamestown should be investigated. There is a possibility that the plant's water disposal system has created the potential for larger than normal amounts of water to percolate through the root zone causing an elevated water table.

7) A study is recommended to explore the potential for using sewage lagoon water to irrigate adjacent land, thus reducing the need for waste treatment or facility improvements in many communities.

8) Further study into the possibility of plugging wetland drains in years when the land is summer fallowed should be considered. This practice could decrease erosion and movement of nutrients, fertilizers, and pesticides from the land.

9) Continued study of Wells County Drain Number One is approved. Channel outlet improvements or lateral drains are necessary to alleviate high water levels in a large slough west of Fessenden which has caused operation problems with the city sewage lagoons, in addition to agricultural flood damages.

10) Further study is recommended concerning snagging and clearing of the James River above the Jamestown Reservoir.

PROBLEMS SUMMARY

TABLE IV-3-1 WATER MANAGEMENT PROBLEMS - RED RIVER BASIN

Problem	Public Involvement Region	Location	General Description
Water Supply	Goose	Riverside Park Dam - Grand Forks, Grand Forks County	This dam provides partial storage for the City of Grand Forks water supply. A new water supply dam below the existing dam has been proposed; however, repairs were done in 1980 which appear to be sufficient at this time.
Water Supply	Lower Red	Minto, Walsh County	The City of Minto needs an improved municipal water supply. The existing water supply dam on the main stem of the Forest River is not structurally sound. Funding was requested in October, 1981, from Farmers Home Administration to build a low-head channel dam. This request was denied. The city is continuing to explore alternatives.
Water Quality	Upper Sheyenne	The Sheyenne River originates in central North Dakota, flows approximately 500 river miles southeasterly, and joins the Red River of the North about ten miles north of Fargo.	The water quality of the Sheyenne River is relatively poor and is directly related to land use in the basin. The river has high levels of ammonia and bacteria.
Water Quality	Wild Rice	Silver Lake - Sargent County	Although an irrigation permit exists for Silver Lake, there is no permit for the appropriation of water in the lake for recreation, and fish and wildlife purposes. The Sargent County Park Board has applied for a water permit to protect their interests in Silver Lake.
Water Quality	Wild Rice	Wild Rice River, S15 and 22, T131, R49 in Great Bend, S25, T131, R50, four miles north of Hankinson, Richland County	Oxbow cutoffs have resulted from roadway construction and channel alterations. Stagnant water within these oxbows constitutes a potential health hazard.
Flooding	Goose Lower Red Lower Sheyenne Wild Rice	The Red River flows 394 river miles from the confluence of the Ottertail and Bois de Sioux Rivers at Wahpeton, North Dakota to the International Boundary. Beyond the International Boundary, the Red River flows to Lake Winnipeg which is drained by the Nelson River into Hudson Bay	Destructive floods occur during the spring months from snowmelt runoff which may be augmented by rainfall. Because of the mild gradient of the Red River and the nearly level floodplain, floods along the main stem inundate wide areas and move so slowly that flooding generally persists for many weeks. Opportunities on the Red River main stem for effectively reducing flood damages are limited. No impoundment sites of sufficient size and capacity to reduce damages exist along the main stem.

Problem	Public Involvement Region	Location	General Description
Flooding	Goose	From its headwaters in central Nelson County, the Goose River flows southeastward through the southwestern part of Grand Forks County the northwestern part of Steele County, and then through Traill County to enter the Red River	The lower 60-mile reach of the Goose River Basin is highly susceptible to flooding. The river at Hillsboro has a capacity of approximately 2,000 cubic feet per second. The major flood on record (1950) occurred with a peak flow of 8,530 cubic feet per second at Portland and 9,420 cubic feet per second at Hillisboro.
Flooding	Goose	The Elm River subbasin drains 510 square miles of Steele, Cass and Traill Counties in eastern North Dakota	The principal flood problem is recurrent damage to agricultural crops and land. Floods occur in the spring when snowmelt runoff often exceeds stream channel capacities. Once the low, natural levees are overtopped, thousands of acres are flooded. Summer rainstorms also produce runoff flows that exceed channel capacities.
Flooding	Goose	The Belmont Road area - South Grand Forks, Grand Forks County	This area is subject to periodic flooding from backwaters of the Red River. Although a project for a dike was proposed in 1976, it was voted down by the Public Service Committee.
Flooding	Goose	English Coulee drains an area of about 125 square miles in southwestern Grand Forks County	An extensive area in the northwest corner of Grand Forks lies along a drainage channel called the English Coulee which is subject to inundation when the Red River is in flood stage. Much residential property in both cities has been inundated by floods of the past. The Soil Conservation Service and the Army Corps of Engineers are working together on a flood control project involving structural and nonstructural measures.
Flooding	Lower Red	The Turtle River subbasin drains 613 square miles of Nelson and Grand Forks Counties in northeastern North Dakota.	The Turtle River stream channel capacity is frequently exceeded, resulting in crop and pastureland flooding. A Flood Hazard Study is currently being conducted.
Flooding	Lower Red	The Forest River Subbasin is located in northeastern North Dakota in Walsh, Grand Forks, Nelson, and Ramsey Counties. The river drains an area of 1,016 square miles and empties into the Red River about 30 miles north of Grand Forks	The Forest River subbasin has a history of periodic flooding causing extensive rural and urban damages. River channels are choked with debris reducing channel capacities. Inadequate waterway openings on river crossings cause restrictions resulting in backwater from floating ice and debris. There is a lack of upstream sites to provide flood storage, which with the poorly-defined river channel and the natural flat topography, causes overland sheet flooding.
Flooding	Lower Red	Minto, Walsh County	The City of Minto is partially located within the floodplain of the Forest River. Floods on the Forest River occur mainly in the spring following snowmelt and occasionally in the summer following intense storms. The problem is compounded in that natural river channel capacity is relatively small and the surrounding floodplain is very flat. Residential areas are developed very close to the river and are subject to frequent flood damage.

Problem	Public Involvement Region	Location	General Description
Flooding	Lower Red	Three principal headwater streams, the South, Middle, and North Branches of the Park River, arise in southeastern Cavalier County and converge approximately three miles west of Grafton in Walsh County From this point, the mainstem Park River flows east and joins the Red River	Floods usually occur in the spring when melting snow causes rapid runoff along the headwater branches. Flood damages result in the area east of the escarpment where the land is flat and streambanks are low.
Flooding	Lower Red	The Pembina River flows east across southern Manitoba, then southeast across the International Boundary into North Dakota after which it turns east in a winding course across northern North Dakota and empties into the Red River at Pembina	Floods along the Pembina River generally have occurred during the spring and are usually the result of rapid snowmelt, sometimes accompanied by rainfall. Downstream of Walhalla, where the land is flat and banks are low, floodwaters have spread over considerable rural area. Frequently, floodwaters escape south overland into the Tongue River Basin or north into the Aux Marais River basin in Canada. The Army Corps of Engineers is developing and evaluating flood control alternatives and their impacts.
Flooding	Lower Red	S3, T163, R57 Cavalier County	Rapid runoff causes flooding after snowmelt and heavy rains. A dry dam and downstream channel improvements were proposed in 1978 by the State Water Commission; however, in 1980 this project was dropped.
Flooding	Lower Sheyenne	The Sheyenne River originates in central North Dakota, flows approximately 500 river miles southeasterly, and joins the Red River of the North about 10 miles north of Fargo.	Floods on the Sheyenne River usually occur in the spring. Larger early spring floods are aggravated by obstructed channel conditions. Since the terrain of the lower basin is very flat, floods along the lower 70 miles of the Sheyenne River inundate large areas. The State Water Commission has conditionally approved the Army Corps of Engineers tentative plan for flood control on the Sheyenne River.
Flooding	Lower Sheyenne	The Maple River joins the Sheyenne River about five miles downstream from West Fargo and drains approximately 1,450 square miles in Cass, Barnes, Steele, and Ransom Counties	Flood problems in this area can be particularly severe because of the flat terrain. Wide-spread flooding results once the river overflows its banks. Spring snowmelt runoff and excessive rainfall occurring individually or in combination contribute to severe flooding of the Maple River. A hydrology study is currently being conducted.
Flooding	Lower Sheyenne	The Rush River and Lower Branch Rush River are in Cass County. The total area drained is about 180 square miles by the Rush River and 68 square miles by the Lower Branch Rush River	Rush River overflows to the Lower Branch have eroded land and reduced the capacity of the Lower Branch channel. The combined capacity of the two forks of the Lower Branch channel is larger than the channel capacity of the main channel. Snow buildup in the channel results in high stages and spring flooding even when flow volumes are relatively low. In 1980, the Corps of Engineers proposed two flood control alternatives, but these were not found to be economically feasible.
Flooding	Wild Rice	The Wild Rice River, a tributary of the Red River, is located in southeastern North Dakota. Its drainage area consists of 2,233 square miles, with 2,020 square miles in southeastern North Dakota, and 213 square miles in northeastern South Dakota.	Flood problems can be quite severe because of the flat terrain which results in widespread flooding once the river overflows its banks. Flooding is compounded by overland floodwaters from the Sheyenne River and backwater from the Red River of the North. Rapid snowmelt, excessive rainfall and/or frozen ground contribute to the flood problems.

Problem	Public Involvement Region	Location	General Description
Flooding	All Regions	Cities throughout Red River Statistical Planning Area	A mechanism is needed to coordinate storm-water management between city and surrounding non-city areas.
Drainage	Lower Red	Rush Lake - Cavalier County	Draining and diking activities in this area have led to litigation over control and operation of the drains.
Drainage	Upper Sheyenne	Northwest Barnes County	There is a flooding problem north and east of of Wimbledon. A large low and flat area of approximately 1,000 acres was under about 30 inches of water in 1979. Barnes County Drain #3 has been proposed, but cost participation has been deferred by the State Water Commission due to legal action taken against the project.
Drainage	Wild Rice	Richland County Drain #65 approximately one mile east of Hankinson, Richland County	Improvements and modifications have been proposed for Drain #65 which are intended to relieve flood damages within the watershed and prevent detriment to adjacent Drain #30 by overloading. Erosion and inadequate capacity have caused problems with the channel.
Low Flow	Goose Lower Red Lower Sheyenne Wild Rice	Red River	Seasonally, flows vary greatly and the lowest usually occur during the fall and winter months largely due to winter freezing. Since groundwater sources of adequate quantity and quality do not exist near urban areas, the lack of surface runoff during drought years causes severe curtailment of water consumption.
Low Flows	Lower Sheyenne Upper Sheyenne	Sheyenne River	The low flow periods on the Sheyenne River typically occur from June through March, with the lowest flows generally coming from September through February. Low flows contribute to poor water quality in the river.
Erosion	All Regions	Red River Statistical Planning Area	The installation of land treatment measures is considered essential for the protection and preservation of the basic soil resources, for reducing air and water pollution, and for assisting in the sustained production of food and fiber.
Dam Seepage	Lower Red	Crystal, Pembina County	Crystal Dam is a water supply dam for the City of Crystal. Water is seeping southward from the reservoir into the adjacent farmland and city park. The boggy, saturated area has been steadily increasing year-by-year. The cumulative effect has caused some adjacent land to become unfarmable and the city park ball diamond to become unusable. The City has lowered the water level of the reservoir to help reduce the seepage.
Outdoor Recreation	Lower Sheyenne	Southeastern North Dakota, particularly Ransom County	There is a lack of outdoor recreational opportunities in southeastern North Dakota.
Channel Obstruction	Lower Red	Pembina River	Snagging and clearing is needed for the lower end of the Pembina River from Neche to the mouth of the river. The local share of the project cost has become prohibitive for the Pembina County Water Resource Board.
Channel Obstruction	Lower Sheyenne Upper Sheyenne	Sheyenne River	The Sheyenne River is in need of extensive snagging and clearing in many badly clogged reaches.
Diking	Goose Lower Red Lower Sheyenne Wild Rice	Red River	There are 21 miles of landowner-built dikes on the Minnesota side of the Red River compared to North Dakota's seven. North Dakota farmers contend the higher dikes on the Minnesota side of the river compound flood problems on the North Dakota side.

Problem	Public Involvement Region	Location	General Description
Fish and Wildlife Habitat Destruction	All Regions	Red River Statistical Planning Area	Serious long-term fish and wildlife problems have occurred due to changes in agricultural land-use practices.

OPPORTUNITIES SUMMARY

TABLE IV-3-2 WATER DEVELOPMENT OPPORTUNITIES - RED RIVER BASIN

Opportunity	Public Involvement Region	Location	General Description
Multi-purpose storage structure (Traill County)	Goose	A reservoir site is located approximately five miles east of Mayville on Highway 200 in Traill County	A dam placed in the northwest quarter of Section 7, Township 146 North, Range 51 West, would be 20 feet high and retain approximately 980 acre-feet over 140 surface acres. The dam would be placed on a tributary to the north branch of the Goose River. It is designed for flood damage reduction, as well as outdoor recreation and wildlife habitat.
Multi-purpose storage structure (Tiber-Vesta Dam)	Lower Red	Designated as the Tiber-Vesta site by locals, this site would be in S3, T157, R57 approximately six miles southwest of Edinburg in Walsh County	This proposed dam has been examined by the Corps of Engineers. It would serve the purposes of flood reduction, water for human consumption, and outdoor recreation. The reservoir would cover 590 acres at control elevation and 1,035 acres at the 100-year flood. The dam could retain 17,700 acre-feet and 42,500 acre-feet, respectively.
Multi-purpose storage structure (Moellenkamp Dry Dam)	Lower Sheyenne	Designated as the Moellenkamp site, this dam would be located in S34, T134, R56 about four miles southwest of Lisbon in Ransom County	This dam would store 490 acre-feet and be beneficial in preventing flood damages immediately downstream from the dam. The dam may increase outdoor recreation and fish and wildlife habitat in the area. An emergency and/or principal spillway will be needed to accommodate most flows.
Multi-purpose storage structure (Hansen Dam)	Lower Sheyenne	Hansen Dam would be a multi-purpose reservoir in S30, T139, R58 about 12 miles southwest of Kathryn	There is an existing reservoir on an unnamed tributary of the Sheyenne River. The dam could be raised for purposes of flood damage reduction, habitat maintenance, irrigation, livestock, outdoor recreation, fish and wildlife, and water quality.
Single-purpose storage structure (Kellys Slough Dam)	Lower Red	Kelly Slough S14 and 23, T152, R52 West about 10 miles northwest of Grand Forks	This project would include raising the outlet of Kellys Slough to enlarge the slough's storage capacity for floodwater retention. The Soil Conservation Service has studied a dam and a diversion from Saltwater Coulee to maintain the reservoir at 850 feet msl on Kellys Slough National Wildlife Refuge. The reservoir size would be 770 surface acres with 6,250 acre-feet of storage.
Single-purpose storage structure (Rush River Dry Dam)	Lower Sheyenne	S36, T142, R53 about five miles southwest of Arthur in Cass County	This structure would be a dry dam which could retain 560 acre-feet over 140 surface acres. It may be effective in reducing potential flood damages from light spring runoff and light summer rains. Moderate spring runoff and moderate summer rains would make use of the emergency and/or principal spillway.

Opportunity	Public Involvement Region	Location	General Description
Single-purpose storage structure (Flood Control Dam)	Wild Rice	S24, T133, R50 three miles north of Mooreton in Richland County	A single-purpose structure would be approximately seven to eight feet high and retain 300 acre-feet of runoff. Approximately 100 surface acres within the natural channel of Antelope Creek would be inundated. The structure would be a dry dam with a low-level drawdown pipe located at the channel elevation. The structure could be beneficial in preventing local flood damages immediately downstream on Antelope Creek.
Single-purpose storage structure (Richland County)	Wild Rice	S27 and 34, T130, R49 in Richland County, about five miles southeast of Hankinson	A structure of this type could slow and temporarily retain water from doing excessive damage to the southeast quarter of Section 26 and flooding downstream Drain #65. Storage capabilities may be limited.
Desilting Dam (Park River)	Lower Red	Upstream from Homme Dam, Walsh County	A desilting dam might lessen the amount of sediment being deposited in Homme Reservoir.
Floodwall (Fargo)	Lower Sheyenne	First and Third Avenues North along Second Street North in downtown Fargo, Cass County	A 600-linear foot concrete floodwall would provide flood protection for the Civic Center area of downtown Fargo.
Drainage (Legal control)	All Regions	Red River Statistical Planning Area	Some control should be established on legal drains during periods of spring runoff. Controls could last until streams and rivers dropped below flood stage. Cooperation could be sought from farmers to retain water on farmland where farmsteads are not involved. Water could be drained off after the flood threat is over.
Drainage	All Regions	Red River Statistical Planning Area	Sound management of an area's surface waters can be enhanced through the use of a watershed or "systems" approach to drainage.
Irrigation (Sewage-lagoon waters)	All Regions	Red River Statistical Planning Area	A possibility exists to utilize community sewage-lagoon waters for irrigation of adjacent farmland.
Irrigation (Education)	All Regions	Red River Statistical Planning Area	Seminars conducted on a local level by knowledgeable representatives of the State Water Commission, the State Agricultural Department, and other agencies or irrigators could educate landowners on the advantages of irrigation.
Irrigation (Groundwater information)	All Regions	Red River Statistical Planning Area	Efforts should be made to gain more specific information on groundwater reserves in order to expedite the irrigation permitting process.
Land Management practice (Wetland values)	All Regions	Red River Statistical Planning Area	Equal consideration should be given to all wetland values in the drainage permitting process.
Land Management Practice (Plugging wetlands)	All Regions	Red River Statistical Planning Area	The possibility of plugging drained wetlands in the years when the land is summer fallowed should be explored. This practice could decrease erosion and the movement of nutrients, fertilizers, and pesticides from the land.
Land Management Practice (State Water Bank Program)	All Regions	Red River Statistical Planning Area	The State Water Bank Program, if funded, would help preserve, restore, and improve inland fresh water and adjacent areas in important migratory waterfowl nesting and breeding areas. Under the program, landowners receive annual payments for conserving and protecting wetlands.
Land Management Practice (Waterfowl production)	All Regions	Red River Statistical Planning Area	Waterfowl production could be increased if more attention is paid to developing habitat and managing wetlands now under Federal control.

Opportunity	Public Involvement Region	Location	General Description
Fish Hatcheries	All Regions	Red River Statistical Planning Area	Fish hatcheries around the State need rejuvenating and/or enlarging. More modern facilities are needed.

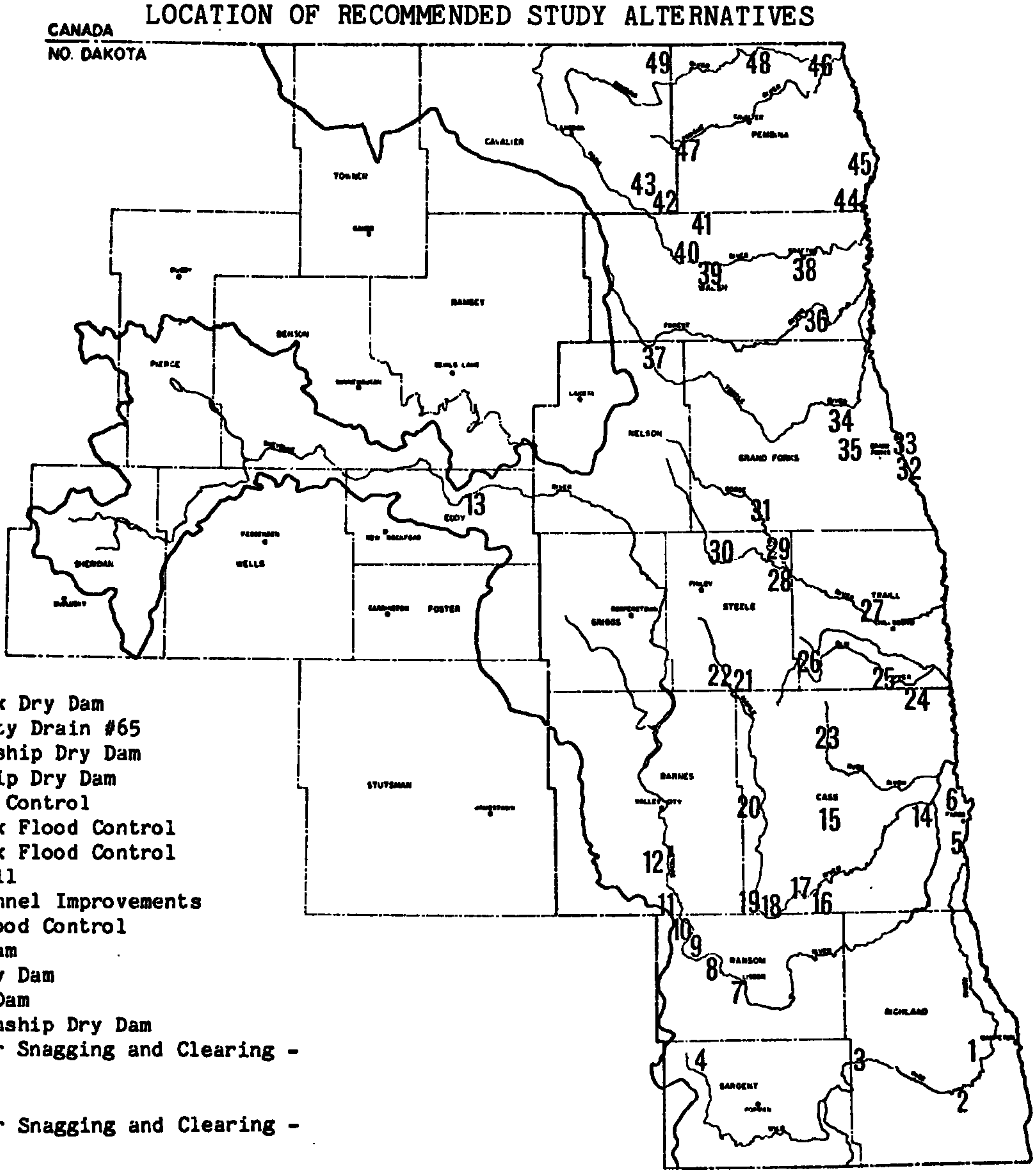
NON-RECOMMENDED STUDY ALTERNATIVES

TABLE IV-3-3 NON-RECOMMENDED STUDY ALTERNATIVES - RED RIVER BASIN

Alternative	Public Involvement Region	Location	General Description
Multi-purpose Reservoir			
Corps Dam	Goose	S12,T147,R54 Steele County	Reservoir size - 48,200 AF storage; 2,145 surface acres. Use: 31,300 AF flood storage; recreation.
Multi-purpose Reservoir	Upper Sheyenne	S9,T151,R69 Benson County	Reservoir size - 2,065 AF storage; 135 surface acres. Use: recreation and water supply.
Single purpose Reservoir			
Moellenkamp Dry Dam	Lower Sheyenne	S34,T134,R56 Ransom County	Reservoir size - 490 AF storage; 56 surface acres. Use: 490 AF flood storage.
South Maple River Dry Dam	Lower Sheyenne	S9,T136,R55 Ransom County	Reservoir size - 4,500 AF storage; 400 surface acres. Use: 4,500 AF flood storage.
Coulee 4-136-51 Dry Dam	Lower Sheyenne	S4,T136,R51 Richland County	Reservoir size - 60 AF storage; 12 surface acres. Use: 60 AF flood storage.
Maple River Dry Dam	Lower Sheyenne	S35,T144,R56 Steele County	Reservoir size - 850 AF storage; 125 surface acres. Use: 850 AF flood storage.
Swan-Buffalo Dry Dam	Lower Sheyenne	S21,T139,R53 Cass County	Reservoir size - 400 AF storage; 82 surface acres. Use: 400 AF flood storage.
Flood Control Projects			
Mayville Urban Levees	Goose	Traill County	2,120 foot levee along the Goose River east of the city park at Mayville to provide protection against the 100-year frequency flood event.
Wahpeton - Urban Levees	Wild Rice	Richland County	A levee along the Red River to provide protection for the city of Wahpeton against the 100-year frequency flood event.
Minto - Flood Control	Lower Red	Walsh County	Widen the Burlington Northern Railroad bridge to provide protection against the 14-year frequency flood event.
Turtle River Flood Control	Lower Red	Grand Forks County	Thirty-five miles of channel improvements to provide protection against the ten-year frequency flood event.
Turtle River Flood Control	Lower Red	Grand Forks County	Agricultural levees from the mouth of the Turtle River to 35 miles upstream. The levees would provide protection from the 100-year frequency flood event.
Turtle River Flood Control	Lower Red	Grand Forks County	Channelize eight miles of Turtle River and construct a diversion channel to contain the ten-year frequency flood event.

Alternative	Public Involvement Region	Location	General Description
Red River Flood Control	Lower Red	Walsh, Pembina, and Grand Forks Counties	151 miles of Red River channel improvements (Grand Forks to the Canadian border) to provide protection against the ten-year frequency flood event.
Maple River Flood Control	Lower Sheyenne	Cass County	Channel improvements and enlargement to the Upper Maple River and the mainstem to provide protection from the ten-year frequency flood event.
Maple River Flood Control	Lower Sheyenne	Cass County	Snagging and clearing of the Upper Maple River and mainstem to provide protection from the 30-year frequency flood event.
Maple River Flood Control	Lower Sheyenne	Cass County	Agricultural levees along each side of the Maple River beginning at the mouth to 25 miles upstream, and seven miles of levees along Swan and Buffalo Creeks to provide protection from the 100-year frequency flood.
Maple River Flood Control	Lower Sheyenne	Cass County	A 47,000 AF dry dam plus 64 miles of channel improvements on the Maple River.
Lower Branch Rush River Flood Control	Lower Sheyenne	Cass County	Alt. A: Enlarge the channel of the Rush River beginning at the mouth to 8.3 miles upstream to provide protection from the ten-year frequency flood. Alt. B: Raise the existing levees one to two feet in the lower 5.2 miles of the river reach and enlarge the channel upstream from levees to the south tributary.
Antelope Creek Flood Control	Wild Rice	Richland County	Channel improvement to 44 miles of Antelope Creek to provide protection from the ten-year frequency flood.
Wild Rice River Flood Control	Wild Rice	Richland County	Channel improvements to 11.2 miles of a lower branch of the Wild Rice River near Hankinson to provide protection from the ten-year frequency flood.
<u>Scenic and Recreation Rivers</u>			
Red River	Goose, Lower Red, Lower Sheyenne, and Wild Rice	Richland, Cass, Traill, Grand Forks, Walsh, and Pembina Counties	Maintain 304 miles of the Red River free-flowing from the South Dakota border to the Canadian border.
Sheyenne River	Lower Sheyenne	Barnes, Cass, and Ransom Counties	Maintain 207 miles of the Sheyenne River free-flowing from Valley City to Horace.
Pembina River	Lower Red	Cavalier and Pembina Counties	Maintain free-flowing a total of 88 miles of the Pembina River from the confluence with the Red River to the Canadian border.
<u>Other</u>			
Weather Modification Programs	Goose, Lower Red, and Wild Rice	Statewide	A) The North Dakota Cloud Modification Program. B) Drought Management Strategies. C) Atmospheric Water Resources Research in conjunction with the North Dakota Cloud Modification Program. D) Public Awareness of Weather Modification.
Weather Modification Programs	Devils Lake	Statewide	A) The North Dakota Cloud Modification Program. B) Drought Management Strategies. C) Public Awareness of Weather Modification.

FIGURE IV-3-1 RED RIVER BASIN
LOCATION OF RECOMMENDED STUDY ALTERNATIVES



1. Antelope Creek Dry Dam
2. Richland County Drain #65
3. Wyndmere Township Dry Dam
4. Harlan Township Dry Dam
5. Harwood Flood Control
5. Brooktree Park Flood Control
5. Rivertree Park Flood Control
5. Fargo Floodwall
5. Red River Channel Improvements
6. Argusville Flood Control
7. Moellenkamp Dam
8. Lund-Steen Dry Dam
9. Billings Dry Dam
10. Northland Township Dry Dam
11. Sheyenne River Snagging and Clearing - Barnes County
12. Hansen Dam
13. Sheyenne River Snagging and Clearing - Eddy County
14. Mapleton Flood Control
15. Swan-Buffalo Dry Dam
16. Watson Township Dry Dam
16. Highland Township Dry Dam S24
17. Highland Township Dry Dam - S16
17. Maple River Dry Dam - Cass Co.
18. Enderlin Flood Control
18. Moore Township Dry Dam
19. Pontiac Township Dry Dam - S17
19. Pontiac Township Dry Dam - S33
20. Hill Township Dry Dam
21. Maple River Dry Dam - Steele Co.
22. Hope Dry Dam
23. Rush River Dry Dam
24. Gunkel Township Dry Dam
25. Bohnsack Township Dry Dam - S5
25. Bohnsack Township Dry Dam - S25
26. Norman Township Dry Dam
27. Norway Township Dam
28. South Branch of the Goose River Reservoir
29. Enger Township Dry Dam
29. Newburg Township Dry Dam
30. Finley East Dam
31. Northwood Dam
32. Grand Forks County Rural Flood Prevention
33. English Coulee Watershed Project
33. English Coulee Flood Control Study
33. Belmont Road Dike
34. Kellys Slough Dam
35. Emerado Flood Control
36. Minto Dam
37. Dry Dam below Sarnia Dam
38. Grafton Flood Control
39. Homme Reservoir Restoration
40. Lundene or Tiber-Vista Dam
41. Langerud Dry Dam
42. South Milton Dry Dam
43. Milton Dry Dam
44. Drayton Flood Control
45. Bowesmont Flood Control
46. Pembina River Snagging and Clearing
47. Cart Creek Dry Dams
48. Neche Flood Control
49. Fremont Township Dry Dam

TABLE IV-3-4 RECOMMENDED STUDY ALTERNATIVES - BENEFICIAL AND ADVERSE EFFECTS OF THE POTENTIAL PROJECTS IN THE RED RIVER BASIN

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Finley East Dam (Figure IV-3-1; Site #30)
S17, T147, R55
Steele County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Multi-purpose Reservoir 1/

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 1,500 AF storage; 117 surface acres; average depth 13 feet;
Use: 1,025 AF flood storage; recreation

ECONOMIC DEVELOPMENT: Capital Cost $845,500 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL DEVELOPMENT:

The dam would be located on the Middle Branch of the Goose River. The reservoir would inundate 117 acres of land and riparian habitat. Habitat loss will have an adverse effect upon terrestrial wildlife and those species affected will be displaced. This reach of river is rated Class III - Substantial Value on the Game and Fish Stream Evaluation Map because of the moderate sport fishery on northern pike, channel catfish, and bullheads in the low reaches in addition to moderate forage fish production. The reservoir would restrict fish migration upstream.

OTHER SOCIAL EFFECTS:

Downstream flood control benefits would be provided in addition to water-based recreational activities.

STATUS:

Recent Investigation. Included in the Goose River Basin Plan.

RECOMMENDATION: Continued Study, with implementation in the 1990-2000 time frame.

1/ This was originally designed as a multi-purpose dam, but could be designed as a dry dam to increase flood storage with 2,525 AF flood storage.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Northwood Dam (Figure IV-3-1; Site #31)
S33, T150, R55
Grand Forks County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Multi-purpose Reservoir 1/

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board.

DESCRIPTION: Reservoir size: 510 AF storage; 61 surface acres; 8 feet average depth;
Use: 370 AF flood storage; recreation

ECONOMIC DEVELOPMENT: Capital Cost $835,500 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL DEVELOPMENT:

The dam would be located on the Goose River approximately seven miles west of Northwood. Sixty-one acres of land would be inundated and terrestrial wildlife species will be displaced. This reach of the Goose River is rated Class II - High Priority on the Game and Fish Stream Evaluation Map because of the moderate sport fishery on northern pike, channel catfish, bullheads, and walleye in addition to moderate forage fish production. The dam will restrict fish migration upstream.

OTHER SOCIAL EFFECTS:

Downstream flood control benefits will be provided in addition to water-based recreational opportunities. Agricultural flood damages will be reduced.

STATUS:

Recent Investigation. Included in the Goose River Basin Plan.

RECOMMENDATION: Continued study with implementation in the 1990-2000 time frame.

1/ This was originally intended to be a multi-purpose reservoir with a permanent pool, but it could be designed as a dry dam to increase flood storage with 800 AF of storage.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: South Branch of the Goose River (Figure IV-3-1; Site #28)
S31, T147, R53
Traill County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Multi-purpose Reservoir

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board.

DESCRIPTION: Reservoir size: 20,650 AF storage; 915 surface acres; average depth 23 feet;
Use: 6,370 AF flood storage; recreation

ECONOMIC DEVELOPMENT: Capital Cost $4,534,500 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL DEVELOPMENT:

The dam would be located on the South Branch of the Goose River. The reservoir would inundate 915 acres of land.

The loss of habitat would adversely affect wildlife and terrestrial species would be displaced. This reach of the river is rated Class III - Substantial Value on the Game and Fish Stream Evaluation Map because of the moderate sport fishery on northern pike, channel catfish, and bullheads in the low reaches in addition to moderate forage fish production.

OTHER SOCIAL EFFECTS:

Downstream flood control benefits would be provided in addition to water-based recreation and a fishery.

STATUS:

Recent investigation. The project is included in the Goose River Basin Plan.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Norway Township Dam (Figure IV-3-1; Site #27)
NW 1/4 S7,
T146, R51
Traill County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Multi-purpose

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board.

DESCRIPTION: Reservoir size: 980 AF storage; 140 surface acres; height 20 feet;
Use: 980 AF flood storage; recreation
The dam would not retain moderate to heavy spring runoff or summer rains. However, the dam would be effective in retaining smaller precipitation events which may be causing flood damages to cropland.

ECONOMIC DEVELOPMENT: Capital Cost $168,000 1/ (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The dam would be located on a tributary to the north branch of the Goose River. The reservoir will inundate 140 acres of land and riparian habitat at the maximum flood storage level. Terrestrial wildlife will be displaced. This tributary of the Goose River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:

Flood damage to cropland would be reduced in smaller precipitation events. The dam would not retain moderate to heavy spring runoff or summer rains. The fishery potential of the reservoir has not been determined. Three township roads and State Highway 200 would require modification.

STATUS:

Recent Investigation.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

1/ Cost does not include modification to existing roads. If a dry dam were considered, costs would be similar.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Lundene or Tiber-Vesta Dam (Figure IV-3-1; Site #40)
S3, T157, R57
Walsh County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Multi-purpose

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board/Army Corps of Engineers

DESCRIPTION: Reservoir size: 17,700 AF storage; 590 surface acres
Use: 24,800 AF flood storage; recreation.

ECONOMIC DEVELOPMENT [1]: Capital Cost $7,476,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The dam will inundate 590 acres of land at conservation pool and 1,035 acres at the maximum flood storage level. Terrestrial wildlife will be displaced due to inundation of habitat. Water quality will be degraded during the construction period, however, downstream water quality should improve over time as sediment load is reduced. This reach of the South Branch of the Park River is rated Class III - Substantial Value on the Game and Fish Stream Evaluation Map because of the moderate forage fish production and habitat for furbearers.

OTHER SOCIAL EFFECTS:

Downstream flood damages to agricultural land will be reduced. The reservoir will provide additional water-based recreation. The reservoir could also include water supplies to Grafton and the Park River.

STATUS:

Recent Investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

[1] This site was investigated by the U.S. Army Corps of Engineers in 1973. The dam was to be a multi-purpose storage structure for flood control and recreation, plus a water supply for the City of Grafton and the Park River. Based upon the Corps design criteria, the estimated cost is $22 million.

MULTI-PURPOSE RESERVOIR

NAME/LOCATION: Moellenkamp Dam (Figure IV-3-1; Site #7)
S34, T134, R56
Ransom County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Multi-purpose

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 490 AF storage; 56 surface acres
Use: 490 AF flood storage; recreation, however fishery potential is questionable.

ECONOMIC DEVELOPMENT: Capital Cost $252,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The dam would be located on a tributary of Timber Coulee, a tributary to the Sheyenne River. The reservoir would inundate 56 acres of land. Wildlife habitat would be lost and terrestrial species displaced. The coulee is not rated on the Game and Fish Stream Evaluation Map. Fishery potential of the reservoir has not been determined.

OTHER SOCIAL EFFECTS:

Downstream flood control benefits will be provided immediately downstream of the reservoir. Fishery potential of the reservoir requires further investigation.

STATUS:

Recent Investigation.

RECOMMENDATION: Implementation in the 2000-2020 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Hope Dry Dam 1/ (Figure IV-3-1; Site #22)
S9, T144, R56
Steele County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Flood Control

LEAD STUDY AGENCY: ND State Water Commission/Steele County Water Resource Board

DESCRIPTION: Reservoir size: 150 AF storage; 20 surface acres
Use: 150 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $106,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

No significant environmental impacts anticipated.

OTHER SOCIAL EFFECTS:

Downstream flood damages to agricultural land will be reduced.

STATUS: Inactive.

RECOMMENDATION: Continued study with implementation in the 1990-2000 time frame.

1/ The reservoir was constructed in 1935 as a recreation dam and washed out in the 1970's.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Bohnsack Township Dry Dam (Figure IV-3-1; Site #25)
S5, T144, R51
Traill County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 1,085 AF storage; 184 surface acres
Use: 1,085 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $300,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 184 acres of vegetation. Plant diversity will be reduced and wildlife displaced to similar available habitat. This reach of the Elm River is rated Class III - Substantial Value on the Game and Fish Stream Evaluation Map because of the moderate forage fish production.

OTHER SOCIAL EFFECTS:
The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Bohnsack Township Dry Dam (Figure IV-3-1; Site #25)
S25, T144, R51
Traill County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 9,367 AF storage; 1,035 surface acres
Use: 9,367 AF flood storage.

ECONOMIC DEVELOPMENT: Capital Cost $1,057,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 1,035 acres of vegetation. Plant diversity will be reduced and wildlife will be displaced to similar available habitat. This reach of the Elm River is rated Class III - Substantial Value on the Game and Fish Stream Evaluation Map because of the moderate forage fish production.

OTHER SOCIAL EFFECTS:
The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Newburg Township Dry Dam (Figure IV-3-1; Site #29)
S6, T148, R54
Steele County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 32,000 AF storage; 2,725 surface acres
Use: 32,000 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $2,750,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 2,725 acres of vegetation. Plant diversity will be reduced and wildlife displaced to similar available habitat. This reach of the Goose River is rated Class II - High Priority on the Game and Fish Stream Evaluation Map because of the moderate sport fishery on northern pike, channel catfish, bullheads, and walleye in addition to moderate forage fish production. The dry dam will restrict migration of fish upstream.

OTHER SOCIAL EFFECTS:
The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION:
Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Gunkel Township Dry Dam (Figure IV-3-1; Site #24)
S10, T142, R51
Cass County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 943 AF storage; 280 surface acres
Use: 943 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $426,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 280 acres of vegetation. Plant diversity will be reduced and wildlife displaced to similar available habitat. This reach of the South Branch of the Elm River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 2000-2020 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Enger Township Dry Dam (Figure IV-3-1; Site #29)
S13, T147, R54
Steele County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 55,000 AF storage; 2,400 surface acres
Use: 55,000 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $3,250,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 2,400 acres of vegetation. Plant diversity will be reduced and wildlife will be displaced to similar available habitat. This reach of the Goose River is rated Class II - High Priority on the Game and Fish Stream Evaluation Map because of the moderate sport fishery on northern pike, channel catfish, bullheads, and walleye in addition to moderate forage fish production. The dry dam will restrict fish migration upstream.

OTHER SOCIAL EFFECTS:
The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 2000-2020 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Norman Township Dry Dam (Figure IV-3-1; Site #26)
S12, T145, R53
Traill County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 700 AF storage; 190 surface acres
Use: 700 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $190,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 190 acres of vegetation. Plant diversity will be reduced and wildlife displaced to similar available habitat. This tributary of the Elm River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Langerud Dry Dam (Figure IV-3-1; Site #41)
S13, T158, R56
Walsh County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: Soil Conservation Service (Middle Branch Park River PL-566 Project)/ND State Water Commission/ Red River Joint Water Resource Board.

DESCRIPTION: Dry Dam.
Reservoir size: 5,000 AF storage; 180 surface acres
Use: 5,000 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $2,007,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would be located on the Middle Branch of the Park River. The capacity of the dam is 5,000 AF of storage. At maximum flood pool, 180 acres of land will be inundated. Vegetation intolerant to an extended period of flooding will be destroyed. Terrestrial species will be displaced when the reservoir is at its maximum storage capacity. A small settling pond will be created after the water has been drawn down. The settling pond should enhance wildlife habitat. The Middle Branch of the Park River is rated Class III - Substantial Value on the Game and Fish Stream Evaluation Map because of the moderate forage fish production.

OTHER SOCIAL EFFECTS:
Downstream flood control benefit will be provided reducing agricultural flood damages.

STATUS:
Recent Investigation.

RECOMMENDATION: Implementation in the 2000-2020 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: South Milton Dry Dam (Figure IV-3-1; Site #42)
S14, T159, R57
Cavalier County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: Soil Conservation Service (PL-566 Project) - Alt. A
ND State Water Commission - Alt. B

DESCRIPTION:	ECONOMIC DEVELOPMENT
Alt A: Reservoir Size: 7,370 AF storage; 190 surface acres; Use: 7,370 AF flood storage	Capital Cost $1,655,350 (estimate) Annual Cost $121, 800 Annual Benefit $31,700 Benefit/Cost Ratio 0.26
Alt B: Reservoir size: 7,370 AF storage; 190 surface acres Use: 7,370 AF flood storage	Capital Cost $1,731,000 (estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dam is located on the North Branch of the Park River. The dam will inundate 190 acres of land at the maximum flood storage level. One hundred acres of woodland will be lost, adversely affecting wildlife resulting in a displacement of terrestrial wildlife species. The North Branch of the Park River, at the Milton site, is rated Class III - Substantial Value on the Game and Fish Stream Evaluation Map because of its moderate forage fish production.

OTHER SOCIAL EFFECTS:
The project would reduce downstream flood damages.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Milton Dry Dam (Figure IV-3-1; Site #43)
S31, T160, R57
Cavalier County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 2,308 AF storage; 250 surface acres
Use: 2,308 AF flood storage

ECONOMIC DEVELOPMENT:
Capital Cost $912,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dam will inundate 250 acres of land at maximum flood storage. Vegetation intolerant to an extended period of flood waters will be destroyed. During this same period, terrestrial wildlife will be displaced. After the water is drawn down, a small settling pond will remain which will enhance wildlife habitat. The North Branch of Park River at the site location is rated Class III - Substantial Value on the Game and Fish Stream Evaluation Map because of its moderate forage fish production.

OTHER SOCIAL EFFECTS:
Downstream flood damages to agricultural lands will be reduced.

STATUS:
Recent Investigation.

RECOMMENDATION: Implementation in the 2000-2020 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Dry Dam below Sarnia Dam (Figure IV-3-1; Site #37)
S12, T154, R58
Nelson County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: Soil Conservation Service/ND State Water Commission/ Red River Joint Water Resource Board.

DESCRIPTION: Reservoir size: 1,038 AF storage; 133 surface acres
Use: 1,038 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $184,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

This dry dam is located on a tributary to the Middle Branch of the Forest River. The reservoir at maximum flood capacity would inundate 133 acres of land. Vegetation intolerant to an extended period of flood water will be destroyed. The dam will create a small settling pond after the water has drawn down. This settling pond should enhance wildlife habitat in the area. This tributary is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:

Downstream flood control benefits will be provided; reducing agricultural flood damages.

STATUS:

Recent Investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Cart Creek Dry Dams (Figure IV-3-1; Site #47)
S18 & 19, T160, R56
Pembina County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Flood Control - Dry Dams

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board.

DESCRIPTION: There are up to three sites below the escarpment in Pembina County. They are small dry dams of low embankment height. Capacities of about 100 acre-feet each.

ECONOMIC DEVELOPMENT: Capital Cost $588,000 for the three sites (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

These dry dams would be located on Cart Creek, a tributary to the North Branch of the Park River. The capacity of each of these dams is estimated at 100 AF of storage. Vegetation intolerant to an extended period of inundation would be destroyed. Terrestrial species would be displaced when the reservoir is at maximum storage capacity. A small settling pond will be created after the water has been drawn down which should enhance wildlife habitat. Cart Creek is rated Class IV - Limited Value on the Game and Fish Stream Evaluation Map because of the moderate forage fish production.

OTHER SOCIAL EFFECTS:

Downstream flood control benefits will be provided; reducing agricultural flood damages.

STATUS:

Recent investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Fremont Township Dry Dam (Figure IV-3-1; Site #49)
S3, T163, R57
Cavalier County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Cavalier County Water Resource Board/Red River Joint Water Resource Board.

DESCRIPTION: Dry Dam. Channel improvements in S2, T163, R57; a dike on each side of the channel with gated inlet culverts in S32, T164, R56; and upgrading the road crossing between S27 and 34, T164 N, R56 W.

ECONOMIC DEVELOPMENT: Capital Cost $425,000 (estimates)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The dry dam would be located on Buffalo Creek. The reservoir will temporarily inundate 31 acres of land at maximum flood storage. Wildlife utilizing the inundated habitat will be displaced. The creek is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:

The dry dam and channel improvements will reduce downstream agricultural flood damages.

STATUS:

Recent Investigation.

RECOMMENDATION: Implementation in the 2000-2020 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Kellys Slough Dam (Figure IV-3-1; Site #34)
S22 & 27, T152, R52
Grand Forks

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Flood Control

LEAD STUDY AGENCY: ND State Water Commission/Grand Forks County Soil Conservation District/Red River Joint Water Resource Board.

DESCRIPTION: A dam and a diversion from Saltwater Coulee to maintain the reservoir at 850 feet msl on Kellys Slough National Wildlife Refuge.
Reservoir size: 6,250 AF storage; 770 surface acres
Use: 6,250 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $456,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

At the present time not enough information is available to determine what the effects of raising the water level will have upon Kellys Slough National Wildlife Refuge and the purpose for which it is managed. A detailed analysis would be required to determine adverse and/or beneficial effects to the biological elements.

OTHER SOCIAL EFFECTS:

The increased flood storage would provide downstream flood control benefits and reduce agricultural flood damages.

STATUS:

Recent Investigation.

RECOMMENDATION: Continued study with implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Minto Dam (Figure IV-3-1; Site #36)
S31, T156, R52
Walsh County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Improved municipal water supply

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: A new dam providing 68 AF storage is proposed 2,200 feet downstream from the existing Minto Dam on the Forest River. The existing Dam is structurally unsound.

ECONOMIC DEVELOPMENT: Capital Cost $188,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
No significant environmental effects are anticipated since a dam presently exists 2,200 feet upstream from the proposed new site.

OTHER SOCIAL EFFECTS:
The dam will assure a better water supply for the City of Minto. Although the new dam is feasible on structural, geologic, and hydrologic grounds, there is some question as to whether there will be enough storage to meet demands during long, dry spells.

STATUS:
The City of Minto is continuing to explore options concerning possible replacement of the existing Minto Dam and/or an alternative water source.

RECOMMENDATION: Continued study investigating all possible alternatives with implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Maple River Dry Dam (Figure IV-3-1; Site #21)
S35, T144, R56
Steele County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 4,600 AF storage; 500 surface acres
Use: 4,600 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $630,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
This dry dam would be located below Hope and Sussex Dams on the Maple River. At maximum flood storage, 500 acres of land would be inundated. Vegetation intolerant to extended periods of flood water inundation will be

lost and terrestrial wildlife will be displaced. This reach of the Maple River is rated Class III - Substantial Value on the Game and Fish Stream Evaluation Map because of the moderately valued seasonal sport fishery; in addition to providing habitat for reproduction of channel catfish, northern pike, and forage species.

OTHER SOCIAL EFFECTS:
The dam would provide flood control benefits immediately downstream of the site.

STATUS:
Recent Investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Swan-Buffalo Dry Dam (Figure IV-3-1; Site #15)
S21, T139, R53
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: Soil Conservation Service/ND State Water Commission

DESCRIPTION: Reservoir size: 850 AF storage; 175 surface acres
Use: 850 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $525,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would be located on Buffalo Creek about eight miles southwest of Casselton. The dam would temporarily inundate 175 acres of land. Vegetation intolerant to an extended period of flood water inundation will be lost and terrestrial wildlife will be displaced. A small settling pond will remain after drawdown of the water providing wildlife habitat. This creek is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The dry dam will provide flood control benefits immediately downstream from the site.

STATUS:
Inactive. The site was studied by the Soil Conservation Service in the Swan-Buffalo Creek Watershed Plan.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Rush River Dry Dam (Figure IV-3-1; Site #23)
S36, T142, R53W
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: The dam may be effective in reducing potential flood damages from light spring runoff and light summer rains. Moderate spring runoff and moderate summer rain would make use of the emergency and/or principal spillway.
Reservoir size: 560 AF storage; 140 surface acres
Use: 560 AF flood storage

ECONOMIC DEVELOPMENT: 1/ Capital Cost $69,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The dry dam would be located on the Rush River. At maximum flood storage, 140 acres of land would be inundated. Vegetation intolerant to an extended period of flood water inundation will be lost and terrestrial wildlife will be temporarily displaced. A small settling pond will remain after drawdown of the water providing wildlife habitat. This reach of the Rush River is rated Class IV - Limited Value on the Game and Fish Stream Evaluation Map because of limited forage production; it does not support a sport fishery.

OTHER SOCIAL EFFECTS:

Downstream flood control benefits will be provided during light spring runoff and light summer rains.

STATUS:

Recent Investigation.

RECOMMENDATION: Implementation in the 2000-2020 time frame.

1/ The cost may increase due to the type of emergency and principal spillways needed to accommodate high flows.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Northland Township Dry Dam (Figure IV-3-1; Site #10)
S26, T136, R58
Ransom County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 1,060 AF storage; 38 surface acres
Use: 1,060 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $337,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would be located on a tributary of the Sheyenne River approximately two miles north of Fort Ransom. At maximum flood storage, 38 acres of land will be inundated. Vegetation intolerant to extended periods of flood water inundation will be lost and terrestrial wildlife will be displaced. This tributary of the Sheyenne River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The dry dam would provide downstream flood control benefits.

STATUS:
Recent Investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Billings Dry Dam (Figure IV-3-1; Site #9)
S4, T135, R57
Ransom County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board.

DESCRIPTION: Reservoir size: 1,080 AF storage; 48 surface acres
Use: 1,080 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $534,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would be located on a tributary of the Sheyenne River. The reservoir would inundate 48 acres of land at maximum flood storage. Vegetation including some woodlands will be inundated for extended periods of time. Those species intolerant to flood water inundation will be lost and terrestrial wildlife will be displaced.

OTHER SOCIAL EFFECTS:
The dry dam will provide downstream flood control benefits.

STATUS:
Recent Investigation.

RECOMMENDATION: Implementation in the 2000-2020 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Lund-Steen Dry Dam (Figure IV-3-1; Site #8)
S16, T135, R57
Ransom County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 2,300 AF storage; 73 surface acres
Use: 2,300 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $952,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would be located on a tributary of the Sheyenne River. At maximum flood storage, 73 acres of land will be inundated. Most of the site consists of woodland; therefore, much of the habitat would be lost because of extended periods of flood water inundation. Wildlife would be adversely affected because of loss of habitat.

OTHER SOCIAL EFFECTS:
The dry dam would provide downstream flood control benefits.

STATUS:

Recent Investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Maple River Dry Dam (Figure IV-3-1; Site #17)
S14, T137, R54
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood control

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: A dry dam located on Maple River seven miles east and four miles north of Enderlin.
Reservoir size: 60,000 AF storage; 3,000 surface acres
Use: 6,000 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $4,500,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The dry dam would be located on the Maple River. At maximum flood storage, 3,000 acres of land would be temporarily inundated. Vegetation intolerant to extended periods of flood water inundation would be lost and terrestrial wildlife would be displaced. During construction water quality will be degraded resulting in increased turbidity and sediment. Maple Creek is rated Class III - Substantial Value on the Game and Fish Stream Evaluation Map because of the moderate sport fishery and reproduction of northern pike and channel catfish. Total impact to the stream fishery were not determined.

OTHER SOCIAL EFFECTS:

The dry dam would provide downstream flood-control benefits with 25 percent flood reduction at Mapleton, and would require relocating four farmsteads.

STATUS:

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Pontiac Township Dry Dam (Figure IV-3-1; Site #19)
S17, T137, R55
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board.

DESCRIPTION: Reservoir size: 8,000 AF storage; 575 surface acres
Use: 8,000 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $1,600,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 575 acres of vegetation. Plant diversity will be reduced and wildlife will be displaced to similar available habitat. This tributary of the Maple River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECT:
The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Pontiac Township Dry Dam (Figure IV-3-1; Site #19)
S33, T137, R55
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 2,500 AF storage; 190 surface acres
Use: 2,500 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $825,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 190 acres of vegetation. Plant diversity will be reduced and wildlife will be displaced to similar available habitat. This tributary of the Maple River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The structure would provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Hill Township Dry Dam (Figure IV-3-1; Site #20)
S9, T139, R55
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 4,200 AF storage; 530 surface acres
Use: 4,200 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $1,000,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 530 acres of vegetation. Plant diversity will be reduced and wildlife will be displaced to similar available habitat. This tributary of the Maple River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The structure will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Highland Township Dry Dam (Figure IV-3-1; Site #17)
S16, T137, R54
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 1,400 AF storage; 120 surface acres
Use: 1,400 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $575,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 120 acres of vegetation. Plant diversity will be reduced and wildlife will be displaced to similar available habitat. This tributary of the Maple River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Highland Township Dry Dam (Figure IV-3-1; Site #16)
S24, T137, R54
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 2,650 AF storage; 215 surface acres
Use: 2,650 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $795,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 215 acres of vegetation. Plant diversity will be reduced and wildlife will be displaced to similar available habitat. This tributary of the Maple River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Watson Township Dry Dam (Figure IV-3-1; Site #16)
S16, T137, R53
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 1,100 AF storage; 90 surface acres
Use: 1,100 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $500,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 90 acres of vegetation. Plant diversity will be reduced and wildlife will be displaced to similar available habitat. This tributary of the Maple River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Moore Township Dry Dam (Figure IV-3-1; Site #18)
S14, T136, R56
Ransom County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 5,000 AF storage; 750 surface acres
Use: 5,000 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $550,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The dry dam would temporarily inundate 750 acres of vegetation. Plant diversity will be reduced and wildlife will be displaced to similar available habitat. This tributary of the Maple River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:

The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 2000-2020 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Antelope Creek Dry Dam (Figure IV-3-1; Site #1)
S24, T133N, R50
Richland County

PUBLIC INVOLVEMENT REGION: Wild Rice

PURPOSE: Flood control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: Reservoir size: 300 AF storage; 100 surface acres
Use: 300 AF flood storage

ECONOMIC DEVELOPMENT [1]: Capital Cost $20,000 (estimate)
Annual Benefit NA
Annual Cost NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The reservoir would be located on Antelope Creek, a tributary of the Wild Rice River, and would inundate 100 acres of land at the maximum flood storage level. Plant diversity will be reduced by the loss of vegetation intolerant to extended periods of inundation. Terrestrial wildlife will be displaced to similar available habitat. Antelope Creek is rated Class III - Substantial Value on the Game and Fish Stream Evaluation Map because of its moderate sport fishery on channel catfish, sauger, walleye, and northern pike. The structure will inhibit upstream migration of fish.

OTHER SOCIAL EFFECTS:

The dam would reduce flood damages immediately downstream. The structure is capable of retaining something less than a one-year flood event.

STATUS:

Recent Investigation.

RECOMMENDATION: Continued study with implementation in the 1980-1990 time frame.

[1] The cost may increase due to the type of emergency and principal spillways needed to accommodate high flows.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Wyndmere Township Dry Dam (Figure IV-3-1; Site #3)
S25, T132, R52
Richland County

PUBLIC INVOLVEMENT REGION: Wild Rice

PURPOSE: Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 22,000 AF storage; 2,000 surface acres
Use: 22,000 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $2,000,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The dry dam would temporarily inundate 2,000 acres of vegetation. Plant diversity will be reduced and wildlife will be displaced to similar available habitat. This reach of the Wild Rice River is rated Class II - High Priority on the Game and Fish Stream Evaluation Map because of a moderate sport fishery on northern pike and channel catfish in addition to moderate reproduction of northern pike, channel catfish, and several forage species.

OTHER SOCIAL EFFECTS:
The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Harlen Township Dry Dam (Figure IV-3-1; Site #4)
S4, T131, R57
Sargent County

PUBLIC INVOLVEMENT REGION: Wild Rice

PURPOSE Flood Control - Dry Dam

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board

DESCRIPTION: Reservoir size: 10,000 AF storage; 5,000 surface acres
Use: 10,000 AF flood storage

ECONOMIC DEVELOPMENT: Capital Cost $5,000,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The dry dam would temporarily inundate 5,000 acres of land much of which is a wetland. Plant diversity may be reduced and wildlife will be displaced to similar available habitat. This area is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:
The dry dam will provide downstream flood control benefits.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 1990-2000 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Belmont Road Dike (Figure IV-3-1; Site #33)
South edge of the City
of Grand Forks,
Traill County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Flood Control

LEAD STUDY AGENCY: ND State Water Commission/Red River Joint Water Resource Board.

DESCRIPTION: Dike. This area is subject to flooding from backwater of the Red River.

ECONOMIC DEVELOPMENT: Capital Cost $350,000 (1982 estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

No significant environmental effects are anticipated to occur to the biological elements.

OTHER SOCIAL EFFECTS:

The dike will reduce property damage due to flooding. Residents benefiting from the flood protection would be assessed $186.00 a year for 18 years.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Grand Forks County (Figure IV-3-1; Site #32)
Rural Flood Prevention
Grand Forks County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Flood Control

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Non-structural measures including flood-proofing dike.

ECONOMIC DEVELOPMENT: Capital Cost $802,000
Average Annual Cost $61,668
Average Annual Benefit $76,939
Benefit/Cost Ratio 1.25

ENVIRONMENTAL QUALITY:
No significant environmental effects anticipated.

OTHER SOCIAL EFFECTS:
An annual income benefit distribution of $76,939 will be created in the region, and an annual local cost of $3,885 will be borne by the region. The flood protection will reduce the risk of loss of life.

STATUS:
Currently being installed - multiyear program total funding for the project has not been appropriated.

RECOMMENDATION: Completion of project.

FLOOD CONTROL PROJECT

NAME/LOCATION: English Coulee Watershed (Figure IV-3-1; Site #33)
Grand Forks County

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Flood Control

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Dam and diversion floodway - Watershed (PL-566) Project

ECONOMIC DEVELOPMENT: Capital Cost $3,032,000 (estimates)
Average Annual Cost $233,247 (estimates)
Average Annual Benefit $312,616 (estimates)
Benefit/Cost Ratio 1.34

ENVIRONMENTAL QUALITY:
No significant wildlife effects addressed to date. Significant effects on the human environment including reduced flooding, erosion, and sediment damages.

OTHER SOCIAL EFFECTS:
The project will create an annual benefit distribution of $312,616; while local costs totaling an estimated $20,000 annually will be borne by the region. Flood protection against the one percent (100-year) flood event will be provided to the City of Grand Forks, improving the quality of life, health, and safety of the residents in addition to flood reduction on agricultural lands, roads, and rural dwellers.

STATUS:
Currently in the planning stages.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: English Coulee Flood Control Study (Figure IV-3-1; Site #33)
Grand Forks, ND

PUBLIC INVOLVEMENT REGION: Goose

PURPOSE: Flood Control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Control structure and nonstructural measures. This project, in conjunction with proposed improvements by Soil Conservation Service in the upper watershed, would provide protection against Red River of the North backwater and English Coulee flooding.

ECONOMIC DEVELOPMENT: Capital Cost $2,500,000 (preliminary estimates)
Annual Cost NA
Annual Benefit $200,000 (preliminary estimate)
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
No significant adverse environmental effects have been identified.

OTHER SOCIAL EFFECTS:
Positive social benefits would accrue to numerous developments in the English Coulee floodplain. No negative social effects are anticipated. The project would provide protection against the one percent (100-year) flood event.

STATUS:
Detailed planning stage. Section 205 Flood Control Study.

RECOMMENDATION: Completion of study with implementation in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Grafton Flood Control (Figure IV-3-1; Site #38)
Walsh County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Flood Control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: A flood bypass channel north of Grafton and a tieback levee upstream and to the west of Grafton.

ECONOMIC DEVELOPMENT: Capital Cost $15,900,000 (preliminary estimate)
Annual Cost $1,332,000
Annual Benefit $1,768,000
Benefit/Cost Ratio 1.33

ENVIRONMENTAL QUALITY:

The project will affect 0.1 mile of aquatic habitat and create 338 acres of grassland area. Two acres of floodplain forest will be cleared while ten acres will be planted. Up to five acres of wetland will be developed. The project will require 340 acres of land. Two hundred seventy-five acres of this land will be agricultural land out of production.

OTHER SOCIAL EFFECTS:

The project will result in a significant reduction of flood threat, protection of existing developments while allowing for adequate future expansion, and will maintain integrity of existing neighborhoods.

STATUS:

Currently in the planning stage by the Army Corps of Engineers. Section 205 Flood Control Study.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Bowesmont Flood Control (Figure IV-3-1; Site #45)
Pembina County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Flood control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Construct a levee to provide protection against the one percent (100-year) frequency flood.

ECONOMIC DEVELOPMENT [1]: Capital Cost $171,000
Average Annual Cost $12,600
Average Annual Benefit (urban) $16,300
Benefit/Cost Ratio 1.29

ENVIRONMENTAL QUALITY:

The construction of the levee would result in the destruction of vegetation. There should be no significant long-term impacts to the biological elements.

OTHER SOCIAL EFFECTS:

The levee will provide protection from the one percent (100-year) frequency flood, thus enhancing the health and safety of residents. There will also be a reduction or prevention of flood damages to personal property.

STATUS: Inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

[1] Cost and benefits (1979 dollar value) were developed by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Drayton Flood Control (Figure IV-3-1; Site #44)
Pembina County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Flood Control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Construct a levee to provide protection against the one percent (100-year) frequency flood.

ECONOMIC DEVELOPMENT [1]: Capital Cost $702,000
Average Annual Cost $51,700
Average Annual Benefit (urban) $30,600
Benefit/Cost Ratio 0.59

ENVIRONMENTAL QUALITY:

The construction of the levee would result in the destruction of vegetation. There should be no significant long-term impacts to the biological elements.

OTHER SOCIAL EFFECTS:

The levee will provide protection from the one percent (100-year) frequency flood, thus enhancing the health and safety of residents. There will also be a reduction or prevention of flood damages to personal property.

STATUS: Inactive.

RECOMMENDATION: Continued study with implementation in the 1990-2000 time frame.

1/ Cost and benefits (1979 dollar value) were developed by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Neche Flood Control (Figure IV-3-1; Site #48)
Pembina County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Flood Control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Levee; providing one percent (100-year) frequency flood event protection.

ECONOMIC DEVELOPMENT: Capital Cost $1,500,000 (1976 preliminary estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
No significant environmental effects are expected with implementation of this project.

OTHER SOCIAL EFFECTS:
Not yet determined.

STATUS:
Preliminary Report is currently in progress. Section 205 Flood Control Project.

RECOMMENDATION: Continued study with implementation in the 2000-2020 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Emerado Flood Control (Figure IV-3-1; Site #35)
Grand Forks County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Flood Control

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Combination floodway and dike

ECONOMIC DEVELOPMENT: Capital Cost $234,000 (estimate)
Average Annual Cost $18,000
Average Annual Benefit $20,000
Benefit/Cost Ratio 1.11

ENVIRONMENTAL QUALITY:
No significant environmental effects are anticipated.

OTHER SOCIAL EFFECTS:
The project will create an annual benefit distribution of $20,000; local costs totaling $500 annually will be borne by the region. Flood protection against the one percent (100-year) frequency flood will be provided to the city of Emerado, protecting the health, life, and safety of the residents.

STATUS:
Preliminary Measure Plan currently in the planning stage.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Enderlin Flood Control (Figure IV-3-1; Site #18)
Ransom County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Urban levees at Enderlin would provide flood protection from the 140-year frequency flood on the Maple River.

ECONOMIC DEVELOPMENT: Capital Cost $3,600,000 (estimate)
Average Annual Cost NA
Average Annual Benefit (urban) $365,000
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
No significant adverse environmental impacts have been identified.

OTHER SOCIAL EFFECTS:
The levees would provide flood protection from the 140-year frequency flood, thus enhancing the health and safety of the 1,151 residents.

Benefits would accrue to approximately 270 homes and 53 business and public buildings.

STATUS:

Detailed study is currently being conducted; Section 205 Flood Control Study. Implementation of the project will begin in September, 1982 with completion scheduled for September, 1984.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Mapleton Flood Control (Figure IV-3-1; Site #14)
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Urban levees at Mapleton would provide flood protection from the one percent (100-year) frequency flood on the Maple River.

ECONOMIC DEVELOPMENT [1/] Capital Cost $544,000
Average Annual Cost $40,000
Average Annual Benefit (urban) $8,200
Benefit/Cost Ratio 0.21

ENVIRONMENTAL QUALITY:

Construction of the levees would result in the destruction of some riparian vegetation. There should be no significant long-term environmental impacts.

OTHER SOCIAL EFFECTS:

The levee will provide protection from the one percent (100-year) frequency flood, thus enhancing the health and safety of 306 residents. There would be a reduction or prevention of flood damages to personal property.

STATUS: Inactive.

RECOMMENDATION: Continued study with implementation in the 2000-2020 time frame.

[1/] Cost and benefits (1979 dollar value) were developed by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Argusville Flood Control (Figure IV-3-1; Site #6)
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Construct a levee to provide protection against the one percent (100-year) frequency flood.

ECONOMIC DEVELOPMENT: Capital Cost $1,400,000 (preliminary estimate)
Average Annual Cost NA
Average Annual Benefit (urban) $150,000
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

No significant adverse environmental effects are expected with implementation of the project.

OTHER SOCIAL EFFECTS:

The levee will provide protection to the City of Argusville from the one percent (100-year) frequency flood, protecting approximately 42 homes, four businesses, and two churches.

STATUS:

Detailed hydrologic studies are being conducted; Section 205 Flood Control Study.

RECOMMENDATION: Continued study with implementation in the 1990-2000 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Harwood Flood Control (Figure IV-3-1; Site #5)
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Construct a levee to provide protection to Harwood against the one percent (100-year) frequency flood.

ECONOMIC DEVELOPMENT [1/] Capital Cost $120,000
Average Annual Cost $8,900
Average Annual Benefit (urban) $99,800
Benefit/Cost Ratio 11.21

ENVIRONMENTAL QUALITY:

The construction of the levee would result in the destruction of vegetation. There should be no significant long-term impacts to the biological elements.

OTHER SOCIAL EFFECTS:

The levee will provide protection from the one percent (100-year) frequency flood, thus enhancing the health and safety of the 326 residents. There will be an annual reduction or prevention of flood damages to personal property totaling $99,800.

STATUS: Inactive.

RECOMMENDATION: Existing dikes should be upgraded to meet the Army Corps of Engineers criteria for permanency. Implementation in the 1980-1990 time frame.

1/ Cost and benefits (1979 dollar value) were developed by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Brooktree Park Flood Control (Figure IV-3-1; Site #5)
S28, T141, R49
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Construction of a levee to provide protection against the one percent (100-year) frequency flood for Brooktree Park.

ECONOMIC DEVELOPMENT 1/: Capital Cost $65,000
Average Annual Cost $4,800
Average Annual Benefit (urban) $28,200
Benefit/Cost Ratio 5.88

ENVIRONMENTAL QUALITY:

The construction of the levee would result in the destruction of vegetation. There should be no significant long-term impacts to the biological elements.

OTHER SOCIAL EFFECTS:

The levee will provide protection from the one percent (100-year) frequency flood. The project will create an annual income benefit distribution of $28,200.

STATUS: Inactive.

RECOMMENDATION: Existing dikes should be upgraded to meet the Army Corps of Engineers criteria for permanency. Implementation in the 1980-1990 time frame.

1/ Cost and benefits (1979 dollar value) were developed by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Rivertree Park Flood Control (Figure IV-3-1; Site #5)
S33, T141, R49
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Construct a levee to provide protection against the one percent (100-year) frequency flood for Rivertree Park.

ECONOMIC DEVELOPMENT 1/: Capital Cost $65,000
Average Annual Cost $4,800
Average Annual Benefit (urban) $60,300
Benefit/Cost Ratio 12.56

ENVIRONMENTAL QUALITY:
The construction of the levee would result in the destruction of vegetation. There should be no significant long-term impacts to the biological elements.

OTHER SOCIAL EFFECTS:
The levee will provide protection from the one percent (100-year) frequency flood, protecting health and safety of the residents. The project will create an annual income benefit distribution of $60,300.

STATUS: Inactive.

RECOMMENDATION: Existing dikes should be upgraded to meet the Army Corps of Engineers criteria for permanency. Implementation in the 1980-1990 time frame.

1/ Cost and benefits (1979 dollar value) were developed by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Fargo Floodwall - (Figure IV-3-1; Site #5)
First and Third Avenues
along Second Street North,
Fargo, Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Provide flood protection for the Civic Center area of downtown Fargo.

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: 600 foot linear dike providing flood protection from the one percent (100-year) flood event.

ECONOMIC DEVELOPMENT: Capital Cost $259,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
No significant environmental effects anticipated.

OTHER SOCIAL EFFECTS:
The dike would provide one percent (100-year) flood protection.

STATUS: Recent Investigation.

RECOMMENDATION: Implementation in the 2000-2020 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Red River Channel Improvements (Figure IV-3-1; Site #5)
Cass County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Flood Control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Forty-six miles of channel improvement on the mainstem of the Red River from Fargo, North Dakota north to Perley, Minnesota.

ECONOMIC DEVELOPMENT [1/]: Capital Cost $13,056,000
Average Annual Cost $961,100
Average Annual Benefit (rural) $812,300
Average Annual Benefit (urban) 747,800
TOTAL $1,560,100
Benefit/Cost Ratio 1.62

ENVIRONMENTAL QUALITY:

Riparian habitat would be destroyed reducing wildlife habitat and plant diversity, adversely affecting biological elements. Water quality would be degraded resulting in increased turbidity and sediment. The Red River is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map because of the good sport fishery it provides on channel catfish, northern pike, walleye, yellow perch, and others. The fishery would be adversely affected and fishery value of the river substantially reduced. The Lake Sturgeon is considered Endangered and seven species of fish are considered threatened in the Red River [2].

OTHER SOCIAL EFFECTS:

The channel improvements will provide flood protection against the ten percent (10-year) frequency flood, thus enhancing health and safety of area residents during flood periods. The average annual area flooded will be reduced to 6,440 acres as compared to 17,003 acres.

STATUS: Inactive

RECOMMENDATION: Continue Study.

1/ Cost and benefits (1979 dollar value) were developed by Gulf South Research Institute for the Army Corps of Engineers.

2/ McKenna, Michael G. and Robert W. Seabloom. Endangered, Threatened, and Peripheral Wildlife in North Dakota, 1979. Research Report No. 28, 62 pp. University of North Dakota Institute for Ecological Studies.

FLOOD CONTROL PROJECT

NAME/LOCATION: Richland County Drain #65 (Figure IV-3-1; Site #2)
T130, R49
Richland County

PUBLIC INVOLVEMENT REGION: Wild Rice

PURPOSE: To relieve flood damages within the watershed and to prevent detriment to Drain #65 and adjacent Drain #30 by overloading.

LEAD STUDY AGENCY: ND State Water Commission/Richland County Water Resource Board

DESCRIPTION:	ECONOMIC DEVELOPMENT
Alt. A. Drain improvements to existing drain	Capital Cost $97,400 (estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Alt. B: A parallel channel approximately two miles west of Drain #65	Capital Cost $354,000 (estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Construction of the parallel channel will result in a permanent land-use change.

OTHER SOCIAL EFFECTS:

Flood damages and erosion problems will be reduced.

STATUS:

Houston Engineering is currently examining the possibility of the parallel channel west of Drain #65.

RECOMMENDATION: Continued study with implementation in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Pembina River Snagging and Clearing (Figure IV-3-1; Site #46)
Neche to the mouth of the
Pembina River
Pembina County

PUBLIC INVOLVEMENT REGION: Lower Red

PURPOSE: Snagging and clearing

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Snagging and clearing of the lower 33 miles of the Pembina River from Neche to the mouth of the Pembina River near Pembina.

ECONOMIC DEVELOPMENT: Capital Cost $431,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Riparian habitat would be destroyed, reducing wildlife and aquatic habitat resulting in losses in biological efficiency, diversity, and balance. The Pembina River is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map because of a moderate sport fishery on northern pike, walleye, and yellow perch. The riparian habitat also supports good furbearer and moderate waterfowl usage. The river has very high aesthetic value and is currently on the final listing of the National Inventory of Wild and Scenic Rivers.

OTHER SOCIAL EFFECTS:

The snagging and clearing of 33 miles of the Pembina River would increase capacity of the channel and reduce agricultural flood damages.

STATUS:

Inactive. Until project costs decrease, or the federal cost limitation is increased, the Pembina Water Resource Board is not able to participate in the project.

RECOMMENDATION: Continued Study.

FLOOD CONTROL PROJECT

NAME/LOCATION: Sheyenne River Snagging and Clearing (Figure IV-3-1;
Barnes and Eddy Counties Sites 11 and 13)

PUBLIC INVOLVEMENT REGION: Lower Sheyenne and Upper Sheyenne

PURPOSE: Increase Channel Capacity

LEAD STUDY AGENCY: ND State Water Commission/Barnes County Water Resource Board

DESCRIPTION: Snagging and clearing of reaches of the Sheyenne River.

ECONOMIC DEVELOPMENT: Capital Cost $2,700-$4,200 per mile (estimate)
$138,000 for 40 miles (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

As a result of disturbance during implementation of the project, water quality would be degraded resulting in increased turbidity and sediment. Long-term water quality impacts are uncertain. Biological elements would be adversely affected, resulting in loss of riparian vegetation and wildlife habitat, reducing plant diversity and altering ecological balance. The Sheyenne River is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map in Barnes County and Class II - High Priority in Eddy County because of a highly valued sport fishery on channel catfish, crappies, northern pike, sauger, walleye, yellow perch, bullheads, freshwater drum, goldeye, rockbass, and white bass. The river also provides forage fish production and moderate reproduction of several sport fish species. The reach of Sheyenne River in lower Barnes County also is one of the few areas in the state that has a trout-perch population. The fishery will be adversely affected due to loss of protective cover resting habitat.

OTHER SOCIAL EFFECTS:

Increased channel capacity will reduce flooding.

STATUS: The Barnes County Water Resource Board is planning to snag and clear 5.5 miles in the fall of 1982. The project in Eddy County is inactive.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Farmstead Levees

PUBLIC INVOLVEMENT REGION: Goose, Lower Red, Lower Sheyenne, and the Wild Rice

PURPOSE: Flood Control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: The construction of levees around individual farmsteads in the one percent (100-year) floodplain.

ECONOMIC DEVELOPMENT [1/]
Capital Cost $5,600 per levee
Average Annual Cost $410.
Average Annual Benefit $840.
Benefit/Cost Ratio 2.05

ENVIRONMENTAL QUALITY:
No significant environmental impacts will occur to biological elements.

OTHER SOCIAL EFFECTS:
The levees will reduce property damages and provide health and safety for the residents of individual farmsteads against the one percent (100-year) flood.

STATUS:
Local Initiative.

RECOMMENDATION: Implementation.

[1/] Cost and benefits (1979 dollar value) were developed by Gulf South Research Institute for the Army Corps of Engineers.

LAKE RESTORATION/STRUCTURE REPAIR PROJECT

NAME/LOCATION: Homme Reservoir [1/] (Figure IV-3-1; Site #39)
S19, T157, R55
Walsh County

PUBLIC INVOLVEMENT REGION: Lower Red

LEAD STUDY AGENCY: ND State Water Commission/Army Corps of Engineers

DESCRIPTION: Dredge reservoir

ECONOMIC DEVELOPMENT: Capital Cost $2,000 per AF of dredging (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The reservoir fishery will be enhanced by providing improved northern pike spawning habitat.

OTHER SOCIAL EFFECTS:
Water-based recreation would be enhanced, additional flood storage capacity would be provided as well as additional water storage for municipal purposes to the cities of Park River and Grafton.

STATUS:
Recent Investigation.

RECOMMENDATION: Continued Study.

1/ An existing reservoir.

LAKE RESTORATION/STRUCTURE REPAIR PROJECT

NAME/LOCATION: Hansen Dam 1/ (Figure IV-3-1; Site #12)
S30, T139, R58
Barnes County

PUBLIC INVOLVEMENT REGION: Lower Sheyenne

PURPOSE: Multi-purpose Reservoir

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION:	ECONOMIC DEVELOPMENT
Alt. A: Raise dam height 8 feet to elevation 1,350 feet msl Reservoir size: 160 AF storage; 20 surface acres; Use: Multi-purpose use	Capital Cost $68,400 (estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Alt. B: Raise dam height 12 feet to elevation 1,355 feet msl Reservoir size: 250 AF storage; 35 surface acres; Use: multi-purpose use	Capital Cost $134,000 (estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Alt. C: Raise dam height 28 feet to elevation 1,370 feet msl Reservoir size: 960 AF storage; 60 surface acres Use: multi-purpose use	Capital Cost $313,000 (estimate Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The existing reservoir is located on an unnamed tributary to the Sheyenne River. Alternatives A, B, and C will inundate 20, 35, and 60 acres of land, respectively. Terrestrial wildlife will be displaced. This tributary of the Sheyenne River is not rated on the Game and Fish Stream Evaluation Map.

OTHER SOCIAL EFFECTS:

Flood damages immediately downstream from the reservoir will be reduced in addition to possibly reducing flood damages on the Sheyenne River. Alternative C has the best potential for supporting a fishery. A detailed analysis would be required to determine the cost of Alternative C.

STATUS:

Recent Investigation.

RECOMMENDATION: Continued Study of Alternative C with implementation in the 1980-1990 time frame.

1/ An existing reservoir.

REGIONWIDE PROGRAMS FOR THE RED RIVER STATISTICAL PLANNING AREA

NAME: Land Treatment Measures

PUBLIC INVOLVEMENT REGION: All Regions in the Red River SPA

PURPOSE: Control soil erosion and flooding

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Land treatment measures are those practices used to reduce soil erosion and control flooding, and include such features as grassed water ways, shelter belts, and strip cropping.

ECONOMIC DEVELOPMENT:

Land Treatment measures on a total of 2,572,000 acres	Capital Cost $31,384,000
	Annual Cost NA
	Annual Benefit NA
	Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Soil erosion by wind and water will be reduced. Water quality and wildlife habitat will be enhanced.

OTHER SOCIAL EFFECTS:

Damages to agricultural lands caused by wind and water erosion of soil will be reduced.

STATUS:

An ongoing program dependent upon voluntary participation by individual landowners and the availability of cost-share monies from the Soil Conservation Service.

RECOMMENDATION: Implementation as indicated in Table IV-3-5.

NAME: Municipal Waste Treatment Facilities

PUBLIC INVOLVEMENT REGION: Upper Sheyenne plus all Regions in the Red River SPA 1/.

PURPOSE: Enhance the capability for treating municipal wastewater.

LEAD STUDY AGENCY: ND State Health Department

DESCRIPTION: New facilities are required and existing facilities need to be improved before the year 2000 in 68 communities. Two unincorporated communities, and a subdivision in Cass County, serving 184,382 people. Incorporated communities and certain other public entities are eligible for financial assistance through the Construction Grant Program of the Environmental Protection Agency. This Program is administered in North Dakota by the State Health Department. Under this Program, 75 percent of the planning and construction costs for new collection and treatment facili- ties and for upgrading existing wastewater treatment plants are reimbursible. Congress appropriates the money for the Program. The State Health Department disperses North Dakota's share according to a priority list it has developed.

ECONOMIC DEVELOPMENT: Capital Cost $14,227,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The wastewater treatment facilities will improve the water quality of the receiving watercourses. Additional solid waste resulting from the treatment process will need disposal.

OTHER SOCIAL EFFECTS:

The communities will have to furnish 25 percent of the total cost of any new or improved facility.

STATUS:

Ongoing program. Other sources of funding will have to furnish 25 percent of the total cost of new or improved facilities.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

1/ Facilities in the Upper Sheyenne Public Involvement Region are included with the Red River SPA because they occur within the hydrologic boundaries of the Red River Basin.

NAME: Municipal Water Supply Treatment Facilities

PUBLIC INVOLVEMENT REGION: All Regions in the Red River SPA

PURPOSE: Enhance municipal water supply treatment capability

LEAD STUDY AGENCY: ND State Health Department

DESCRIPTION: Additional or improved treatment facilities are needed in seven communities serving 138,782 people in order to meet the recommended Standards for Safe Drinking Water Supplies set by the Environmental Protection Agency.

ECONOMIC DEVELOPMENT: Capital Cost $3,915,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The additional or improved water supply treatment facilities will enhance the quality of municipal water supplies. Additional solid wastes generated by the treatment processes will require disposal.

OTHER SOCIAL EFFECTS:
Municipal water supplies will be improved, enhancing the safety, health and well-being, and quality of life for community residents. The only funding available is currently derived from the tax base of the community. No State or Federal funds are currently available.

STATUS:
Facilities are constructed on an individual basis as community funding allows.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

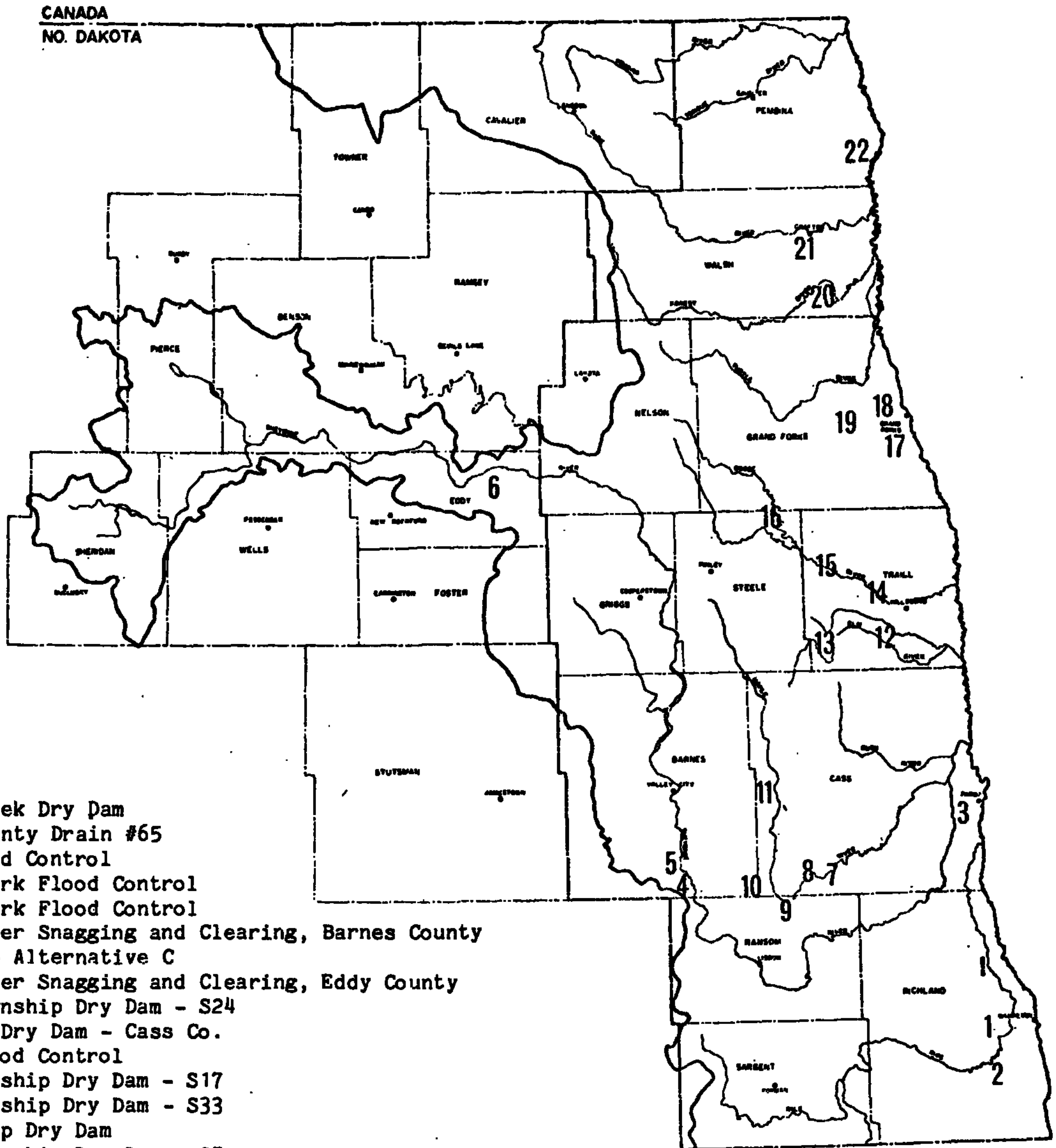
TABLE IV-3-5 RECOMMENDED PLAN AND ESTIMATED INVESTMENTS IN 1980 DOLLARS RED RIVER BASIN

Water and Related Land Resources Category	Units	Composition and Estimated Investments (All Values are Incremental)														
		1980-1990 (Early Action Program)					1990-2000					2000-2020				
			Initial Investment		Annual O.M.&R.			Initial Investment		Annual O.M.&R.			Initial Investment		Annual O.M.&R.	
		Quantity	Federal ($1000)	State/Local ($1000)	Federal ($1000)	State/Local ($1000)	Quantity	Federal ($1000)	State/Local ($1000)	Federal ($1000)	State/Local ($1000)	Quantity	Federal ($1000)	State/Local ($1000)	Federal ($1000)	State/Local ($1000)
SURFACE WATER CONTROL																
Multi-purpose Reservoir																
Total Storage	1000AF	29.1[1][3]	--	4,703[2]	--	47	45.9	--	9,157	--	92	0.5	--	252	--	3
Flood Control	1000AF	(7.1)					(26.2)									
Other Purpose[4]	1000AF	(21.6)					(19.7)					(0.5)				
Single Purpose Reservoir																
Flood Control	1000AF	111.4	--	11,980	--	119.8	67.8[5]	--	14,185	--	142	70.3	--	8,173	--	82
Irrigation	1000AF															
Municipal	1000AF	0.07	--	188	--	2										
Recreation	1000AF															
Instream Control																
Channel Improvement	Miles	40	--	138	--	7	33	250	181	--	22					
Levees, Floodwalls, etc.[6]	Each	6	3,337	1,034	--	87	2	1,745	357	--	42	3	1,245	1,058	--	46
Streambank Stabilization	Each															
Diversion																
Irrigation	1000AF															
Municipal	1000AF															
Multi-feature Project[7]	Each	5	19,352[8]	3,116[8]	--	367	1	342	114	--	5					
RELATED LAND PROGRAMS																
Drainage	Each	1	--	354	--	5										
Irrigation																
Private	1000Ac															
Public	1000Ac															
ENVIRONMENTAL AND RESOURCE ENHANCEMENT[9]																
Protection and Management[10]																
Cropland	1000Ac	1058	8,729	2,909	NA	NA	705	5,816	1,939	NA	NA	424	3,498	1,166	NA	NA
Pasture	1000Ac	68	510	170	NA	NA	46	345	115	NA	NA	46	345	115	NA	NA
Range	1000Ac	71	533	177	NA	NA	48	360	120	NA	NA	49	368	122	NA	NA
Forest	1000Ac	24	1,278	426	NA	NA	16	852	284	NA	NA	17	905	302	NA	NA
Outdoor Recreation																
Stream Preservation	Miles															
Facilities	Each															
Waste Water Management[11] Municipal	1000PS[12]	184.4	10,670	3,557	--	3,319										
Water Supply Treatment																
Municipal	1000PS	138.8	--	3,915	--	196										
ADDITIONS AND MODIFICATIONS TO EXISTING PROJECTS																
Reservoir Storage	Each	1		313	--	3										
TOTAL COST			44,409	32,980	--	4,152.8		9,710	26,452	--	303		6,361	11,188	--	131

1/ Total includes 1,000 AF of additional storage at Hansen Dam from the Category - Additions and Modifications to Existing Projects.
2/ Cost does not include major modification to an existing highway that is involved with the Norway Township Dam in Traill County.
3/ Figures in parentheses are non-additive.
4/ Storage included for municipal and industrial water supply, water quality control, sedimentation, fish and wildlife, and recreation.
5/ Total storage reflects storage available from multi-feature projects.
6/ Cost does not include individual farmstead levees.
7/ Multi-feature projects are defined as those projects consisting of more than one element, including structural and non-structural measures. Example: a dam and diversion floodway.
8/ Included is the SCS Grand Forks County Rural Flood Prevention project which is currently being installed. This is a multi-year project and total funding has not been appropriated.
9/ The data used to compute the figures displayed in this category are useable on a County basis; therefore the figures are for the Red River Statistical Planning Area (Figure I-1-2) rather than the Basin.
10/ Land Treatment measures have been accelerated from the Future Without Plan Projections (Table III-1-3) as follows: 1980-1990 figures accelerated by 1.5 percent, 1990-2000 figures by 1.0 percent, 2000-2020 figures by 0.5 percent.
11/ Some of the projects will be constructed in the 1990-2000 time frame. However, since the construction date of each specific project could not be determined, all costs have been placed in the 1980-1990 time frame. Included are communities in the Red River SPA and the Upper Sheyenne Public Involvement Region (Figure I-1-3).
12/ P.S. represents population served based upon the highest projection.

FIGURE IV-3-2 RED RIVER BASIN

LOCATION OF RECOMMENDED PLAN - EARLY ACTION PROGRAM



1. Antelope Creek Dry Dam
2. Richland County Drain #65
3. Harwood Flood Control
3. Brooktree Park Flood Control
3. Rivertree Park Flood Control
4. Sheyenne River Snagging and Clearing, Barnes County
5. Hansen Dam - Alternative C
6. Sheyenne River Snagging and Clearing, Eddy County
7. Highland Township Dry Dam - S24
8. Maple River Dry Dam - Cass Co.
9. Enderlin Flood Control
10. Pontiac Township Dry Dam - S17
10. Pontiac Township Dry Dam - S33
11. Hill Township Dry Dam
12. Bohnsack Township Dry Dam - S5
13. Norman Township Dry Dam
14. Norway Township Dam
15. South Branch Goose River Reservoir
16. Newburg Township Dry Dam
17. Grand Forks County Rural Flood Prevention
18. Belmont Road Dike
18. English Coulee Watershed Project
18. English Coulee Flood Control Study
19. Emerado Flood Control
20. Minto Dam
21. Grafton Flood Control
22. Bowesmont Flood Control

TABLE IV-3-6 RED RIVER BASIN RECOMMENDED PLAN - EARLY ACTION PROGRAM

Program	Description & Purpose	Initial Costs "1980 Dollars" Federal	Initial Costs State/Local	Initial Costs Total	Annual Operation, Maintenance, and Replacement Costs "1980 Dollars" Federal	Annual State/Local	Annual Total
SURFACE WATER CONTROL Multi-purpose Reservoirs	South Branch Goose River Reservoir - This 20,650 AF reservoir would be located in Traill County 3.5 miles west of Portland.	-	$4,534,500	$4,534,500	-	$45,000	$45,000
	Norway Township Dam - This reservoir would store 980 AF and be located two miles south and five miles east of Mayville in Traill County.	-	$168,000 [1/]	$168,000 [1/]	-	$1,700	$1,700
Single Purpose Reservoirs	Norman Township Dry Dam - This reservoir would store 700 AF and be located on a tributary of the Elm River seven miles south of Mayville in Traill County.	-	$190,000	$190,000	-	$1,900	$1,900
	Bohnsack Township Dry Dam Section 5 - This reservoir would store 1,085 AF. It would be located on the Elm River six miles south and 4.5 miles west of Hillsboro in Traill County.	-	$300,000	$300,000	-	$3,000	$3,000
	Newburg Township Dry Dam - This 32,000 AF reservoir would be located on the North Branch of the Goose River in Steele County one mile west and 4.5 miles south of Northwood.	-	$2,750,000	$2,750,000	-	$27,500	$27,500
	Minto Dam - This reservoir would store 68 AF and be located on the Forest River near Minto in Walsh County.	-	$188,000	$188,000	-	$2,000	$2,000
	Maple River Dry Dam (Cass County) - This 60,000 AF reservoir would be located seven miles east and four miles north of Enderlin in Cass County.	-	$4,500,000	$4,500,000	-	$45,000	$45,000
	Pontiac Township Dry Dam Section 33 - This reservoir would store 2,500 AF and be located on a tributary of the Maple River one mile northwest of Enderlin in Cass County.	-	$1,600,000	$1,600,000	-	$16,000	$16,000
			$825,000	$825,000	-	$8,300	$8,300

Program	Description & Purpose	Initial Costs "1980 Dollars" Federal	State/Local	Total	Annual Operation, Maintenance, and Replacement Costs "1980 Dollars" Federal	State/Local	Total
	Hill Township Dry Dam - This 4,200 AF reservoir would be located on a tributary of the Maple River four miles south and one mile east of Tower City in Cass County.	-	$1,000,000	$1,000,000	-	$10,000	$10,000
	Highland Township Dry Dam Section 24 - This reservoir would store 2,650 AF and would be located on a tributary of the Maple River eight miles east and 2.5 miles north of Enderlin in Cass County.	-	$795,000	$795,000	-	$8,000	$8,000
	Antelope Creek Dry Dam - This reservoir would store 300 AF and would be located three miles north of Mooreton in Richland County.	-	$20,000 2/	$20,000 2/	-	$200	$200
<u>Instream Control</u> Channel Improvements	Sheyenne River Snagging and Clearing - Many reaches of the River through Barnes and Eddy Counties are in need of snagging and clearing.	-	$138,000	$138,000	-	$6,900	$6,900
Levees, Floodwall, etc.	Belmont Road Dike - This project involves constructing a dike on the south edge of the City of Grand Forks, Grand Forks County to provide protection from backwater of the Red River.	-	$350,000	$350,000	-	$7,000	$7,000
	Bowesmont Flood Control - Construction of a levee would provide protection in Bowesmont, Pembina County against the one percent (100-year) frequency flood on the Red River.	$141,930	$29,070	$171,000	-	$3,420	$3,420
	Enderlin Flood Control - Construction of levees would provide protection against the 140-year frequency flood event on the Maple River.	$2,988,000	$612,000	$3,600,000		$72,000	$72,000
	Harwood Flood Control - Construction of a levee would provide protection against the one percent (100-year) frequency flood event on the Red River.	$99,600	$20,400	$120,000	-	$2,400	$2,400
	Brooktree Park Flood Control - Construction of levees would provide protection against the one percent (100-year) frequency flood event on the Red River.	$53,950	$11,050	$65,000	-	$1,300	$1,300

Program	Description & Purpose	Initial Costs "1980 Dollars" Federal	State/Local	Total	Annual Operation, Maintenance, and Replacement Costs "1980 Dollars" Federal	State/Local	Total
	Rivertree Park Flood Control - Construction of levees would provide protection against the one percent (100-year) frequency flood event on the Red River.	$53,950	$11,050	$65,000	-	$1,300	$1,300
	Farmstead levees - Construction of levees around individual farmsteads would provide protection in the one percent (100-year) frequency floodplain for the Goose, Lower Red, Lower Sheyenne, and Wild Rice Public Involvement Regions. The cost is estimated at $5,600 per individual levee.	NA	NA	NA	-	NA	NA
Multi-Feature Project	Grand Forks County Rural Flood Prevention Program 3/ - This multi-year project is currently being installed and involves non-structural measures including floodproofing a dike.	$561,400	$240,600	$802,000	-	$3,885	$3,885
	English Coulee Watershed Project 4/ - This SCS (PL-566) Project involves a dam and diversion floodway in Grand Forks County.	$2,728,800	$303,200	$3,032,000	-	$20,000	$20,000
	English Coulee Flood Control Study - This Corps of Engineers 205 Study includes a control structure and non-structural measures to provide protection for Grand Forks from Red River backwaters and flooding from English Coulee.	$2,075,000	$425,000	$2,500,000	-	$25,000	$25,000
	Grafton Flood Control - This project involves constructing a flood bypass channel north of Grafton and a tie-back levee upstream and to the west of Grafton in Walsh County.	$13,776,000	$2,124,000	$15,900,000	-	$318,000	$318,000
	Emerado Flood Control - This project involves construction of a floodway and dike for Emerado which would provide protection against the one percent (100-year) frequency flood event.	$210,600	$23,400	$234,000		$500	$500
RELATED LAND PROGRAMS Drainage	Richland County Drain #65 - This project involves constructing a channel parallel to the existing channel in Richland County.	-	$354,000	$354,000	-	$5,000	$5,000

Program	Description & Purpose	Initial Costs "1980 Dollars" Federal	State/Local	Total	Annual Operation, Maintenance, and Replacement Costs "1980 Dollars" Federal	State/Local	Total
ENVIRONMENTAL AND RESOURCE ENHANCEMENT Protection and Management	Land Treatment Measures - Measures are needed to reduce soil erosion on 1,221,000 acres of land in the Red River SPA.	$11,049,000	$3,683,000	$14,732,000	NA	NA	NA
Waste Water Management Municipal 5/	Development of new and/or improvement of existing municipal waste treatment facilities is needed for 68 communities serving 184,382 people, in addition to three unincorporated communities.	$10,670,250	$3,556,750	$14,227,000	-	$3,318,876	$3,318,876
Water Supply Treatment Municipal 6/	Development of additional or improvement of existing treatment facilities is needed to meet the recommended limits for a domestic water supply in seven communities serving 138,782 people.	-	$3,915,000	$3,915,000		$195,800	$195,800
ADDITIONS AND MODIFICATIONS TO EXISTING PROJECTS Reservoir Storage	Hansen Dam Alternative C - Storage would be increased to 960 AF by raising the dam height 28 feet. The dam is located six miles south of Valley City in Barnes County.	-	$313,000	$313,000	-	$3,000	$3,000

1/ Cost does not include modification to existing highways.

2/ The cost may increase substantially due to the type of emergency and principal spillways needed to accommodate high flows.

3/ A multi-year program that is currently being installed. Total project funding has not been appropriated.

4/ The project is currently being implemented.

5/ As identified by the ND State Health Department, some of the projects will be constructed in the 1990-2000 time frame. However, since the construction date of each specific project could not be determined, all costs have been placed in the 1980-1990 time frame. The communities in the Red River Statistical Planning Area (SPA) and also the Upper Sheyenne Public Involvement Region include: Sharon, Grand Forks, Larimore, Hunter, Northwood, Hillsboro, Mayville, Buxton, Hatton, Finley, Grandin, Hope, Galesburg, Edinburg, Cavalier, Fordville, Walhalla, Forest River, Grafton, Hoople, Manvel, Adams, Crystal, Park River, Conway, Hamilton, Hensel, Neche, Gilby, St. Thomas, Litchville, Arthur, Valley City, Harwood, Kathryn, Casselton, Alice, Ayr, Buffalo, Davenport, Kindred, Leonard, Nome, Reile's Acres, Rogers, Walcott, Oriska, Sanborn, Amenia, Argusville, Fingal, Horace, Fargo, Enderlin, Esmond, Goodrich, Cooperstown, Luverne, Maddock, Binford, Wimbledon, Lidgerwood, Abercrombie, Mooreton, Great Bend, Fairmont, Milnor, and Dwight, in addition to two unincorporated communities - Chaffee and Arvilla, plus a subdivision in Stanley Township in Cass County.

6/ As identified by the ND State Health Department, the communities in the Red River SPA include: Grand Forks, Walhalla, Fargo, Kindred, Forman, Gwinner, and Lidgerwood.

ADDITIONAL SPECIAL STUDIES AND PROGRAMS -

1) Multi-purpose reservoirs requiring continued study include: A) Finley East Dam - a 1500 acre-foot (AF) reservoir located six miles east and three miles north of Finley in Steele County; B) Northwood Dam - a 510 AF reservoir located six miles west and three miles north of Northwood in Grand Forks County; and C) Moellenkamp Dam - a 490 AF reservoir located four miles south and three miles west of Lisbon in Ransom County.

2) The Lower Red Citizens Advisory Board recommended that all potential retention structures be investigated from a total systems-type perspective; where the benefits accruing from one project in excess of what is needed for equity can be used to bolster another project whose benefit/cost ratio falls below equity. Reservoirs to be investigated include:

   A) Lundene (Tiber-Vesta) Dam - a 17,700 AF multi-purpose reservoir located three miles north of Adams in Walsh County.

   B) Langerud Dry Dam - a 5,000 AF dry dam located two miles northeast of Edinburg in Walsh County.

   C) South Milton Dry Dam - a 7,370 AF dry dam located two miles south and four miles east of Milton in Cavalier County.

   D) Milton Dry Dam - a 2,308 AF dry dam located one mile north of Milton in Cavalier County.

   E) Dry Dam below Sarnia Dam - a 1,038 AF dry dam located 10 miles north and three miles east of Michigan in Nelson County.

   F) Cart Creek Dry Dams - three dry dams totaling 300 AF storage located three miles west of Mountain in Pembina County.

   G) Fremont Township Dry Dam - a 410 AF dry dam, including channel improvements and a dike, located 16 miles east and 14 miles north of Walhalla in Cavalier County.

3) Single-purpose reservoirs requiring additional study include:

   A) Hope Dry Dam - a 150 AF dry dam located one mile south and three miles west of Hope in Steele County.

   B) Kellys Slough Dam - a 6,250 AF dam located on Kellys Slough National Wildlife Refuge, nine miles west and two miles north of Grand Forks in Grand Forks County. This project also includes a diversion from Saltwater Coulee.

   C) Maple River Dry Dam - a 4,600 AF dry dam located four miles south of Hope in Steele County.

D) Swan-Buffalo Dry Dam - a 850 AF dry dam located five miles south of Wheatland in Cass County.

E) Rush River Dry Dam - a 560 AF dry dam located two miles south and five miles west of Hunter, Cass County.

F) Northland Township Dry Dam - a 1,060 AF dry dam located three miles north of Fort Ransom in Ransom County.

G) Billings Dry Dam - a 1,080 AF dry dam located four miles east and one mile north of Fort Ransom, Ransom County.

H) Lund-Steen Dry Dam - a 2,300 AF dry dam located four miles east and two miles south of Fort Ransom in Ransom County.

I) Antelope Creek Dry Dam - a 300 AF dry dam located three miles north of Mooreton, Richland County.

J) Bohnsack Township Dry Dam Section 25 - a 9,367 AF dry dam located 1 1/2 miles north and 3 1/2 miles west of Grandin in Traill County.

K) Gunkel Township Dry Dam - a 943 AF dry dam located four miles east and one mile north of Arthur in Cass County.

L) Enger Township Dry Dam - a 55,000 AF dry dam located 4 1/2 miles south and one mile west of Hatton in Steele County.

M) Watson Township Dry Dam - a 1,100 AF dry dam located 1 1/2 miles north and six miles west of Leonard in Cass County.

N) Highland Township Dry Dam Section 16 - a 1,400 AF dry dam located four miles east and 3 1/2 miles north of Enderlin in Cass County.

O) Moore Township Dry Dam - a 5,500 AF dry dam located four miles west and 1 1/2 miles south of Enderlin in Ransom County.

P) Maple River Dry Dam (Cass County) - a 60,000 AF dry dam located seven miles east and four miles north of Enderlin, Cass County.

4) Continued study is recommended for snagging and clearing 33 miles of the Pembina River from Neche in Pembina County to the mouth of the river.

5) Continued study is recommended for 46 miles of channel improvements on the Red River from Fargo in Cass County north to Perley, Minnesota.

6) Continued study of all water supply alternatives, including a new downstream reservoir, is recommended to assure an improved water supply for the City of Minto in Walsh County.

7) Further investigation is recommended for Bemont Road Dike which would be located on the south edge of the City of Grand Forks in Grand Forks County.

8) Future construction of levees should be studied for Drayton, Neche, Argusville, Mapleton, and First and Third Avenues along Second Street in North Fargo. These levees would provide protection from the one percent (100-year) frequency flood event.

9) Richland County Drain #65 should be studied in more detail with implementation of the most favorable alternative. A viable solution to the problem would reduce agricultural flood damages.

10) Continued study into lake restoration of Homme Reservoir is recommended, including dredging of the reservoir to enhance water-based recreation, fishery value, and flood control storage.

11) Consensus was not reached among the Public Involvement Regions of the Red River SPA to support the Weather Modification Programs. The regions supporting the programs include the Upper and Lower Sheyenne Public Involvement Regions.

12) A study is recommended to determine the feasibility of constructing small dams in the Sheyenne River watershed to retain spring runoff which could be released throughout the year to enhance streamflow and water quality. This would include lowhead dams on the river mainstem.

13) The Corps of Engineer's tentative plan for flood control on the Sheyenne River is supported with the exception that the Lower Sheyenne Citizens Advisory Board opposed raising Baldhill Dam.

14) Recommended is studying the possibility of the Fish and Wildlife Service or North Dakota Game and Fish buying Rush Lake lands in Cavalier County for habitat purposes.

15) The Upper Sheyenne Board recommends that fish and wildlife easements should include annual rent payments and be limited in term and/or the lease should terminate with a change in land ownership.

16) Studies should be conducted to determine the extent to which flooding could be reduced by the installation of control features on legal drains. A watershed approach should be emphasized in the design of future drainage improvement projects.

17) It is recommended that the current level of research regarding wetland habitat values be accelerated.

18) The Wild Rice Citizens Advisory Board recommends that the State Water Commission re-examine the manner in which water permits are granted to irrigators or other heavy water users where high potential exists for such withdrawals to adversely impact adjacent domestic wells.

19) It is recommended that reaches of the Forest and Park Rivers be identified for snagging and clearing.

20) The Lower Red Citizens Advisory Board recommends that the State seek needed changes to the Principal and Procedure Guidelines to Federal Agencies in determining the feasibility of federal water projects for the benefit and protection of rural areas.

21) The Lower Red Citizens Advisory Board recommends researching the amount of annual rainfall and spring snowmelt runoff for all past years of record in the Red River and its main tributary basins, in addition to conducting pilot studies on a few minor agriculture drainage areas in upper parts of the river basins by monitoring spring run-off flows. The study would be conducted to determine if the use of control structures at available sites could reduce flood damages and be cost effective if done on a broad scale.

22) The Lower Sheyenne Citizens Advisory Board recommends that the State Water Commission draft a bill to present to the Legislature providing compensation or an incentive program to landowners willing to retain water on their land during peak flood periods.

23) Farmsteads located in the 100-year floodplain should be identified and funding avenues for constructing individual farmsteads levees should be investigated.

PROBLEMS SUMMARY

TABLE IV-4-1 WATER MANAGEMENT PROBLEMS - DEVILS LAKE BASIN

Problem Type	Public Involvement Region	Location	General Description
Water Supply	Devils Lake	Devils Lake Statistical Planning Area	Rural water systems are needed to meet the water quantity and quality requirements of rural communities and farms.
Water Quality	Devils Lake	Devils Lake - Ramsey and Benson Counties	Studies indicate that Devils Lake is suffering from a "sink effect" in which nutrients, especially phosphorus, have built up in sediment on the lake's bottom. Agricultural runoff and wind erosion are the prime contributors of nutrients to the lake. The infusion of sewage into the lake has aggravated the condition and further contributed to degradation of water quality.
Flooding	Devils Lake	Hurricane L. T157, R68, 13 miles west and five miles south of Cando, Towner County	Frequent flooding of agricultural lands has occurred due to high water levels in Hurricane Lake. Construction of the Hurricane Lake outlet control channel is continuing while negotiations are proceeding with the various parties to solve any problems which may exist.
Flooding	Devils Lake	Devils Lake - Ramsey and Benson Counties	Major fluctuations in the water level of Devils Lake have occurred and threaten the City of Devils Lake, shoreline property, and several roads. The Army Corps of Engineers proposed a flood control project involving a Devils Lake outlet in 1980.
Flooding	Devils Lake	Lake Alice, Lake Irvine, and Mauvais Coulee - northwestern Ramsey County	Flooding has occurred due to inadequate capacities and outlets of Lake Alice, Lake Irvine, and Mauvais Coulee. Nineteen miles of channel improvements, a new lake control structure, and upgrading and replacing insufficient roadway openings have been proposed by the Devils Lake Advisory Committee.
Flooding	Devils Lake	Southwest Cavalier County	Sheet flooding results when rapid snowmelt or heavy rains occur.
Flooding	Devils Lake	Badger Creek - northern Towner County	Sheet flooding results when rapid snowmelt or heavy rains occur. Channel clearing has been suggested for this creek.
Flooding	Devils Lake	Devils Lake Statistical Planning Area	A mechanism is needed to coordinate storm water management between city and surrounding non-city areas.
Drainage	Devils Lake	Southwest Cavalier County	Numerous wildlife easements in this area effectively block drainage. County, State, and Federal help is needed to allow the non-easement landowners to drain water through easement areas to Devils Lake.
Erosion	Devils Lake	Devils Lake Statistical Planning Area	The installation of land treatment practices is considered essential for the protection and preservation of the basic soil resources, and for assisting in the sustained production of food and fiber.

Problem Type	Public Involvement Region	Location	General Description
Dam Deterioration	Devils Lake	Big Coulee (Bisbee) Dam - northeast of Bisbee in Towner County	In recent years, Big Coulee (Bisbee) Dam has had structural problems due to heavy runoff. The Water Resource Board has decided to raise the structure four feet. They are now in the process of trying to raise their share of the money needed to fund the project.
Fish and Wildlife Habitat Destruction	Devils Lake	Devils Lake Statistical Planning Area	Serious long-term fish and wildlife problems have occurred due to changes in agricultural land-use practices.

OPPORTUNITIES SUMMARY

TABLE IV-4-2 WATER DEVELOPMENT OPPORTUNITIES - DEVILS LAKE BASIN

Opportunity	Public Involvement Region	Location	General Description
Single-Purpose storage structure(s)	Devils Lake	Devils Lake Statistical Planning Area	Efforts to improve natural channels for accelerated flows and a search for sites to construct small impoundments must continue at a faster pace. These impoundments could be useful as settling basins as well as flood control structures. Studies will provide further information regarding the types of structures and the benefits they may provide.
Irrigation (Sewage-lagoon waters)	Devils Lake	Devils Lake Statistical Planning Area	The possibility of using community sewage lagoon waters to irrigate adjacent farmlands should be investigated.
Land Management Practice (State Water Bank Program)	Devils Lake	Devils Lake Statistical Planning Area	The State Water Bank Program, if funded, would help preserve, restore, and improve inland fresh water and adjacent areas in important migratory waterfowl nesting and breeding areas. Under the program, landowners receive annual payments for conserving and protecting wetlands.
Land Management Practice (Conservation)	Devils Lake	Devils Lake Statistical Planning Area	There is a lack of water and soil conservation practices on upstream tributaries which result in gullies, silting, and flooding. Non-structural and structural measures were proposed in the 1976 Devils Lake Basin Study.
Land Management Practice (Waterfowl production)	Devils Lake	Devils Lake Statistical Planning Area	Waterfowl production could be increased if more attention is paid to developing habitat and managing wetlands now under federal control.
Drainage	Devils Lake	Devils Lake Statistical Planning Area	Sound management of an area's surface waters can be enhanced through the use of a watershed or "systems" approach to drainage.
Lake Restoration (Stump Lake)	Devils Lake	Stump Lake - Nelson County	Restoration of Stump Lake has been proposed for many years under the plan for Garrison Diversion. The operation plan for Devils Lake under Garrison Diversion is currently being developed.
Control Outlet (Stump Lake)	Devils Lake	Stump Lake and Devils Lake - Ramsey and Nelson Counties	An outlet from Devils Lake to Stump Lake could stabilize the level of Devils Lake and freshen the west portion of Stump Lake. By diking across Stump Lake, the lake could be separated into a fresh west bay and an east sump for saline water.

Opportunity	Public Involvement Region	Location	General Description
Fish Hatcheries	Devils Lake	Devils Lake Statistical Planning Area	Fish hatcheries around the state need rejuvenating and/or enlarging. More modern facilities are needed.
Irrigation (Education)	Devils Lake	Devils Lake Statistical Planning Area	Seminars conducted on a local level by knowledgeable representatives of the State Water Commission, the State Agricultural Department, and other agencies or irrigators could educate landowners on the advantages of irrigation.
Irrigation (Ground-water information)	Devils Lake	Devils Lake Statistical Planning Area	Efforts should be made to gain more specific information on ground water reserves in order to expedite the irrigation permitting process.
Land Management Practice (Plugging wetlands)	Devils Lake	Devils Lake Statistical Planning Area	The possibility of plugging drained wetlands in the years when the land is summer fallowed should be explored. This practice could decrease erosion and the movement of nutrients, fertilizers, and pesticides from the land.

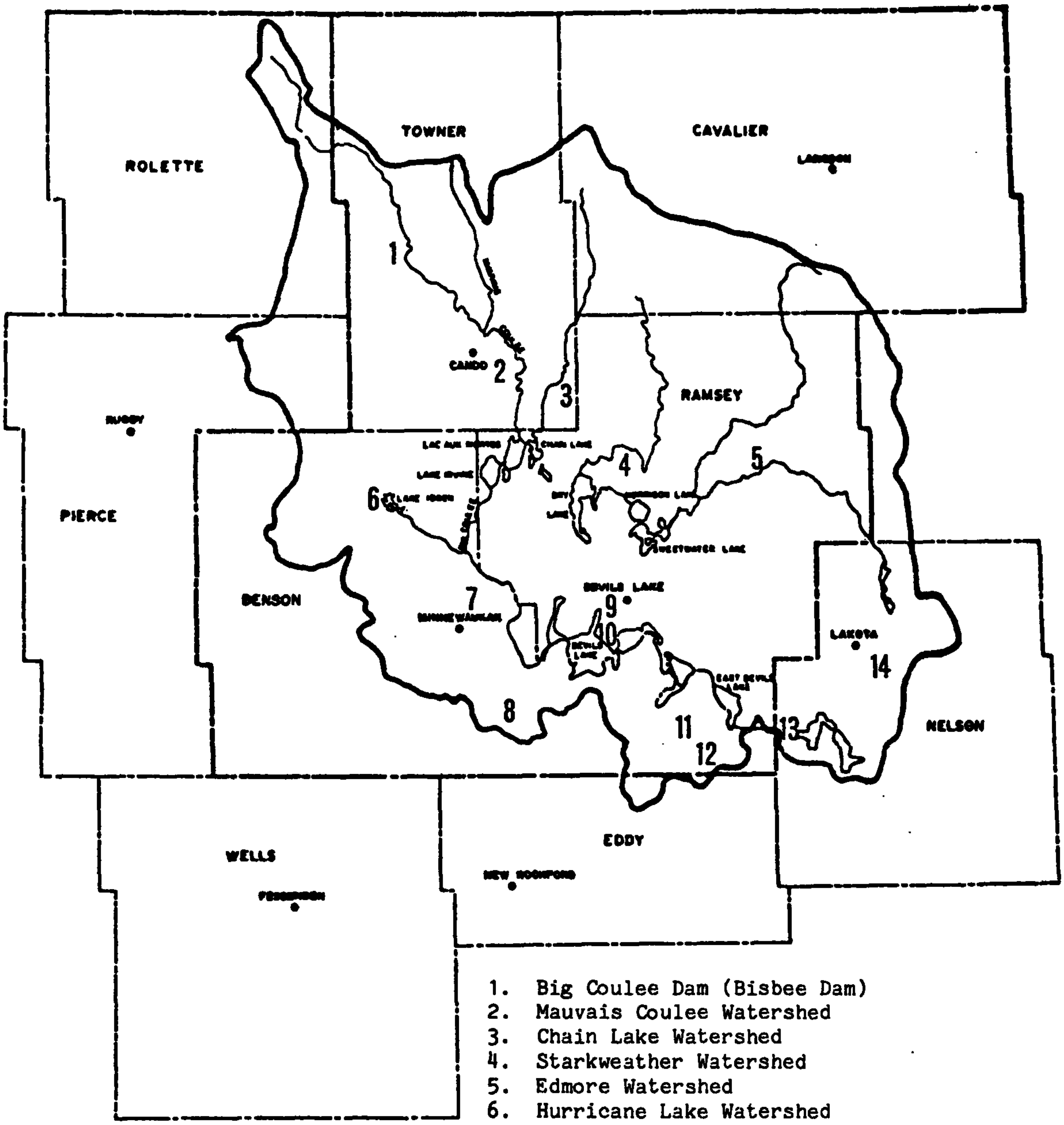
NON-RECOMMENDED STUDY ALTERNATIVES

TABLE IV-4-3 NON-RECOMMENDED STUDY ALTERNATIVES - DEVILS LAKE BASIN

Alternative	Public Involvement Region	Location	General Description
Weather Modification Programs	Devils Lake	Statewide	A) The North Dakota Cloud Modification Program. B) Drought Management Strategies. C) Public Awareness of Weather Modification.

FIGURE IV-4-1 DEVILS LAKE BASIN

LOCATION OF RECOMMENDED STUDY ALTERNATIVES



1. Big Coulee Dam (Bisbee Dam)
2. Mauvais Coulee Watershed
3. Chain Lake Watershed
4. Starkweather Watershed
5. Edmore Watershed
6. Hurricane Lake Watershed
7. Comstock Watershed
8. Devils Lake Outlet via West Bay
9. Creel Bay Levee
10. East Bay (Camp Grafton) Recreation Facility
11. South Slope Watershed
12. Devils Lake Outlet via East Devils Lake
13. Devils Lake Outlet Channel via Stump Lake
14. Stump Lake Watershed

TABLE IV-4-4 RECOMMENDED STUDY ALTERNATIVES - BENEFICIAL AND ADVERSE EFFECTS OF THE POTENTIAL PROJECTS IN THE DEVILS LAKE BASIN

FLOOD CONTROL PROJECT

NAME/LOCATION: Hurricane Lake Watershed (Figure IV-4-1; Site #6)
Benson, Pierce, and
Rolette Counties

PUBLIC INVOLVEMENT REGION: Devils Lake

PURPOSE: Flood control

LEAD STUDY AGENCY: Devils Lake Advisory Committee

DESCRIPTION: Twenty-four miles of channel improvements, two new lake control structures, plus modify one existing lake control structure.

ECONOMIC DEVELOPMENT [1/]: Capital Cost $999,800
Average Annual Cost $73,600
Average Annual Benefit $158,200
Benefit/Cost Ratio 2.15

ENVIRONMENTAL QUALITY:

Earthwork associated with channelization will destroy existing riparian vegetation. Replacement vegetation will represent a shift in plant species and a modification of the area's ecosystem. Resultant long-term changes in resident wildlife populations have not been determined. Water quality will be degraded during and for a period of time after construction due to increased turbidity and sediment. Long-term changes in water quality are uncertain.

OTHER SOCIAL EFFECTS:

Flood damages to agricultural land would be reduced creating an average annual income benefit distribution of $158,200.

STATUS:

Phase development for the lake control structure is in progress.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

[1/] "Devils Lake Basin Study", 1976. Cost and benefits were updated to 1979 dollar value by Gulf South Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Comstock Watershed (Figure IV-4-1; Site #7)
Benson County

PUBLIC INVOLVEMENT REGION: Devils Lake

PURPOSE: Flood control

LEAD STUDY AGENCY: Devils Lake Advisory Committee

DESCRIPTION: Five miles of channel improvement, one grade stabilization structure.

ECONOMIC DEVELOPMENT 1/: Capital Cost $193,000
Average Annual Cost $14,200
Average Annual Benefit $31,700
Benefit/Cost Ratio 2.23

ENVIRONMENTAL QUALITY:

Earthwork associated with channelization will destroy existing riparian vegetation. Replacement vegetation will represent a shift in plant species and a modification of the area's ecosystem. Resultant long-term changes in resident wildlife populations have not been determined. Water quality will be degraded during and for a period of time after construction due to increased turbidity and sediment. Long-term changes in water quality are uncertain.

OTHER SOCIAL EFFECTS:

Flood damages to agricultural land would be reduced creating an average annual income benefit distribution of $31,700.

STATUS: Inactive.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

1/ "Devils Lake Basin Study", 1976. Cost and benefits were updated to 1979 dollar value by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Stump Lake Watershed (Figure IV-4-1; Site #14)
Nelson and Ramsey Counties

PUBLIC INVOLVEMENT REGION: Devils Lake

PURPOSE: Flood Control

LEAD STUDY AGENCY: Devils Lake Advisory Committee

DESCRIPTION: Twenty-six miles of channel improvements, one lake control structure, and two control structures on wetlands.

ECONOMIC DEVELOPMENT 1/: Capital Cost $1,451,000
Average Annual Cost $106,800
Average Annual Benefit $237,300
Benefit/Cost Ratio 2.22

ENVIRONMENTAL QUALITY:

Earthwork associated with channelization will destroy existing riparian vegetation. Replacement vegetation will represent a shift in plant species and a modification of the area's ecosystem. Resultant long-term changes in resident wildlife populations have not been determined. Water quality will be degraded during and for a period of time after construction due to increased turbidity and sediment. Long-term changes in water quality are uncertain.

OTHER SOCIAL EFFECTS:

Flood damages to agricultural lands will be reduced creating an average annual income benefit distribution of $237,300.

STATUS: Inactive.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

1/ "Devils Lake Basin Study", 1976. Cost and benefits were updated to 1979 dollar value by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Edmore Watershed (Figure IV-4-1; Site #5)
Ramsey County

PUBLIC INVOLVEMENT REGION: Devils Lake

PURPOSE: Flood control

LEAD STUDY AGENCY: Devils Lake Advisory Committee

DESCRIPTION: Fifty-five miles of channel improvements, and grade stabilization structures.

ECONOMIC DEVELOPMENT 1/: Capital Cost $4,651,000
Average Annual Cost $342,400
Average Annual Benefit $435,000
Benefit/Cost Ratio 1.27

ENVIRONMENTAL QUALITY:

Earthwork associated with channelization will destroy existing riparian vegetation. Replacement vegetation will represent a shift in plant species and a modification of the area's ecosystem. Resultant long-term changes in resident wildlife populations have not been determined. Water quality will be degraded during and for a period of time after construction due to increased turbidity and sediment. Long-term changes in water quality are uncertain.

OTHER SOCIAL EFFECTS:
Flood damages to agricultural land will be reduced creating an average annual income benefit distribution of $435,000.

STATUS: Inactive.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

1/ "Devils Lake Basin Study", 1976. Cost and benefits were updated to 1979 dollar value by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Starkweather Watershed (Figure IV-4-1; Site #4)
Ramsey and Cavalier Counties

PUBLIC INVOLVEMENT REGION: Devils Lake

PURPOSE: Flood control

LEAD STUDY AGENCY: Devils Lake Advisory Committee

DESCRIPTION: Fifty-six miles of channel improvements.

ECONOMIC DEVELOPMENT 1/: Capital Cost $10,046,000
Average Annual Cost $739,500
Average Annual Benefit $737,800
Benefit/Cost Ratio 1.00

ENVIRONMENTAL QUALITY:
Earthwork associated with channelization will destroy existing riparian vegetation. Replacement vegetation will represent a shift in plant species and a modification of the area's ecosystem. Resultant long-term changes in resident wildlife populations have not been determined. Water quality will be degraded during and for a period of time after construction due to increased turbidity and sediment. Long-term changes in water quality are uncertain.

OTHER SOCIAL EFFECTS:
Flood damages to agricultural land will be reduced creating an average annual income benefit distribution of $737,800.

STATUS: Inactive.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

1/ "Devils Lake Basin Study", 1976. Cost and benefits were updated to 1979 dollar value by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Chain Lake Watershed (Figure IV-4-1; Site #3)
Towner, Cavalier, and
Ramsey Counties

PUBLIC INVOLVEMENT REGION: Devils Lake

PURPOSE: Flood control

LEAD STUDY AGENCY: Devils Lake Advisory Committee

DESCRIPTION: Twenty-four miles of channel improvements plus new channel construction and two lake control structures.

ECONOMIC DEVELOPMENT [1]: Capital Cost $9,007,000
Average Annual Cost $668,200
Average Annual Benefit $170,100
Benefit/Cost Ratio .25

ENVIRONMENTAL QUALITY:

Earthwork associated with channelization will destroy existing riparian vegetation. Replacement vegetation will represent a shift in plant species and a modification of the area's ecosystem. Resultant long-term changes in resident wildlife populations have not been determined. Water quality will be degraded during and for a period of time after construction due to increased turbidity and sediment. Long-term changes in water quality are uncertain.

OTHER SOCIAL EFFECTS:

Flood damages will be reduced creating an average annual income benefit distribution of $170,100.

STATUS: Inactive.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

[1] Devils Lake Basin Study, 1976. Cost and benefits were updated to 1979 dollar value by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Mauvais Coulee Watershed (Figure IV-4-1; Site #2)
Towner, Ramsey, and
Benson Counties

PUBLIC INVOLVEMENT REGION: Devils Lake

PURPOSE: Flood control

LEAD STUDY AGENCY: Devils Lake Advisory Committee

DESCRIPTION: Nineteen miles of channel improvements, a new lake control structure, and upgrading and replacing roadway openings that have insufficient capacities.

ECONOMIC DEVELOPMENT 1/: Capital cost $1,996,000
Average Annual Cost $146,900
Average Annual Benefit $187,600
Benefit/Cost Ratio 1.28

ENVIRONMENTAL QUALITY:

Earthwork associated with channelization will destroy existing riparian vegetation. Replacement vegetation will represent a shift in plant species and a modification of the area's ecosystem. Resultant long-term changes in resident wildlife populations have not been determined. Water quality will be degraded during and for a period of time after construction due to increased turbidity and sediment. Long-term changes in water quality are uncertain. The coulee is rated Class I - Highest Value on the Game and Fish Stream Evaluation Map because of its moderate forage fish production, high northern pike reproduction, and very high waterfowl usage. Channelization will have adverse effects upon the fishery value of the coulee and will reduce the productivity of northern pike reproduction.

OTHER SOCIAL EFFECTS:

Flood damages will be reduced creating an average annual income benefit distribution of $187,600.

STATUS:

Phase development is being considered.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

1/ "Devils Lake Basin Study", 1976. Cost and benefits were updated to 1979 dollar value by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: South Slope Watershed (Figure IV-4-1; Site #11)
Benson and Eddy Counties

PUBLIC INVOLVEMENT REGION: Devils Lake

PURPOSE: Flood control

LEAD STUDY AGENCY: Devils Lake Advisory Committee

DESCRIPTION: Three miles of channel improvements and four grade stabilization structures.

ECONOMIC DEVELOPMENT [1/]: Capital Cost $382,000
Average Annual Cost $28,100
Average Annual Benefit $79,100
Benefit/Cost Ratio 2.81

ENVIRONMENTAL QUALITY:

Earthwork associated with channelization will destroy existing riparian vegetation. Replacement vegetation will represent a shift in plant species and a modification of the area's ecosystem. Resultant long-term changes in resident wildlife populations have not been determined. Water quality will be degraded during and for a period of time after construction due to increased turbidity and sediment. Long-term changes in water quality are uncertain.

OTHER SOCIAL EFFECTS:

Flood damages to agricultural lands will be reduced while providing an average annual income benefit distribution of $79,100.

STATUS: Inactive.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

1/ "Devils Lake Basin Study", 1976. Cost and benefits were updated to 1979 dollar value by Gulf South Research Institute for the Army Corps of Engineers.

FLOOD CONTROL PROJECT

NAME/LOCATION: Creel Bay Levee (Figure IV-4-1; Site #9)
City of Devils Lake
Ramsey County

PUBLIC INVOLVEMENT REGION: Devils Lake

PURPOSE: Flood Control

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION: Levee/Dam at Creel Bay constructed at the 1,445 feet msl, providing protection to the 1,440 foot elevation.

ECONOMIC DEVELOPMENT: Capital Cost $2,800,000 (estimate)
Annual Cost NA
Annual Benefit $26,000,000 (estimate)
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

No significant negative environmental impacts have been identified.

OTHER SOCIAL EFFECTS:

Substantial benefits would result from protecting the city sewage lagoon and a large amount of public and commercial development should the lake continue to rise.

STATUS:

Section 205 Flood Control Study.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

FLOOD CONTROL PROJECT

NAME/LOCATION: Devils Lake Outlet 1/ Ramsey, Benson, and Nelson Counties (Figure IV-4-1; Site #13 - Alt. A, Site #12 - Alt. B, Site #8 - Alt. C)

PUBLIC INVOLVEMENT REGION: Devils Lake

PURPOSE: Flood Control for the City of Devils Lake

LEAD STUDY AGENCY: Army Corps of Engineers

DESCRIPTION:	ECONOMIC DEVELOPMENT 2/
Alt. A. - Devils Lake Outlet Channel via Stump Lake to Tolna Coulee - 11.6 miles of new channel; two pump stations at West Bay; drop structures on Tolna Coulee, a tributary of the Sheyenne River.	Capital Cost $13,669,000 Average Annual Cost $1,006,200 Average Annual Benefit $3,000,000 3/ Benefit/Cost Ratio 2.98
Alt. B. - Devils Lake Outlet Channel via East Devils Lake to Tolna Coulee - one pump station at East Devils Lake with a 40-foot lift and 12 miles of channel to Tolna Coulee.	Capital Cost $6,386,000 Average Annual Cost $470,100 Average Annual Benefit $3,000,000 3/ Benefit/Cost Ratio 6.38
Alt. C. - Devils Lake Outlet Channel via West Bay through Round, Long, and Stony Lakes into Peterson Coulee	Capital Cost $14,383,000 Average Annual Cost $1,058,700 Average Annual Benefit $3,000,000 3/ Benefit/Cost Ratio 2.83

ENVIRONMENTAL QUALITY:

Vegetation and wildlife habitat will be destroyed by channelization. Water quality will be adversely affected due to increased turbidity and sediment during the construction period. Further detailed analysis would be required to determine the impact to the Sheyenne River's water quality and aquatic ecosystem.

OTHER SOCIAL EFFECTS:

The lake outlet will create an average annual income benefit distribution of three million dollars.

STATUS:

The Army Corps of Engineers will begin a study of the Devils Lake Basin in October, 1982, which will identify potential solutions to water resource problems in the Basin. It is anticipated that all alternatives addressing a lake outlet will be investigated further in the study.

RECOMMENDATION: Continued Study.

1/ Three additional Devils Lake Outlets alternatives have also been investigated by the Army Corps of Engineers, however, they have not been included since very limited information was available.

2/ Cost and benefits were updated to 1979 dollar value by Gulf South Research Institute for the Army Corps of Engineers.

3/ The figure represents benefits that result by preventing the water level in the lake from reaching elevation 1,435 feet msl; not average annual benefits.

LAKE RESTORATION/STRUCTURE REPAIR

NAME/LOCATION: Big Coulee Dam (Bisbee Dam) 1/ (Figure IV-4-1; Site #1)
Towner County

PUBLIC INVOLVEMENT REGION: Devils Lake

PURPOSE: Multi-purpose

LEAD STUDY AGENCY: ND State Water Commission/Towner County Water Resource Board.

DESCRIPTION: Repair dam and raise the reservoir four feet increasing the storage capacity by 900 AF.

ECONOMIC DEVELOPMENT: Capital Cost $390,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The additional four feet of water may reduce the probability of winterkill and will enhance the value of the sport fishery of the reservoir.

OTHER SOCIAL EFFECTS:

Raising the lake level should enhance the water-based recreation opportunities at Big Coulee Dam and assure a water supply for the 257 residents of Bisbee.

STATUS:

Avenues for funding are being investigated.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

1/ An existing reservoir.

RECREATION FACILITY

NAME/LOCATION: East Bay (Camp Grafton) (Figure IV-4-1; Site #10)
Ramsey County

PUBLIC INVOLVEMENT REGION: Devils Lake

PURPOSE: Water-based Recreation

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Public facilities providing access to the lake.

ECONOMIC DEVELOPMENT: Capital Cost $357,000
Average Annual Cost $27,500
Average Annual Benefit $57,600
Benefit/Cost Ratio 2.09

ENVIRONMENTAL QUALITY:

No significant environmental effects anticipated.

OTHER SOCIAL EFFECTS:

The project will create an annual income benefit distribution of $57,000, and local costs totaling $8,000 annually will be borne by the region. The public facilities will provide access to the lake.

STATUS:

Currently being installed, multi-year program; funding for the total project has not been appropriated.

RECOMMENDATION: Implementation of project in the 1980-1990 time frame.

REGIONWIDE PROGRAMS FOR THE
DEVILS LAKE STATISTICAL PLANNING AREA

NAME: Land Treatment Measures

PUBLIC INVOLVEMENT REGION: All Regions in the Devils Lake SPA

PURPOSE: Control soil erosion and flooding

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Land treatment measures are those practices used to reduce soil erosion and control flooding, and include such features as grassed water ways, shelter belts and strip cropping.

ECONOMIC DEVELOPMENT:

Land treatment measures on a total of 767,000 acres

Capital Cost $7,899,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Soil erosion by wind and water will be reduced. Water quality and wildlife habitat will be enhanced.

OTHER SOCIAL EFFECTS:

Damages to agricultural lands caused by wind and water erosion of soil will be reduced.

STATUS:

An ongoing program dependent upon voluntary participation by individual landowners and the availability of cost-share monies from the Soil Conservation Service.

RECOMMENDATION: Implementation as indicated in Table IV-4-5.

NAME: Municipal Waste Treatment Facilities

PUBLIC INVOLVEMENT REGION: All Regions in the Devils Lake SPA

PURPOSE: Enhance the capability for treating municipal wastewater.

LEAD STUDY AGENCY: ND State Health Department

DESCRIPTION: New facilities are required and existing facilities need to be improved before the year 2000 in 14 communities and one unincorporated community serving 16,000 people. Incorporated communities and certain other public entities are eligible for financial assistance through the Construction Grant Program of the Environmental Protection Agency. This Program is administered in North Dakota by the State Health Department. Under this Program, 75 percent of the planning and construction costs for new collection and treatment facilities and for upgrading existing wastewater treatment plants are reimbursible. Congress appropriates the money for the Program. The State Health Department disperses North Dakota's share according to a priority list it has developed.

ECONOMIC DEVELOPMENT: Capital Cost $5,703,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The wastewater treatment facilities will improve the water quality of the receiving watercourses. Additional solid waste resulting from the treatment process will need disposal.

OTHER SOCIAL EFFECTS:

The communities will have to furnish 25 percent of the total cost of any new or improved facility.

STATUS:

Ongoing program. Other sources of funding will have to furnish 25 percent of the total cost of new or improved facilities.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

NAME: Municipal Water Supply Treatment Facilities

PUBLIC INVOLVEMENT REGION: All Regions in the Devils Lake SPA

PURPOSE: Enhance municipal water supply treatment capability

LEAD STUDY AGENCY: ND State Health Department

DESCRIPTION: Additional or improved treatment facilities are needed in two communities serving 1,193 people in order to meet the recommended standards for Safe Drinking Water Supplies set by the Environmental Protection Agency.

ECONOMIC DEVELOPMENT: Capital Cost $1,195,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

The additional or improved water supply treatment facilities will enhance the quality of municipal water supplies. Additional solid wastes generated by the treatment processes will require disposal.

OTHER SOCIAL EFFECTS:

Municipal water supplies will be improved, enhancing the safety, health and well-being, and quality of life for community residents. The only funding available is currently derived from the tax base of the community. No State or Federal funds are currently available.

STATUS:

Facilities are constructed on an individual basis as community funding allows.

RECOMMENDATION: Implementation in the 1980-1990 time frame.

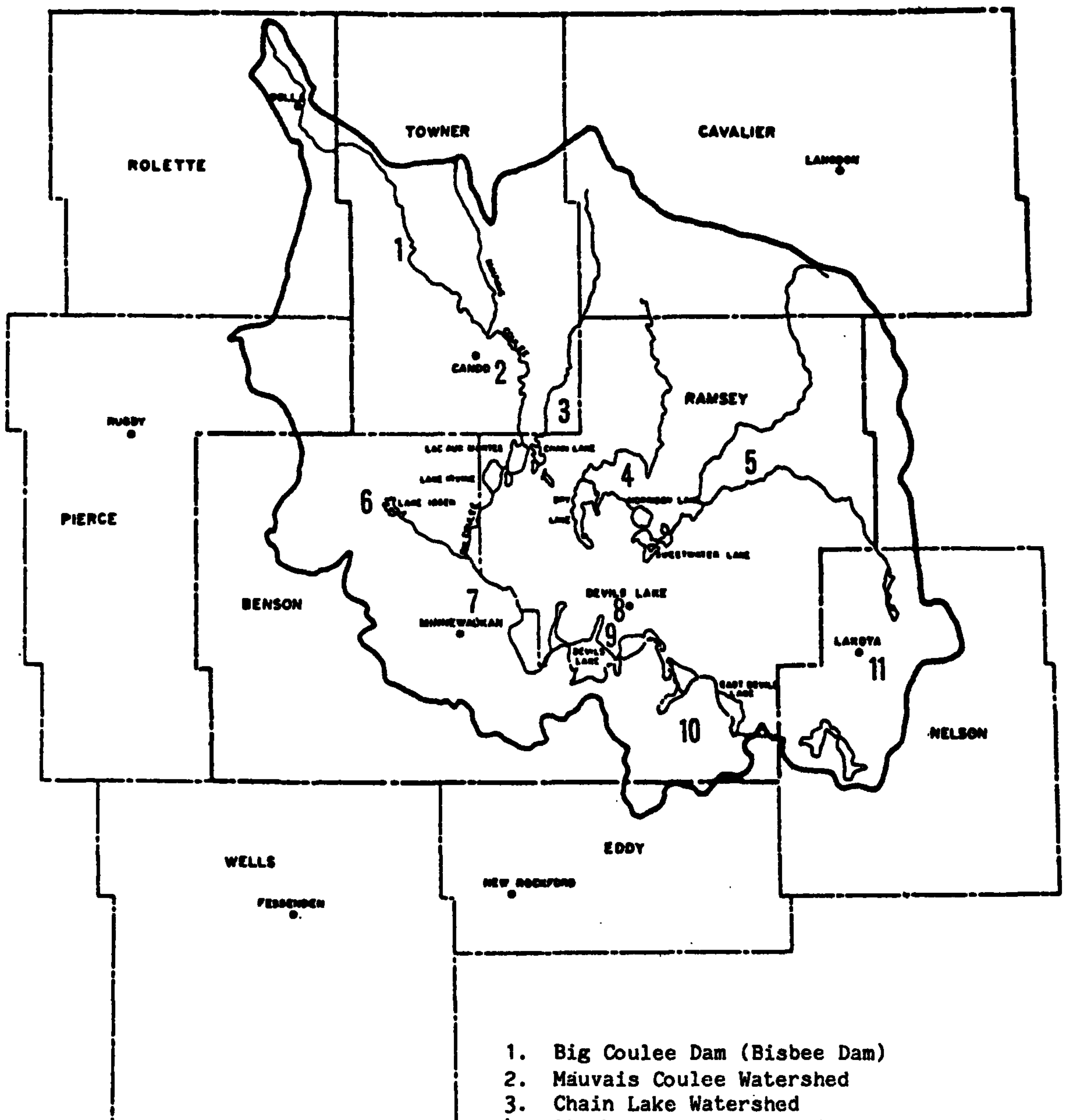
TABLE IV-4-5 RECOMMENDED PLAN AND ESTIMATED INVESTMENTS IN 1980 DOLLARS DEVILS LAKE BASIN

Water and Related Land Resources Category	Units	Composition and Estimated Investments (All Values are Incremental) 1980-1990 (Early Action Program) Quantity	Initial Investment Federal ($1000)	Initial Investment State/Local ($1000)	Annual O,M&R Federal ($1000)	Annual O,M&R State/Local ($1000)	1990-2000 Quantity	Initial Investment Federal ($1000)	Initial Investment State/Local ($1000)	Annual O,M,&R Federal ($1000)	Annual O,M,&R State/Local ($1000)	2000-2020 Quantity	Initial Investment Federal ($1000)	Initial Investment State/Local ($1000)	Annual O,M,&R Federal ($1000)	Annual O,M,&R State/Local ($1000)
SURFACE WATER CONTROL																
Multi-purpose Reservoir																
Total Storage	1000AF	0.9 1/														
Flood Control	1000AF															
Other Purpose	1000AF	(0.9) 2/														
Single Purpose Reservoir																
Flood Control	1000AF															
Irrigation	1000AF															
Municipal	1000AF															
Recreation	1000AF															
Instream Control																
Channel Improvement	Miles	56	--	10,046	--	1,547										
Levees, Floodwalls, etc. 3/	Each	1	2,670	130	NA	NA										
Streambank Stabilization	Each															
Diversion																
Irrigation	1000AF															
Municipal	1000AF															
Multi-feature Project 4/	Each	7	--	18,680	--	1,170										
RELATED LAND PROGRAMS																
Drainage	Each															
Irrigation																
Private	1000Ac															
Public	1000Ac															
ENVIRONMENTAL AND RESOURCE ENHANCEMENT 5/																
Protection and Management 6/																
Cropland	1000Ac	402	3,317	1,105	NA	NA	240	1,980	660	NA	NA					
Pasture	1000Ac	34	140	47	NA	NA	23	95	32	NA	NA					
Range	1000Ac	28	116	38	NA	NA	19	79	26	NA	NA	18	74	25	NA	NA
Forest	1000Ac	3	124	41	NA	NA										
Outdoor Recreation																
Stream Preservation	Miles															
Facilities	Each	1	178.5 7/	178.5 7/	--	8										
Waste Water Management																
Municipal 8/	1000PS 9/	16	4,277	1,426	--	288										
Water Supply Treatment																
Municipal	1000PS	1.2	--	1,195	--	60										
ADDITIONS AND MODIFICATIONS TO EXISTING PROJECTS																
Reservoir Storage	Each	(1)	(156)	(234)	(--)	(4)										
TOTAL COST			10,978.5	33,120.5	--	3,077		2,154	718	NA	NA		74	25	NA	NA

1/ Total includes 900 AF of additional storage at Big Coulee Dam (Bisbee Dam) from the Category - Additions and Modification to Existing Projects or Developments.
2/ Figures in parentheses are non-additive.
3/ OM & R Cost for the Creel Bay Levee is not available.
4/ Multi-feature projects are defined as those projects which consist of more than one element, including structural and non-structural measures. Example: a dam and diversion floodway.
5/ The data used to compute the figures displayed in this Category are useable on a county basis; therefore the figures are for the Devils Lake Statistical Planning Area (Figure I-1-2) rather than the Basin.
6/ Land Treatment measures have been accelerated from the Future Without Plan Projections (Table III-1-4) as follows: 1980-1990 figures accelerated by 1.5 percent, 1990-2000 figures by 1.0 percent, and 2000-2020 figures by 0.5 percent.
7/ A multi-year program currently being installed; funding for the total project has not been appropriated.
8/ Some of the projects will be constructed in the 1990-2000 time frame. However, since the construction date of each specific project could not be determined, all costs have been placed in the 1980-1990 time frame.
9/ P.S. represents population served based upon the highest projection.

FIGURE IV-4-2 DEVILS LAKE BASIN

LOCATION OF RECOMMENDED PLAN - EARLY ACTION PROGRAM



1. Big Coulee Dam (Bisbee Dam)
2. Mäuvais Coulee Watershed
3. Chain Lake Watershed
4. Starkweather Watershed
5. Edmore Watershed
6. Hurricane Lake Watershed
7. Comstock Watershed
8. Creel Bay Levee
9. East Bay (Camp Grafton) Recreation Facility
10. South Slope Watershed
11. Stump Lake Watershed

TABLE IV-4-6 DEVILS LAKE BASIN RECOMMENDED PLAN - EARLY ACTION PROGRAM

Program Feature	Description & Purpose	Initial Costs "1980 Dollars" Federal	State/Local	Total	Annual Operation, Maintenance and Replacement Costs "1980 Dollars" Federal	State/Local	Total
SURFACE WATER CONTROL Instream Control Channel Improvements	Starkweather Watershed - Improvement of 56 miles of channel is proposed.	-	$10,046,000	$10,046,000	-	$1,546,600	$1,546,600
Levees, Floodwall, etc.	Creel Bay Levee - This project would involve constructing a levee/dam at the 1,445 foot msl level, providing protection to the 1,440 foot msl elevation for the City of Devils Lake.	$2,670,000	$130,000	$2,800,000	-	NA 1/	NA 1/
Multi-feature Project	Hurricane Lake Watershed - This project would involve 24 miles of channel improvements, two new lake control structures, and modification of one existing lake control structure. Phase development for the lake control structure is in progress.	-	$999,800	$999,800	-	$103,000	$103,000
	Comstock Watershed - This project would involve five miles of channel improvements and one grade stabilization structure.	-	$193,000	$193,000	-	$28,000	$28,000
	Stump Lake Watershed - This project would involve 26 miles of channel improvements, one lake control structure, and two control structures on wetlands.	-	$1,451,000	$1,451,000	-	$177,800	$177,800
	Edmore Watershed - This project would involve 55 miles of channel improvements and construction of grade stabilization structures.	-	$4,651,000	$4,651,000	-	$484,000	$484,000
	Chain Lake Watershed - This project would involve 24 miles of channel improvements, new channel construction, and two lake control structures.	-	$9,007,000	$9,007,000	-	$110,900	$110,900
	Mauvais Coulee Watershed - This project would involve 19 miles of channel improvements, a new lake control structure, and upgrading and replacing roadway openings that have insufficient capacity.	-	$1,996,000	$1,996,000	-	$203,100	$203,100
	South Slope Watershed - Three miles of channel improvements and four grade stabilization structures are proposed.	-	$382,000	$382,000	-	$62,300	$62,300

Program Feature	Description & Purpose	Initial Costs "1980 Dollars" Federal	State/Local	Total	Annual Operation, Maintenance, and Replacement Costs "1980 Dollars Federal	State/Local	Total
ENVIRONMENTAL AND RESOURCE ENHANCEMENT							
Protection and Management	Land Treatment Measures-Measures are needed to reduce soil erosion on 467,000 acres of land in the Devils Lake SPA.	$3,696,000	$1,232,000	$4,928,000	-	NA	NA
Outdoor Recreation Facilities	East Bay (Camp Grafton) Recreation Facility 2/ - This multi-year project for developing public facilities and providing access to Devils Lake is currently being implemented.	$178,500	$178,500	$357,000	-	$8,000	$8,000
Waste Water Management Municipal 3/	Development of new and/or improvement of existing municipal waste treatment facilities is proposed for 14 communities and one unincorporated community serving 16,000 people.	$4,277,250	$1,425,750	$5,703,000	-	$288,000	$288,000
Water Supply Treatment Municipal 4/	Development of additional or improvement of existing treatment facilities are required to meet the recommended limits for domestic water supply for two communities serving 1,193 people.	-	$1,195,000	$1,195,000	-	$59,800	$59,800
ADDITIONS AND MODIFICATIONS TO EXISTING PROJECTS OR DEVELOPMENTS							
Reservoir Storage	Big Coulee Dam (Bisbee Dam) - Repairing the dam and raising the reservoir four feet is proposed. This would assure a water supply for the 257 residents of Bisbee and would enhance the sport fishery.	$156,000	$234,000	$390,000	-	$3,900	$3,900

1/ Cost could vary greatly depending upon the lake level and the amount of pumping that would be required.

2/ This multi-year project is currently being installed; funding for the total project has not been appropriated.

3/ As identified by the ND State Health Department, some of the projects will be constructed in the 1990-2000 time frame. However, since the construction date of each specific project could not be determined, all costs have been placed in the 1980-1990 time frame. The communities in the Devils Lake Statistical Planning Area (SPA) include: Churchs Ferry, Devils Lake, Leeds, Rock Lake, Osnabrock, Calio, Calvin, HHannah, Knox, Sarles, York, Langdon, Nekoma, and Milton, in addition to the unincorporated community of Creel Bay Domestic Utilities.

4/ As identified by the ND State Health Department, the communities in the Devils Lake SPA include Leeds and Minnewaukan.

ADDITIONAL SPECIAL STUDIES AND PROGRAMS -

1) The State Water Commission should expedite studies to determine and set an optimum management level for Devils Lake. The Devils Lake Citizens Advisory Board recommends that the best management level be set at an elevation between 1,425 and 1,427 feet msl.

2) Further studies are required with respect to the following:

   A) The relationship between wetlands, soil salinity, and salinity caused reductions in crop yields.

   B) The economics of the physical and biological relationships affecting water quality.

   C) The value of wildlife and wetland habitat in the Devils Lake Basin.

   D) The potential impact of flooding on communities in the Devils Lake Basin.

3) A basin-wide, weather reporting system should be established.

4) A basin-wide, water quality monitoring system should be established. It is recommended that the State Health Department tighten regulations pertaining to phosphate and nitrate discharges and the enforcement effort be increased.

5) Completion and use of a hydrologic model for the Basin is recommended.

6) Determination of an acceptable outlet from the Basin is recommended. A Devils Lake Subbasin Flood Control Analysis Report under the Red River of the North General Authority will be initiated early in 1983 by the Corps of Engineers. The Devils Lake Citizens Advisory Board recognizes the Sheyenne River as the Basin's natural outlet and that Canadian concerns should not limit the full assessment of all alternatives. In addition, the Devils Lake Board recommends that the ordinary high water mark be established between elevation 1,435 and 1,438 feet msl.

7) Accelerating extensive soil studies is recommended for the Basin. The 1982 status of the county soil surveys is as follows: Benson County is completed, Cavalier and Ramsey Counties are in progress, and Rolette and Towner Counties have no soil surveys.

8) A comprehensive flood plain zoning program for the land below the meander line of Devils Lake should be established.

9) A study is encouraged to determine the need for rural water systems, and possible alternative funding sources.

10) The State Water Commission in cooperation with the State Health Department, should expedite studies of alternative treatment measures including cost and effectiveness of new sewage treatment facilities for the City of Devils Lake.

11) A study is recommended to examine the possibility of cleaning channels through Fish and Wildlife Service easement lands to facilitate upstream flood control projects.

12) The problem of roads washing out or being inundated by the rising level of Devils Lake should be studied.

13) Efforts to improve natural channels to contain high flows and the search for sites to construct small impoundments should continue at a faster pace.

14) Further study should be conducted concerning the possibility of using community sewage lagoon waters to irrigate adjacent farmlands.

15) Funding of the State Water Bank Program is encouraged. The program should emphasize voluntary choice and include time limitations.

16) More intensive development and management is recommended for wildlife habitat and wetlands under Federal control.

17) Continuation of studies for the restoration of Stump Lake is recommended.

18) State and/or Federal study is recommended for a farm drainage mitigation plan suggested by one of the Board members. This plan's purpose is to allow efficient farming by replacing drained croplands with acreage of wildlife habitat on marginal land on the same farm. The Board recommends that the State Water Commission develop and submit legislation to initiate the program as stated.

19) Maintaining and increasing the stream gauging network within the Basin is recommended.

20) The Devils Lake Citizens Advisory Board supports the Weather Modification Program titled "Atmospheric Water Resources Research in Conjunction with the North Dakota Cloud Modification Program".

CHAPTER 5

SOURIS RIVER BASIN

PROBLEMS SUMMARY

TABLE IV-5-1 WATER MANAGEMENT PROBLEMS - SOURIS RIVER BASIN

Problem Type	Public Involvement Region	Location	General Description
Water Supply	Upper Souris	Minot, Ward County	The City of Minot does not have an adequate supply of municipal water. Several solutions have been explored, most recently, development of a predictive model for the Sundre Aquifer System. Approximately 25% of Minot's water supply is expected to come from five wells in the Sundre Aquifer, with about 15% taken from other wells and 60% from the Souris River. Long range plans include obtaining water from the Garrison Diversion Unit.
Water Supply	Upper Souris	Upper Souris	Efforts should be made to construct rural water lines to benefit farmers as well as small towns and populated rural areas. Cost-sharing should be included in efforts to provide water lines that will serve the needs of rural people.
Water Quality	Upper Souris	Souris River - downstream from Minot	Concern has been expressed over the timing of effluent releases from the Minot sewage lagoon. Two new lagoons, to be constructed in 1982, should alleviate the problem.
Flooding	Lower Souris	Rush Lake, Horseshoe Lake, Round Lake - Pierce County	These three lakes are in an area that generally slopes toward Snake Creek as its overflow outlet. This is a poorly developed channel which joins Willow Coulee in McHenry County. Flooding occurs due to an inadequate outlet for overflow waters from the lakes.
Flooding	Lower Souris	Ox, Oak, and Willow Creek watersheds - eastern Bottineau County, northern McHenry County, northern Pierce County, and western Rolette County	This area is located downstream from a number of streams draining the Turtle Mountains, with the lower part of this area being extremely flat and subject to flooding. Runoff into the single Willow Creek outlet from Oak, Indian, Mud, Wolf, and Ox Creeks, plus some unnamed tributaries, compounds the problem. Inadequate channel capacities of the creeks cause overbank flooding of agricultural and urban areas. A Soil Conservation Service flood hazard analysis is being conducted for Oak and Willow Creeks.
Flooding	Lower Souris	Stone Creek - Bottineau County	The Stone Creek upper watershed, descending from the Turtle Mountains, has a very steep gradient which can produce high water flows. "White Spur" Drain and improvements within the Stone Creek drainage areas have been proposed as possible solutions.
Flooding	Lower Souris	S17, T154, R78 in McHenry County, about five miles northwest of Karlsruhe	A washout on the Souris River affects eight families during major floods. It has been suggested that a block could be installed with a large pipe and gate that would contain the water within the major channel and still provide for inflows from the floodplain.
Flooding	Lower Souris	Wintering River - McHenry County	Flooding and erosion have occurred along this major tributary to the Souris River.
Flooding	Lower Souris Upper Souris	Souris River	Floodwater inundation and bank erosion are problems along the entire length of the Souris River in North Dakota.

Problem Type	Public Involvement Region	Location	General Description
Flooding	Lower Souris Upper Souris	Souris River Statistical Planning Area	A mechanism is needed to coordinate storm-water management between city and surrounding non-city areas.
Flooding	Upper Souris	S5, 8, 9, 15, and 16, T162, R97 and S32, T163, R97 just south of Crosby Divide County	High water levels have occurred in Crosby due to spring runoff into a large slough south of the town. Because of the past few dry years, this has not been a major problem; however, in a wet year, it may occur again.
Flooding	Upper Souris	S3, 9, 11, 14, 15, and 16, T162, R86 in Renville County just north of the Upper Souris National Wildlife Refuge	A series of locked-in low areas overfill and do not soak away in time to allow cultivation of land normally farmed. Except for Seven Mile Coulee, there is little or no channel drainage from this area. A Soil Conservation Service project was proposed in 1978; however, landowners objected. The Water Resource Board has provided extra culverts where requested.
Flooding	Upper Souris	Norma-Tolley area between the Des Lacs and Souris River watersheds in Ward and Renville Counties	An extensive low area, with no drainage system, located between the Des Lacs and the Souris River watersheds, is subject to flooding from spring runoff accumulated from upper areas of the drainage basin.
Flooding	Upper Souris	South of Makoti on Ward County Route No. 9	Inadequate drainage has created a lake two miles long and at one point along the road, 15 feet deep. The road has been rebuilt several times, most recently in 1980.
Flooding	Upper Souris	Minot, Ward County	Floodwater inundation and bank erosion have occurred in Minot and surrounding areas due to flooding of the Souris and Des Lacs Rivers. Raising Lake Darling Dam four feet and flood control measures upstream and downstream of the dam have been included as a part of the Lake Darling Compromise Plan.
Flooding	Upper Souris	Des Lacs River Valley	Floodwater inundation and bank erosion have occurred all along the Des Lacs River Valley.
Drainage	Lower Souris Upper Souris	Souris River Statistical Planning Area	Sound management of an area's surface waters can be enhanced through the use of a watershed or "systems" approach to drainage.
Erosion	Lower Souris Upper Souris	Souris River Statistical Planning Area	The installation of land treatment measures is considered essential for protection and preservation of the basic soil resources, for reducing air and water pollution, and for assisting in the sustained production of food and fiber.
Lake Restoration	Lower Souris	Lake Metigoshe - Bottineau County	Lake Metigoshe has a history of excessive aquatic plant growth causing rapid aging (eutrophication) of the lake.
Fish and Wildlife Habitat Destruction	Upper Souris	Souris River Statistical Planning Area	Serious long-term fish and wildlife problems have occurred due to changes in agricultural land-use practices.
Saline Seeps	Lower Souris Upper Souris	Souris River Statistical Planning Area	Saline seeps are recently developed wet, salty areas in non-irrigated soil on which crop production is reduced or eliminated. The soil surface is intermittently or continuously wet and white salt crusts are often present.

OPPORTUNITIES SUMMARY

TABLE IV-5-2 WATER DEVELOPMENT OPPORTUNITIES - SOURIS RIVER BASIN

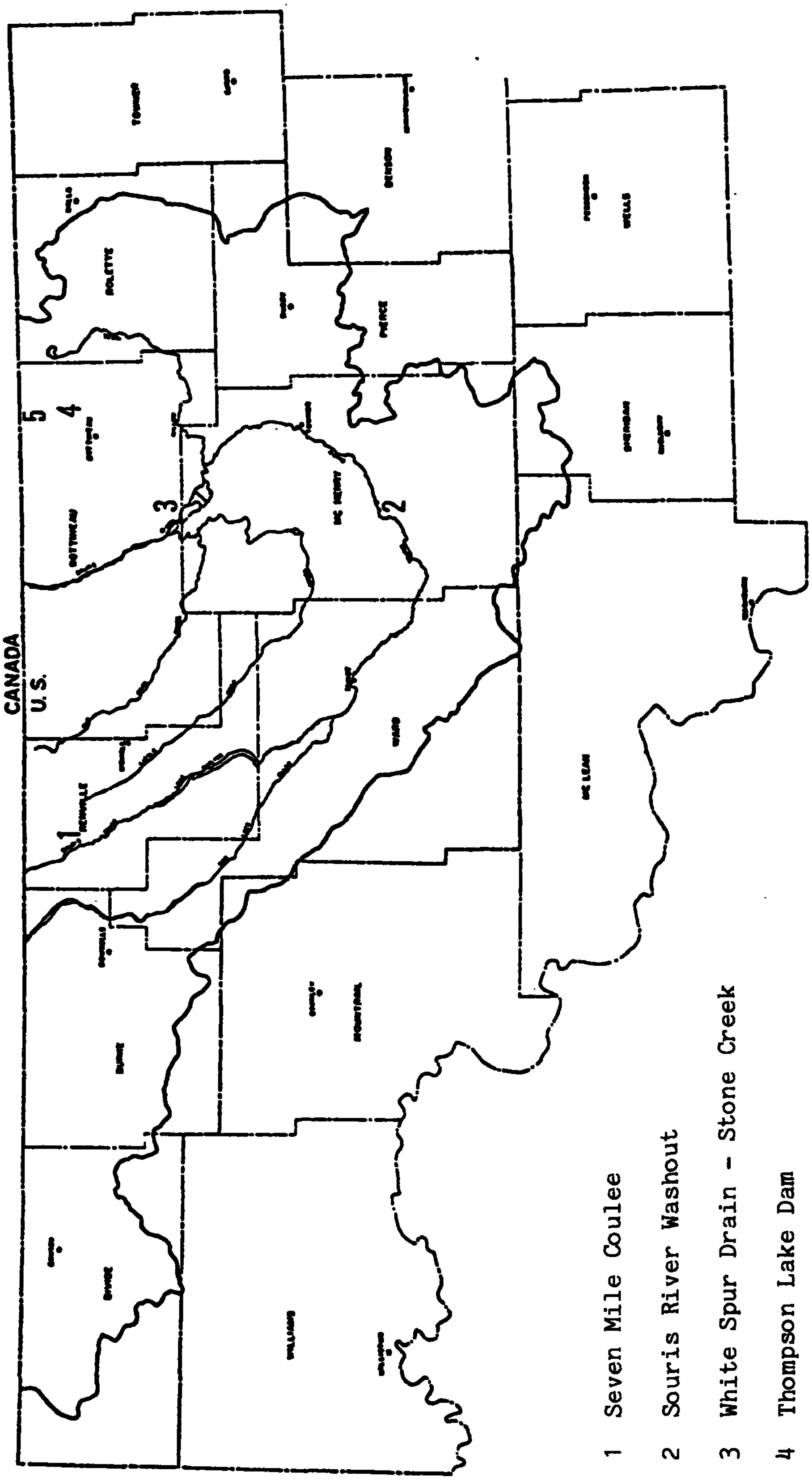
Opportunity	Public Involvement Region	Location	General Description
Multi-purpose storage structure	Lower Souris Upper Souris	Des Lacs and Souris Rivers Watersheds	Small dams could be built to reduce the flow into these rivers. Flooding and bank erosion could be lessened, and the stored water could be put to beneficial use.
Single-purpose storage structure	Lower Souris	S26, T160, R73 about 10 miles west of Rolette in Rolette County	The maximum storage available at this location is under 800 acre-feet. The maximum reservoir would have an average depth of six to seven feet and a maximum depth of 25 feet.
Single-purpose storage structure	Lower Souris	S36, T163, R75 about five miles northeast of Bottineau in Bottineau County	This project would raise the water level in Thompson Lake for the purpose of providing additional recreational benefits to the area. The lake is located on the Thompson Lake State Game Management Area which is owned and operated by the North Dakota Game and Fish Department.
Irrigation (Education)	Lower Souris Upper Souris	Souris River Statistical Planning Area	Seminars conducted on a local level by knowledgeable representatives of the State Water Commission, the State Agricultural Department, and other agencies or irrigators could educate landowners on the advantages of irrigation.
Irrigation (Sewage-lagoon waters)	Lower Souris Upper Souris	Souris River Statistical Planning Area	A possibility exists to utilize community sewage lagoon waters for irrigation of adjacent farmland.
Irrigation (Groundwater information)	Lower Souris Upper Souris	Souris River Statistical Planning Area	Efforts should be made to gain more specific information on groundwater reserves in order to expedite the irrigation permitting process.
Land Management Practice (Plugging wetlands)	Lower Souris Upper Souris	Souris River Statistical Planning Area	The possibility of plugging drained wetlands in the years when the land is summer fallowed should be explored. This practice could decrease erosion and the movement of nutrients, fertilizers, and pesticides from the land.
Land Management Practice (State Water Bank Program)	Lower Souris Upper Souris	Souris River Statistical Planning Area	The State Water Bank Program, if funded, would help preserve, restore, and improve inland fresh water and adjacent areas in important migratory waterfowl nesting and breeding areas. Under the program, landowners receive annual payments for conserving and protecting wetlands.
Land Management Practice (Waterfowl Production)	Lower Souris Upper Souris	Souris River Statistical Planning Area	Waterfowl production could be increased if more attention is paid to developing habitat and managing wetlands already under federal control.
Fish Hatcheries	Lower Souris Upper Souris	Souris River Statistical Planning Area	Fish hatcheries around the State need rejuvenating and/or enlarging. More modern facilities are needed.
Other	Upper Souris	Des Lacs National Wildlife Refuge - Ward and Burke Counties	Des Lacs Lake could be raised to increase fish and wildlife needs as well as furnishing recreation.

TABLE IV-5-3 NON-RECOMMENDED STUDY ALTERNATIVES - SOURIS RIVER BASIN

Alternative	Public Involvement Region	Location	General Description
Bottineau Flood Control Project	Lower Souris	Bottineau County	Alternative A: Two miles of channel diversion on Oak Creek. Alternative B: Dike along the existing channel.
Souris River - Scenic and Recreation River	Lower and Upper Souris	McHenry and Ward Counties	Maintain 131 miles of the Souris River as a free-flowing stream from the bridge at Burlington to the dam at Upham.
Weather Modification Programs	Lower Souris	Statewide	A) The North Dakota Cloud Modification Program. B) Drought Management Strategies. C) Atmospheric Water Resources Research in conjunction with the North Dakota Cloud Modification Program. D) Public Awareness of Weather Modification

FIGURE IV-5-1 SOURIS RIVER BASIN

LOCATION OF RECOMMENDED STUDY ALTERNATIVES



1 Seven Mile Coulee

2 Souris River Washout

3 White Spur Drain - Stone Creek

4 Thompson Lake Dam

5 Lake Metigoshe Restoration

TABLE IV-5-4 RECOMMENDED STUDY ALTERNATIVES - BENEFICIAL AND ADVERSE EFFECTS OF THE POTENTIAL PROJECTS IN THE SOURIS RIVER BASIN

SINGLE PURPOSE RESERVOIR

NAME/LOCATION: Thompson Lake Dam 1/ (Figure IV-5-1; Site #4)
S36, T163, R75
Bottineau County

PUBLIC INVOLVEMENT REGION: Lower Souris

PURPOSE: Stabilize water level of the natural lake and provide additional recreation.

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION:	ECONOMIC DEVELOPMENT
• Construct a dam and raise the lake level three feet to provide 450 AF storage.	
Alt. A is an earthen weir allowing flow over the entire length.	Capital Cost $11,560 (estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Alt. B is a sheet pile weir requiring less maintenance.	Capital Cost $16,983 (estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Wildlife and recreation values would be enhanced. The increased water level would probably have minimal effects upon the fishery value of the lake.

OTHER SOCIAL EFFECTS:

Water-based recreation would be available to area residents.

STATUS:

Recent Investigation. Additional study is required to determine if an adequate water supply is available within the 1,230 acres watershed.

RECOMMENDATION: Implementation in the 1980-1990 time frame utilizing an average cost of the two alternatives.

1/ An existing natural lake.

FLOOD CONTROL PROJECT

NAME/LOCATION: Souris River Washout (Figure IV-5-1; Site #2)
T154, R78
McHenry County

PUBLIC INVOLVEMENT REGION: Lower Souris

PURPOSE: Flood Control

LEAD STUDY AGENCY: ND State Water Commission

DESCRIPTION: A washout on the Souris River affects eight families during major floods. Area affected includes all of Sections 8, 10, 11, 12, 15, 16, 17, and 19 and parts of Sections 6, 7, 13, and 14. It has been suggested that a block could be installed with a large pipe and gate that would contain the water within the main channel and still provide for inflows from the floodplain. A project of this nature would also require some shaping of river banks and installation of riprap.

ECONOMIC DEVELOPMENT: Capital Cost $50,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
Erosion of the highwater floodway would be reduced. The project proposal also requires some shaping of river banks and installation of riprap resulting in a loss of some riparian vegetation. No significant long-term adverse environmental impacts are anticipated.

OTHER SOCIAL EFFECTS:
The project would reduce erosion problems and flood damages which affect eight families during major flooding.

STATUS:
Recent Investigation.

RECOMMENDATION:
Continued Study.

FLOOD CONTROL PROJECT

NAME/LOCATION: Seven Mile Coulee (Figure IV-5-1; Site #1)
S3,9,11,14,15, & 16
T162, R86
Renville County

PUBLIC INVOLVEMENT REGION: Upper Souris

PURPOSE: Flood Control

LEAD STUDY AGENCY: ND State Water Commission/Renville County Water Resource Board

DESCRIPTION: The project includes: a channel block to prevent the easterly flow toward West Cut Bank Coulee, improving the natural outlet channel along Seven Mile Coulee in selected areas, and the construction of a control structure at the south end of Section 8.

ECONOMIC DEVELOPMENT: Capital Cost $40,000-$55,000 (estimate)
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
Channel improvements would destroy vegetation and disturb wildlife habitat resulting in losses in biological diversity, balance, and efficiency.

OTHER SOCIAL EFFECTS:
Flood damages to agricultural lands and roadways would be reduced. The flows along the natural outlet and Seven Mile Coulee would be increased.

STATUS:
Inactive. The Renville County Water Resource Board has decided not to pursue this alternative in favor of utilizing extra and/or larger culverts whenever they are requested along the existing eastern route.

RECOMMENDATION: Continued Study.

DRAINAGE PROJECT

NAME/LOCATION: White Spur Drain (Figure IV-5-1; Site #3)
T160, R77
Stone Creek
Bottineau County

PUBLIC INVOLVEMENT REGION: Lower Souris

PURPOSE: Prevent flooding in Stone Creek Watershed

LEAD STUDY AGENCY: Bottineau County/ND State Water Commission

DESCRIPTION:

Improvements in Stone Creek drainage area. The North Project involves ditching in Pickering and Oak Valley Township. The South Project involves ditching in Oak Creek Township.

ECONOMIC DEVELOPMENT

North Project Alt. A: 218,000 cubic yards of excavation.	Capital Cost $327,000 preliminary estimate
Alt. B: 148,400 cubic yards of excavation.	Capital Cost $222,000 preliminary estimate Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
South Project	Capital Cost $93,600 preliminary estimate Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Channel improvements with excavation will destroy vegetation reducing plant diversity and result in a loss of wildlife habitat.

OTHER SOCIAL EFFECTS:

The project will reduce flood damages to agricultural lands and roadways.

STATUS:

Preliminary investigation has been done to determine the feasibility of drainage project within the Stone Creek Drainage Watershed.

RECOMMENDATION: Implementation of the South Project in the 1980-1990 time frame with continued study of the North Project.

LAKE RESTORATION PROJECT

NAME/LOCATION: Lake Metigoshe, Bottineau County (Figure IV-5-1; Site #5)

PUBLIC INVOLVEMENT REGION: Lower Souris

PURPOSE: Improve water quality in Lake Metigoshe and increase water levels in Lake Metigoshe

LEAD STUDY AGENCY: ND State Water Commission/ND State Health Department/ Lake Metigoshe Recreation Service Department.

DESCRIPTION:

ECONOMIC DEVELOPMENT

Two alternatives are being analyzed for storing water and to maintain the level of Lake Metigoshe. Both alternatives will drain Rost Lake/ School Section Lake.

Alt. A:	A dam on the outlet to School Section Lake; channels to allow excess water from four square miles of numerous small lakes southeast of School Section Lake to flow into Rost Lake. The normal lake level of these lakes would be maintained. Rost Lake/School Section Lake, containing excess water from the lakes, would be drained to supply water to Lake Metigoshe.	Capital Cost $319,000 (estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA
Alt. B:	A dam on the outlet to School Section Lake; channels to completely drain the four square miles of numerous small lakes into Rost Lake and also the drainage of Rost Lake/School Section Lake.	Capital Cost $691,000 (estimate) Annual Cost NA Annual Benefit NA Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Water quality in Lake Metigoshe may be adversely affected which may cause additional water quality problems to the lake. Both alternatives may result in a loss and/or damage to trees around Rost/School Section Lake because of changing lake levels. Alternative B will have an adverse affect upon wildlife because of loss of habitat.

OTHER SOCIAL EFFECTS:

Water quality in Lake Metigoshe will be adversely affected which may cause additional water quality problems to the lake.

STATUS:

Ongoing Investigation. The State Water Commission is currently investigating the alternatives. Findings to date indicate that Alternative A will not benefit Lake Metigoshe because not enough water is available in Rost/School Section Lake to supply the water required. Alternative B will provide marginal benefit since it does not appear to assure a dependable water supply. The State Health Department is also analyzing the water quality of Rost/School Section Lake to determine the impact of the additional water from these lakes upon Lake Metigoshe.

RECOMMENDATION: Continued Study.

REGIONWIDE PROGRAMS FOR THE SOURIS RIVER STATISTICAL PLANNING AREA

NAME: Land Treatment Measures

PUBLIC INVOLVEMENT REGION: All Regions in the Souris River SPA

PURPOSE: Control soil erosion and flooding

LEAD STUDY AGENCY: Soil Conservation Service

DESCRIPTION: Land treatment measures are those practices used to reduce soil erosion and control flooding, and include such features as grassed water ways, shelter belts, and strip cropping.

ECONOMIC DEVELOPMENT:

Land treatment measures on a total of 2,195,000 acres

Capital Cost $21,513,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:

Soil erosion by wind and water will be reduced. Water quality and wildlife habitat will be enhanced.

OTHER SOCIAL EFFECTS:

Damages to agricultural lands caused by wind and water erosion of soil will be reduced.

STATUS:

An ongoing program dependent upon voluntary participation by individual landowners and the availability of cost-share monies from the Soil Conservation Service.

RECOMMENDATION: Implementation as indicated in Table IV-5-5.

NAME: Municipal Waste Treatment Facilities

PUBLIC INVOLVEMENT REGION: All Regions in the Souris River SPA

PURPOSE: Enhance the capability for treating municipal wastewater

LEAD STUDY AGENCY: ND State Health Department

DESCRIPTION: New facilities are required and existing facilities need to be improved before the year 2000 in 26 communities serving 63,530 people, in addition to Lake Metigoshe State Park. Incorporated communities and certain other public entities are eligible for financial assistance through the Construction Grant Program of the Environmental Protection Agency. This Program is administered in North Dakota by the State Health Department. Under this Program, 75 percent of the planning and construction costs for new collection and treatment facilities and for upgrading existing wastewater treatment plants are reimbursible. Congress appropriates the money for the Program. The State Health Department disperses North Dakota's share according to a priority list it has developed.

ECONOMIC DEVELOPMENT: Capital Cost $5,302,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The wastewater treatment facilities will improve the water quality of the receiving watercourses. Additional solid waste resulting from the treatment process will need disposal.

OTHER SOCIAL EFFECTS:
The communities will have to furnish 25 percent of the total cost of any new or improved facility.

STATUS:
Ongoing program. Other sources of funding will have to furnish 25 percent of the total cost of new or improved facilities.

RECOMMENDATION:
Implementation in the 1980-1990 time frame.

NAME: Municipal Water Supply Treatment Facilities

PUBLIC INVOLVEMENT REGION: All Regions in the Souris River SPA

PURPOSE: Enhance municipal water supply treatment capability

LEAD STUDY AGENCY: ND State Health Department

DESCRIPTION: Additional or improved treatment facilities are needed in six communities serving 8,955 people in order to meet the recommended Standards for Safe Drinking Water Supplies set by the Environmental Protection Agency.

ECONOMIC DEVELOPMENT: Capital Cost $4,915,000
Annual Cost NA
Annual Benefit NA
Benefit/Cost Ratio NA

ENVIRONMENTAL QUALITY:
The additional or improved water supply treatment facilities will enhance the quality of municipal water supplies. Additional solid wastes generated by the treatment processes will require disposal.

OTHER SOCIAL EFFECTS:
Municipal water supplies will be improved, enhancing the safety, health and well-being, and quality of life for community residents. The only funding available is currently derived from the tax base of the community. No State or Federal funds are currently available.

STATUS:

Facilities are constructed on an individual basis as community funding allows.

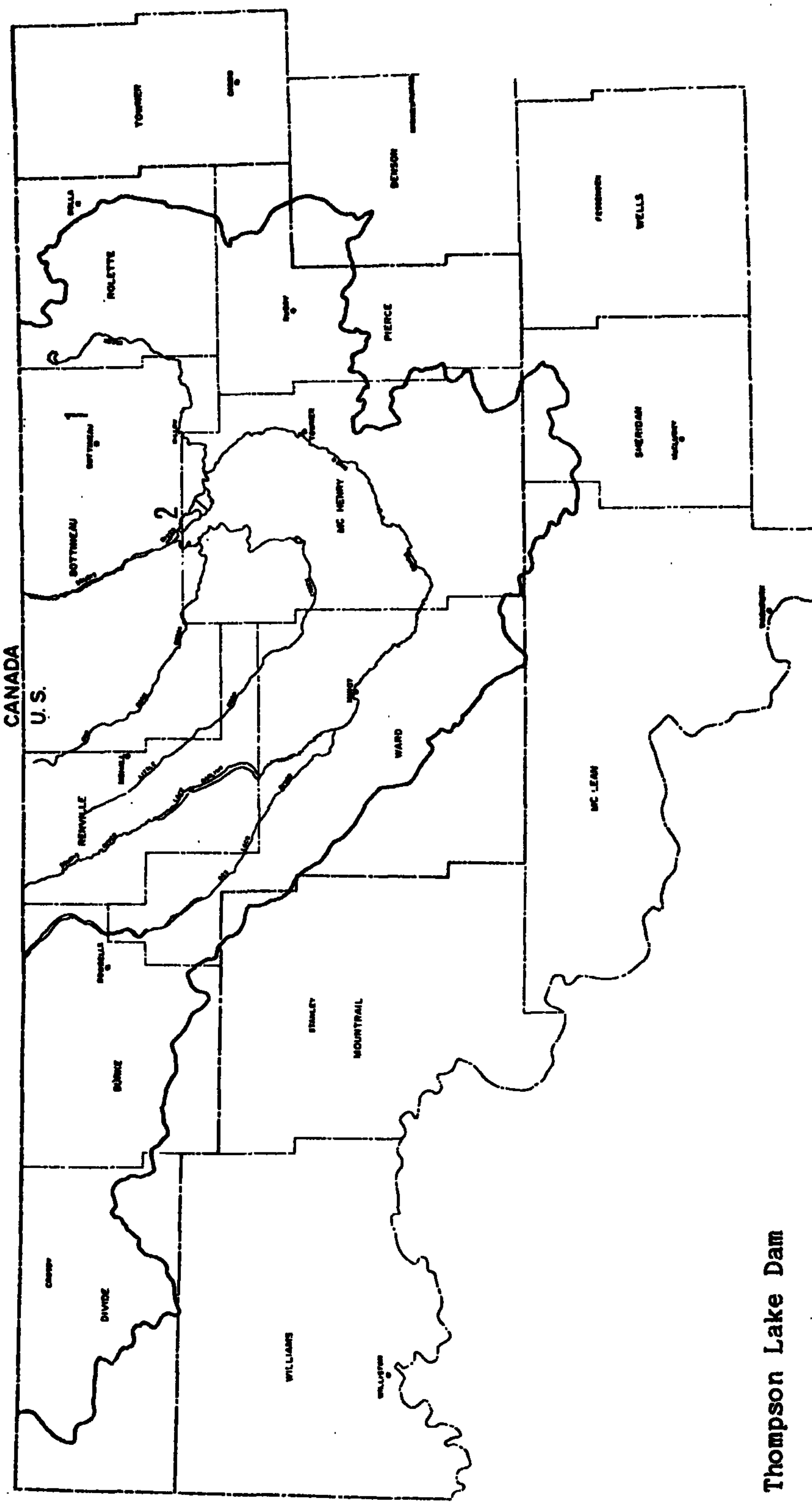
RECOMMENDATION: Implementation in the 1980-1990 time frame.

TABLE IV-5-5 RECOMMENDED PLAN AND ESTIMATED INVESTMENTS IN 1980 DOLLARS SOURIS RIVER BASIN

Water and Related Land Resources Category	Units	Composition and Estimated Investments (All Values are Incremental): 1980-1990 (Early Action Program)					1990-2000					2000-2020				
			Initial Investment		Annual O.M.&R.			Initial Investment		Annual O.M.&R.			Initial Investment		Annual O.M.&R.	
		Quantity	Federal ($1000)	State/Local ($1000)	Federal ($1000)	State/Local ($1000)	Quantity	Federal ($1000)	State/Local ($1000)	Federal ($1000)	State/Local ($1000)	Quantity	Federal ($1000)	State/Local ($1000)	Federal ($1000)	State Local ($1000)
SURFACE WATER CONTROL																
Multi-purpose Reservoir																
Total Storage	1000AF															
Flood Control	1000AF															
Other Purpose	1000AF															
Single Purpose Reservoir																
Flood Control	1000AF															
Irrigation	1000AF															
Municipal	1000AF															
Recreation	1000AF	0.45	--	14 1/	--	0.1										
Instream Control																
Channel Improvement	Miles															
Levees, Floodwalls, etc.	Each															
Streambank Stabilization	Each															
Diversion																
Irrigation	1000AF															
Municipal	1000AF															
Multi-feature Project 2/	Each															
RELATED LAND PROGRAMS																
Drainage	Each	1	--	94	--	1.4										
Irrigation																
Private	1000Ac															
Public	1000Ac															
ENVIRONMENTAL AND RESOURCE ENHANCEMENT 3/																
Protection and Management 4/																
Cropland	1000Ac	712	5,874	1,958	NA	NA	475	3,919	1,306	NA	NA	448	3,696	1,232	NA	NA
Pasture	1000Ac	37	153	51	NA	NA	24	99	33	NA	NA	15	62	21	NA	NA
Range	1000Ac	205	846	282	NA	NA	135	557	186	NA	NA	135	557	186	NA	NA
Forest	1000Ac	9	371	124	NA	NA										
Outdoor Recreation																
Stream Preservation	Miles															
Facilities	Each															
Waste Water Management																
Municipal 5/	1000PS 6/	3.5 7/	3,977	1,325	--	1,137 8/										
Water Supply Treatment																
Municipal	1000PS	9.0	--	4,915	--	246										
ADDITIONS AND MODIFICATIONS TO EXISTING PROJECTS																
Reservoir Storage	Each															
TOTAL COST			11,221	8,763	NA	1,384.5		4,575	1,525	NA	NA		4,315	1,439	NA	NA

1/ Represents an average of estimated costs for two alternatives.
2/ Multi-feature projects are defined as those projects which consist of more than one element, including structural and non-structural measures. Example: dam and diversion floodway.
3/ The data used to compute the figures displayed in this Category are useable on a County basis; therefore the figures are for the Souris River Statistical Planning Area (Figure 1-1-2) rather than the Basin.
4/ Land treatment measures have been accelerated from the Future Without Plan Projections (Table IV-1-5) as follows: 1980-1990 figures accelerated by 1.5 percent, 1990-2000 figures by 1.0 percent, and 2000-2020 figures by 0.5 percent.
5/ Some of the projects will be constructed in the 1990-2000 time frame. However, since the construction date of each specific project could not be determined, all costs have been placed in the 1980-1990 time frame.
6/ P.S. represents population served based upon the highest projection.
7/ Does not include Lake Metigoshe State Park waste treatment facilities capacity based upon population served.
8/ Does not include Lake Metigoshe State Park OM & R Cost.

FIGURE IV-5-2 SOURIS RIVER BASIN
LOCATION OF RECOMMENDED PLAN - EARLY ACTION PROGRAM



1 Thompson Lake Dam

2 White Spur Drain - Stone Creek South Project

TABLE IV-5-6 SOURIS RIVER BASIN RECOMMENDED PLAN - EARLY ACTION PROGRAM

Program Feature	Description & Purpose	Initial Cost "1980 Dollars" Federal	State/Local	Total	Annual Operation, Maintenance, and Replacement Costs "1980 Dollars" Federal	State/Local	Total
SURFACE WATER CONTROL							
Single Purpose Reservoirs	Thompson Lake Dam - Construction of a dam would raise the level of a natural lake three feet to enhance the recreation value of Thompson Lake located in Bottineau County.	-	$14,271	$14,271 1/	-	$143	$143
RELATED LAND PROGRAMS							
Drainage	White Spur Drain - Stone Creek South Project - Improvements are proposed for Stone Creek watershed in Oak Creek Township, Bottineau County.	-	$93,600	$93,600	-	$1,400	$1,400
ENVIRONMENTAL AND RESOURCE ENHANCEMENT							
Protection and Management	Land Treatment Measures - Measures are required to reduce soil erosion of 963,000 acres in the Souris River SPA.	$7,244,250	$2,414,750	$9,659,000	NA	NA	NA
Waste Water Management Municipal 2/	Development of new and/or improvement of existing municipal waste treatment facilities is required for 26 communities serving 63,530 people, in addition to a treatment facility at Lake Metigoshe State Park.	$3,976,500	$1,325,500	$5,302,000	-	$1,137,240 3/	$1,137,240 3/
Water Supply Treatment Municipal 4/	Development of additional or improvement of existing treatment facilities is required to meet recommended limits for domestic water supplies in six communities serving 8,955 people.	-	$4,915,000	$4,915,000	-	$245,800	$245,800

1/ Represents the average of estimated costs for the two alternatives shown in Table IV-5-4.

2/ As identified by the ND State Health Department, some of the projects will be constructed in the 1990-2000 time frame. However, since the construction date of specific projects could not be determined, all costs have been placed in the 1980-1990 time frame. The communities in the Souris River Statistical Planning Area (SPA) include: Antler, Willow City, Bottineau, Westhope, Balfour, Ambrose, Deering, Gardena, Landa, Newburg, St. John, Rolla, Portal, Kenmare, Minot, Sawyer, Glenburn, Donnybrook, Burlington, Powers Lake, Surrey, Noonan, Tolley, Fortuna, Flaxton, and Crosby, in addition to Lake Metigoshe State Park.

3/ Figure does not include Lake Metigoshe State Park OM&R Costs.

4/ As identified by the ND State Health Department, the communities in the Souris River SPA include: Bottineau, Drake, Rolla, Burlington, Bowbells, and Surrey.

ADDITIONAL SPECIAL STUDIES AND PROGRAMS

1) Alternatives should be investigated for the Souris River washout problem located five miles west and five miles north of Karlsruhe in McHenry County.

2) Continued study of the Lake Metigoshe water quality problblem is recommended in order to determine a viable solution.

3) A detailed watershed study is recommended for Seven Mile Coulee which is located nine miles north of Tolley in Renville County.

4) Consensus was not reached between the Upper and Lower Souris Public Involvement Regions regarding support of the Weather Modification Programs. The Upper Souris Region supports the programs.

5) It is recommended that rural water lines better serve the needs of individual farmers as well as small towns and populated areas. Cost sharing alternatives should be investigated.

6) A flooding problem with Rush Lake, Horseshoe Lake and Round Lake in Pierce County requires additional study.

7) Studies are recommended to find solutions to the flooding and erosion problems caused by the Wintering River in McHenry County. An alternative that should be considered is the use of one of three potential diversion routes for transferring Wintering River flood flows into lakes at the upper end of the Sheyenne River watershed in Pierce County for irrigation and lake enhancement.

8) Additional study should be considered for a flooding problem near Crosby in Divide County.

9) A watershed study should be undertaken to find a solution to a flooding problem in Grover Township of Renville County.

10) Review of existing studies of the Tolley Flats problem in Renville and Ward Counties is recommended. Studies should continue until a workable solution is found.

11) Recommended is a detailed analysis of a flooding problem near Makoti, to include the additional problem of seepage in a roadway of Section 33 - Township 154 North - Range 87 West near Hiddenwood Lake, and determination of the feasibility of a flood control dam in Section 28 - Township 154 North - Range 87 West.

12) Studies should be continued to determine suitable measures for addressing flood damages that would remain after implementation of the Lake Darling Compromise Plan.

13) Recommended is a study of flooding and erosion problems in the Des Lacs River Valley.

14) A study is requested to identify and analyze potential multi-purpose reservoir sites and sites for small, single purpose dry dams in the Des Lacs and Souris River watersheds.

15) A possible storage site 10 miles west of Rolette in Rolette County should be studied in greater detail. Although this particular site has questionable feasibility, support is voiced for the concept of water retention structures where landowners are willing to retain water.

16) An engineering study should be conducted of a single-purpose storage structure on Thompson Lake, five miles northeast of Bottineau in Bottineau County.

CHAPTER 6

STATEWIDE RECOMMENDATIONS AND SUMMARY

Most of the alternatives considered in the planning process are specific to a particular river basin while a few were considered statewide in nature. Table IV-6-1 contains a description of the statewide alternatives that were approved by the Citizens Advisory Boards and the public for inclusion in the plan recommendations.

Table IV-6-2 represents a statewide summary of the costs to implement all components of the recommended plan.

THREE-ACCOUNT ANALYSIS OF RECOMMENDED ALTERNATIVES

TABLE IV-6-1 STATEWIDE RECOMMENDED STUDY ALTERNATIVES - BENEFICIAL AND ADVERSE EFFECTS OF THE PROGRAMS

WEATHER MODIFICATION PROGRAM

NAME: The North Dakota Cloud Modification Program (NDCMP)

PUBLIC INVOLVEMENT REGION: Beaver Creek, Cannonball/Grand, James, Lake Sakakawea, Little Missouri, Lower Sheyenne, Middle Missouri, Upper Missouri, Upper Sheyenne, Upper Souris

PURPOSE: Continue State research efforts and provide funds to participate in State/Federal Cooperative Research Programs.

LEAD STUDY AGENCY: North Dakota Weather Modification Board (NDWMB)

DESCRIPTION: Continue the NDCMP conducted by the NDWMB, to enforce standards for the operational program to protect the public health and the environment, to coordinate State atmospheric water resources needs with local and federal agencies, to coordinate all weather modification activities within the State, and provide a unique opportunity for research groups to study an operational atmospheric water resources management program.

ECONOMIC DEVELOPMENT:

The operational program, depending on the acreage covered within the State, could add up to $132 million annually (1974 dollars) to the farm economy.

ENVIRONMENTAL QUALITY:

Past research indicates the NDCMP has the potential of increasing the critical growing season rainfall in North Dakota by one inch and decreasing hail damage by 30% to 60%.

OTHER SOCIAL EFFECTS:

Research strongly suggests a potential direct economic benefit/cost ratio for weather modification exceeding 20:1 in the State for rainfall enhancement alone. Indirect benefits multiply this ratio several times. Hail suppression benefits are undoubtedly great but difficult to quantify without continued operations and research.

STATUS: Ongoing program.

RECOMMENDATION: Continue program.

WEATHER MODIFICATION PROGRAM

NAME: Drought Management Strategies

PUBLIC INVOLVEMENT REGION: Beaver Creek, Cannonball/Grand, James, Lake Sakakawea, Little Missouri, Lower Sheyenne, Middle Missouri, Upper Missouri, Upper Sheyenne, Upper Souris

PURPOSE: Develop methods to utilize the State's atmospheric water resources in drought situations.

LEAD STUDY AGENCY: North Dakota Weather Modification Board (NDWMB)

DESCRIPTION: Distinguish the differences in cloud characteristics during drought and non-drought situations to the extent possible from recent research data. Determine alternative seeding methodologies and/or agents which are appropriate to the clouds present in drought situations. Establish an emergency cloud modification plan utilizing the alternative methodologies and agents, which can be quickly implemented when the onset of drought conditions is recognized. Set criteria to indicate when to initiate the emergency plan, when to terminate, and how to evaluate its effectiveness.

ECONOMIC DEVELOPMENT:

Economic development will be drived from the planning strategies to minimize drought impacts in the State.

ENVIRONMENTAL QUALITY:

Establish specific methods of utilizing the atmosphere's water resource during drought which may lessen the magnitude and extent of the effects of the situation and develop definitions for drought situations.

OTHER SOCIAL EFFECTS:

The development of drought management strategies through cloud modification will provide a tangible approach to dealing with drought through the broad function of the ND State Water Commission. The knowledge of such strategies will help instill confidence in the public during drought and eliminate to some extent the feeling of helplessness and despair often associated with the situation.

STATUS: Program enhancement.

RECOMMENDATION: Implementation of program.

WEATHER MODIFICATION PROGRAM

NAME: Public Awareness of Weather Modification

PUBLIC INVOLVEMENT REGION: Beaver Creek, Cannonball/Grand, James, Lake Sakakawea, Little Missouri, Lower Sheyenne, Middle Missouri, Upper Missouri, Upper Sheyenne, Upper Souris

PURPOSE: Promote public awareness of technologies for atmospheric water-resource management. Attempt to expand the scope of weather modification activities within the State to benefit a larger segment of the population.

LEAD STUDY AGENCY: North Dakota Weather Modification Board

DESCRIPTION: Develop, publish, and make available for distribution new literature directed at increasing public awareness of state-of-the-art atmospheric water-resource management technologies, research results, and pertinent issues. Expand lecture materials on these topics and provide speakers for interested civic groups, farm organizations, schools, etc. Stress explanation of operations, activities, and research results in non-technical terminology. Particularly emphasize the considerable economic value and benefit to the environment of weather modification to the State.

ECONOMIC DEVELOPMENT:
Estimated gross business volume resulting from increased farm income and expenditures due to one inch of added growing season rainfall over the State is $300 million in 1974 dollars.

ENVIRONMENTAL QUALITY:
Increased public awareness of weather modification technologies and potential benefits will promote the expansion of their use and maximize their effectivenss.

OTHER SOCIAL EFFECTS:
Inform the public of the legal mechanism already in place in the State for regulating and conducting weather modification activities. Verify the meaning and significance of research results as they relate to the State's economy and environment. Establish a sense of public pride in the worldwide recognition of North Dakota's pioneering efforts in atmospheric water resources management. Create additional public support for this powerful tool to help meet the State's water needs. Present the very real need for North Dakota's continued involvement in national and international efforts to utilize the atmospheric water resources to meet growing needs in agriculture, municipalities, industries, and energy production.

STATUS: Program enhancement.

RECOMMENDATION: Implementation of program.

WEATHER MODIFICATION PROGRAM

NAME: Atmospheric Water Resources Research in conjunction with the North Dakota Cloud Modification Program (NDCMP)

PUBLIC INVOLVEMENT REGION: Beaver Creek, Cannonball/Grand, James, Lake Sakakawea, Little Missouri, Lower Sheyenne, Middle Missouri, Upper Missouri, Upper Sheyenne, Devils Lake, and Upper Souris

PURPOSE: Continue State research efforts and provide funds to participate in State/Federal Cooperative Research Programs.

LEAD STUDY AGENCY: North Dakota Weather Modification Board (NDWMB)

DESCRIPTION: Maintain and expand the existing raingauge network to broaden the State's climatic data base and to further define the effects of cloud seeding on rainfall. Refine hail observation procedures to improve knowledge of the State's hail climatology and determine the effects of cloud seeding on hail suppression. Provide State funds to participate in State/Federal Cooperative Research Programs, possibly as an element of a future National Weather Modification Program. Explore the feasibility and effectiveness of various seeding agents. Develop new seeding methodologies and new operation assessment techniques.

ECONOMIC DEVELOPMENT:

Derived from total area of effects and confirmatory research.

ENVIRONMENTAL QUALITY:

Continued research efforts are vital in defining weather modification's role in helping meet the State's water needs. The State's research programs conducted through or by the NDWMB are a very cost effective means of gaining scientific and technical knowledge about management methodologies of atmospheric water resources.

OTHER SOCIAL EFFECTS:

State research efforts provide support for research and education at UND and NDSU, as well as a means of directing Federal research monies into North Dakota. The State has a long-term heritage of weather modification. On-going research related to the NDCMP has and will continue to create favorable recognition on an international scale for North Dakota efforts to manage the total spectrum of water-related problems. Such international recognition establishes North Dakota as a frontrunner in national and international efforts to better utilize atmospheric water resources.

STATUS: Program enhancement

RECOMMENDATION: Implementation of program.

TABLE IV-6-2 RECOMMENDED PLAN AND ESTIMATED INVESTMENTS IN 1980 DOLLARS STATEWIDE

Composition and Estimated Investments (All Values are Incremental)

Water and Related Land Resources Category	Units	1980-1990 (Early Action Program) Quantity	Initial Investment Federal ($1000)	Initial Investment State/Local ($1000)	Annual O,M&R. Federal ($1000)	Annual O,M&R. State/Local ($1000)	1990-2000 Quantity	Initial Investment Federal ($1000)	Initial Investment State/Local ($1000)	Annual O,M,&R. Federal ($1000)	Annual O,M,&R. State/Local ($1000)	2000-2020 Quantity	Initial Investment Federal ($1000)	Initial Investment State/Local ($1000)	Annual O,M,&R. Federal ($1000)	Annual O,M,&R. State/Local ($1000)
SURFACE WATER CONTROL																
Multi-purpose Reservoir																
Total Storage	1000AF	191.8 1/ 4/	--	37,018 2/	--	370	417.4	20,992	35,935	--	569.7	95.2 3/	--	33,249	--	333
Flood Control	1000AF	(75.1)					(274.7)									
Other Purpose 5/	1000AF	(114.8)					(142.7)					(95.2)				
Single Purpose Reservoir																
Flood Control	1000AF	114.8	--	12,813	--	128.1	67.8 6/	--	14,185	--	142	70.3	--	8,173	--	82
Irrigation	1000AF	17.4	--	3,670	--	36.7	11.6	--	4,335	--	43.4	295.2	--	46,502	--	485
Municipal	1000AF	0.07	--	188	--	2										
Recreation	1000AF	11.9	--	4,653	--	46.5	6.0	--	4,404	--	44					
Instream Control																
Channel Improvement	Miles	181.5	343	10,494	--	1,564.5	33	250	181	--	22					
Levees, Floodwalls, etc. 7/	Each	10	6,454	1,218	--	92.1	2	1,745	357	--	42	3	1,245	1,058	--	45
Streambank Stabilization	Each	33	7,250	220	24	126.2 8/										
Diversion																
Irrigation	1000AF	68	45,739	31,040	--	696	168.6	156,378 9/	34,327 9/	--	1,421	120	60,680	13,320	--	740
Municipal	1000AF						0.4	2,461	-- 10/	194	-- 10/					
Multi-feature Project 11/	Each	14	19,446	22,930	--	1,560	2	801	165	--	10					
RELATED LAND PROGRAMS																
Drainage	Each	4	--	841	--	12.4	2	--	384	--	5.8					
Irrigation																
Private 12/	1000Ac	14														
Public 13/	1000Ac	31.1					102.1					256.1 14/				
ENVIRONMENTAL AND RESOURCE ENHANCEMENT																
Protection and Management 15/																
Cropland	1000Ac	3994	32,952	10,982	NA	NA	2656	21,912	7,304	NA	NA	1940	16,005	5,334	NA	NA
Pasture	1000Ac	445	2,066	688	NA	NA	297	1,331	461	NA	NA	225	1,088	363	NA	NA
Range	1000Ac	1723	7,349	2,448	NA	NA	1144	4,882	1,627	NA	NA	1144	4,885	1,528	NA	NA
Forest	1000Ac	61	2,805	934	NA	NA	31	1,471	490	NA	NA	32	1,524	508	NA	NA
Outdoor Recreation																
Stream Preservation 16/	Miles	106	--	--	--	--										
Facilities 17/	Each	1	178.5	178.5	--	8										
Waste Water Management 18/																
Municipal	1000PS 19/	306.5 20/	25,905	8,636	--	5,502 21/										
Water Supply Treatment																
Municipal	1000PS	243.6	--	22,169	--	1,105.5	2	--	287	--	0.3					
ADDITIONS AND MODIFICATIONS TO EXISTING PROJECTS																
Reservoir Storage	Each	5	156	651	--	8										
TOTAL COST			150,683.5	171,771.5	24	11,258		212,273	104,442	194	2,300.2		85,427	112,135		1,6[illegible]

1/ Total includes storage from the category - Additions and Modifications to Existing Projects. Big Coulee Dam (Bisbee Dam) in Towner County - 900 AF of additional storage. Hansen Dam in Barnes County - 1000 AF of additional storage.
2/ Cost does not include major modification to an existing highway that is involved with Norway Township Dam in Traill County.
3/ Only reservoir capacity has been listed; in addition, approximately 368,000 AF would be diverted from Lake Sakakawea to meet the potential demand. Cost of the diversion system has not been determined.
4/ Figures in parentheses are non-additive.
5/ Storage included for municipal and industrial water supply, water quality control, sedimentation, fish and wildlife, and recreation.
6/ Total storage reflects storage available from multi-feature projects.
7/ Cost does not include individual farmstead levees. OM & R Cost for the Creel Bay levee in Ramsey County is not available.
8/ The current policy requiring local entities to bear the OM & R Cost of streambank stabilization projects on the Missouri and Yellowstone Rivers is a matter of dispute between the State of North Dakota and the Federal Government.
9/ Cost includes a Fish and Wildlife and Recreation Development Plan as part of the 20,400 acre Apple Creek Unit Irrigation Project located in southwestern Burleigh County (North Dakota Pumping Division, Pick-Sloan Missouri Basin Program).
10/ The City of Garrison must pay the initial cost of the treatment plant and annual OM & R Costs. The cost has been added to the Water Supply Treatment Category.
11/ Multi-feature projects are defined as those projects which consist of more than one element including structural and non-structural measures. Example: a dam and diversion floodway. Included in the 1980-1990 time frame is the SCS Grand Forks County Rural Flood Prevention Project which is currently being installed. This is a multi-year project and total funding has not been appropriated.
12/ Costs are shown under Surface Water Control - Diversion (Irrigation) totaling 21 million dollars.
13/ Acres irrigated reflect reservoir and diversion development. Costs are shown under Surface Water Control (Multi-purpose Reservoirs, Single Purpose Reservoirs, and Diversion). Cost under Reservoirs does not include distribution cost.
14/ The total includes 155,500 acres of land that could be irrigated with water diverted from Lake Sakakawea, including 7,375 acres and 9,100 acres of land which would be irrigated with water stored in Lake Patterson and Lake Tschida, respectively. Also associated with the diversion system will be 56,100 acre-feet for industrial use. Cost for the diversion system has not been determined.
15/ Land Treatment measures have been accelerated from the Future Without Plan Projections as follows: 1980-1990 figures accelerated by 1.5 percent, 1990-2000 figures by 1.0 percent, and 2000-2020 figures by 0.5 percent.
16/ The Heart River from Heart Butte Dam to the Missouri River should remain free flowing and designated as a State Scenic River.
17/ Seat Bay (Camp Grafton) - a multi-year project currently being installed in Ramsey County; funding for the total project has not been appropriated.
18/ Some of the projects will be constructed in the 1990-2000 time frame. However, since the construction date of each specific project could not be determined, all costs have been placed in the 1980-1990 time frame.
19/ P.S. represents population served based upon the highest projection.
20/ The population served does not include the Fort Lincoln, Lake Sakakawea, Lewis and Clark, and Lake Metigoshe State Parks facilities, nor the Fort Berthold Reservation.
21/ The annual OM & R Cost does not include the Fort Lincoln, Lake Sakakawea, Lewis and Clark, and Lake Metigoshe State Parks facilities, nor the Fort Berthold Reservation.

INTRODUCTION

WATER REQUIREMENTS

An emphasis of the State Water Plan Update process has been to reexamine North Dakota's long-range water requirements. The tables that follow in this Chapter have been developed using the Future Without Plan condition projections depicted in Part Three as a base. To this base were added the impacts of recommended water developments. The assumptions outlined in the Future Without Plan also apply to base conditions represented in each table. The relative magnitude of water use statewide for the categories in Table IV-7-6 are represented below.

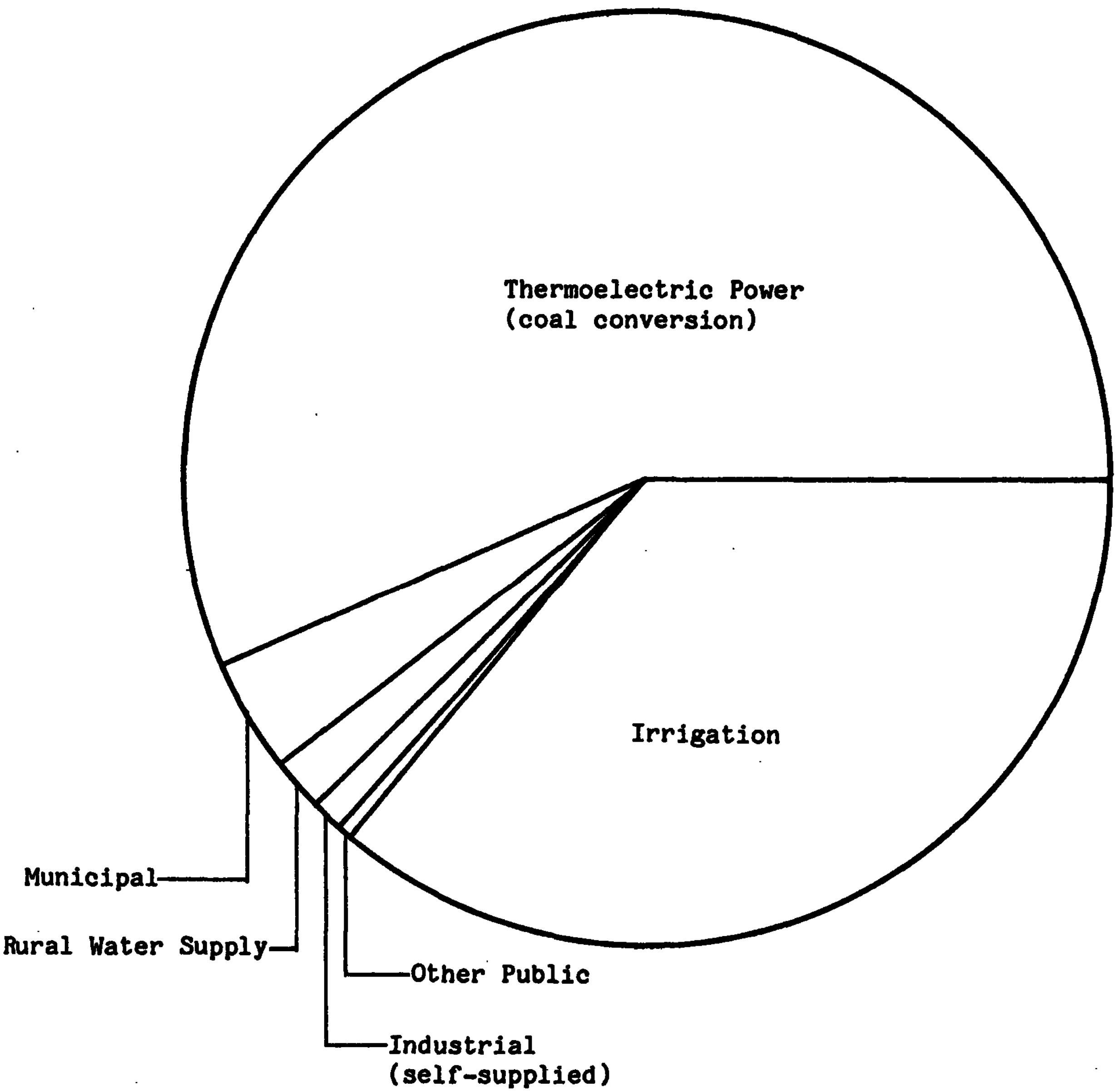


TABLE IV-7-1a ANNUAL WATER USE

MISSOURI RIVER BASIN

1990 TIME FRAME

	Units	1980 Developed Supply	Recommended Plan	1990 Developed Supply	Future Without Gross Requirement	Unmet Need [1]
Municipal	AF	20,250		20,250	25,375	5,125
Other Public	AF	905		905	985	80
Rural Water Supply						
Rural Water Systems (self-supplied)	AF	645		645	610	
Domestic	AF	4,810		4,810	4,530	
Livestock	AF	13,040		13,040	13,510	470
Irrigation						
Land Irrigated	(Ac)	(100,000)	(45,100)	(145,100)	(143,915)	
Water Required [2]	AF	186,250	90,200	275,450	260,385	
Industrial (self-supplied)	AF	4,480		4,480	4,935	455
Thermoelectric Power (coal conversion)	AF	1,035,575		1,035,575	1,050,570	14,995
TOTAL AF		1,265,955	90,200	1,356,155	1,360,900	21,125
Recreation [4]						
Boating/Waterskiing	Ac.	336,496	1,044	337,540	450,905	113,365
Boat Ramps	No.	120	4	124	145	21
Additional Reservoir Storage [5]	AF		193,400	193,400		

TABLE IV-7-1b ANNUAL WATER USE

MISSOURI RIVER BASIN

2000 TIME FRAME

	Units	1990 Developed Supply	Recommended Plan	2000 Developed Supply	Future Without Gross Requirement	Unmet Need [1]
Municipal	AF	20,250	1,400	21,650	31,850	10,200
Other Public	AF	905		905	1,195	290
Rural Water Supply						
Rural Water Systems (self-supplied)	AF	645		645	2,775	2,130
Domestic	AF	4,810		4,810	4,315	
Livestock	AF	13,040		13,040	15,395	2,355
Irrigation						
Land Irrigated	(Ac)	(145,100)	(102,100)	(247,200)	(181,315)	
Water Required [2]	AF	276,450	204,200	480,650	321,490	
Industrial (self-supplied)	AF	4,480		4,480	5,075	595
Thermoelectric Power (coal conversion)	AF	1,035,575	10,000	1,045,575	1,095,570	49,995
TOTAL AF		1,356,155	215,600	1,571,755	1,477,665	65,565
Recreation						
Boating/Waterskiing	Ac.	337,540	522	338,062	487,919	149,857
Boat Ramps	No.	124	2	126	157	31
Additional Reservoir Storage [5]	AF	193,400	389,100	582,500		

TABLE IV-7-1c ANNUAL WATER USE

MISSOURI RIVER BASIN

2020 TIME FRAME

	Units	2000 Developed Supply	Recommended Plan	2020 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	21,650	3,300	24,950	48,435	23,485
Other Public	AF	905		905	915	10
Rural Water Supply						
Rural Water Systems	AF	645		645	2,495	1,850
(self-supplied)						
Domestic	AF	4,810		4,810	3,885	
Livestock	AF	13,040		13,040	16,180	3,140
Irrigation						
Land Irrigated	(Ac)	(247,200)	(256,100)	(503,300)	(256,115)	
Water Required 2/	AF	480,650	512,200 3/	992,850	443,700	
Industrial (self-supplied)	AF	4,480		4,480	5,365	885
Thermoelectric Power (coal conversion)	AF	1,045,575	56,100 3/	1,101,675	1,140,570	38,895
TOTAL AF		1,571,755	571,600	2,143,355	1,661,545	68,265
Recreation 4/						
Boating/Waterskiing	Ac.	338,062		338,062	535,029	196,967
Boat Ramps	No.	126		126	175	49
Additional Reservoir Storage 5/	AF	582,500	389,900	972,400		

1/ Unmet need by water-use category is indicated only where the gross requirement from the Future Without Plan (Table III-1-6) exceeds the developed supply. Total unmet need is the sum of all indicated unmet need.

2/ A farm efficiency factor of 60 percent necessitates the diversion of 1.45 acre-feet of water per acre of land irrigated via ground-water sources and two acre-feet via surface water.

3/ Requires diversion of water from Lake Sakakawea.

4/ Recreation pertains only to boating/waterskiing and the number of boat ramps; other benefits will occur but could not be measured.

5/ Net gain in storage; does not reflect gross storage.

TABLE IV-7-2a ANNUAL WATER USE

JAMES RIVER BASIN

1990 TIME FRAME

	Units	1980 Developed Supply	Recommended Plan	1990 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	4,675		4,675	5,040	365
Other Public	AF	110		110	115	5
Rural Water Supply						
Rural Water Systems	AF	25		25	215	190
(self-supplied)						
Domestic	AF	1,650		1,650	1,555	
Livestock	AF	3,150		3,150	3,215	65
Irrigation						
Land Irrigated	(Ac)	(28,000)		(28,000)	(90,575)	(62,575)
Water Required 2/	AF	43,218		43,218	169,989	126,771
Industrial (self-supplied)	AF	1,735		1,735	1,770	35
Thermoelectric Power (coal conversion)	AF					
TOTAL AF		54,563		54,563	181,899	127,431
Recreation 3/						
Boating/Waterskiing	Ac.	6,103		6,103	7,446	1,343
Boat Ramps	No.	20		20	22	2
Additional Reservoir Storage 4/	AF					

TABLE IV-7-2b ANNUAL WATER USE

JAMES RIVER BASIN

2000 TIME FRAME

	Units	1990 Developed Supply	Recommended Plan	2000 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	4,675		4,675	5,854	1,179
Other Public	AF	110		110	140	30
Rural Water Supply						
Rural Water Systems	AF	25		25	420	395
(self-supplied)						
Domestic	AF	1,650		1,650	1,480	
Livestock	AF	3,150		3,150	3,635	485
Irrigation						
Land Irrigated	(Ac)	(28,000)		(28,000)	(98,650)	(70,650)
Water Required 2/	AF	43,218		43,218	179,760	136,542
Industrial (self-supplied)	AF	1,735		1,735	1,805	70
Thermoelectric Power (coal conversion)	AF				9,995	9,995
TOTAL AF		54,563		54,563	203,089	148,696
Recreation 3/						
Boating/Waterskiing	Ac.	6,103		6,103	8,422	2,319
Boat Ramps	No.	20		20	23	3
Additional Reservoir Storage 4/	AF					

TABLE IV-7-26 ANNUAL WATER USE

JAMES RIVER BASIN

2020 TIME FRAME

	Units	2000 Developed Supply	Recommended Plan	2020 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	4,675		4,675	8,655	3,980
Other Public	AF	110		110	105	
Rural Water Supply						
Rural Water Systems	AF	25		25	380	355
(self-supplied)						
Domestic	AF	1,650		1,650	1,335	
Livestock	AF	3,150		3,150	3,325	675
Irrigation						
Land Irrigated	(Ac)	(28,000)		(28,000)	(114,800)	(86,800)
Water Required 2/	AF	43,218		43,218	207,303	164,085
Industrial (self-supplied)	AF	1,735		1,735	1,880	145
Thermoelectric Power (coal conversion)	AF				9,995	9,995
TOTAL AF		54,563		54,563.	233,478	179,235
Recreation 3/						
Boating/Waterskiing	Ac.	6,103		6,103	10,558	4,455
Boat Ramps	No.	20		20	25	5
Additional Reservoir Storage 4/	AF					

1/ Unmet need by water-use category is indicated only where the gross requirement from the Future Without Plan (Table III-1-7) exceeds the developed supply. Total unmet need is the sum of all indicated unmet need.

2/ A farm efficiency factor of 60 percent necessitates the diversion of 1.45 acre-feet of water per acre of land irrigated via ground-water sources and two acre-feet via surface water.

3/ Recreation pertains only to boating/waterskiing, and the number of boat ramps; other benefits will occur but could not be measured.

4/ Net gain in storage; does not reflect gross storage.

TABLE IV-7-3a ANNUAL WATER USE

RED RIVER BASIN

1990 TIME FRAME

	Units	1980 Developed Supply	Recommended Plan	1990 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	23,780	68	23,848	28,035	4,187
Other Public	AF	485		485	515	30
Rural Water Supply						
Rural Water Systems (self-supplied)	AF	3,950		3,950	3,740	
Domestic	AF	2,365		2,365	2,230	
Livestock	AF	3,835		3,835	4,200	365
Irrigation						
Land Irrigated	(Ac)	(45,000)		(45,000)	(63,750)	(18,750)
Water Required 2/	AF	69,458		69,458	98,021	28,563
Industrial (self-supplied)	AF	4,255		4,255	4,980	725
Thermoelectric Power (coal conversion)	AF	275		275	275	
TOTAL AF		108,403	68	108,471	141,996	33,870
Recreation 3/						
Boating/Waterskiing	Ac.	9,493	1,055	10,548	15,188	4,640
Boat Ramps	No.	51	2	53	64	11
Additional Reservoir Storage 4/	AF		141,170	141,170		

TABLE IV-7-3b ANNUAL WATER USE

RED RIVER BASIN

2000 TIME FRAME

	Units	1990 Developed Supply	Recommended Plan	2000 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	23,848		23,848	35,110	11,262
Other Public	AF	485		485	620	135
Rural Water Supply						
Rural Water Systems (self-supplied)	AF	3,950		3,950	3,785	
Domestic	AF	2,365		2,365	2,125	
Livestock	AF	3,835		3,835	4,690	855
Irrigation						
Land Irrigated	(Ac)	(45,000)		(45,000)	(91,273)	(46,273)
Water Required 2/	AF	69,458		69,458	149,130	79,672
Industrial (self-supplied)	AF	4,255		4,255	5,070	815
Thermoelectric Power (coal conversion)	AF	275		275	275	
TOTAL AF		108,471		108,471	200,605	92,739
Recreation 3/						
Boating/Waterskiing	Ac.	10,548	768	11,316	16,518	5,202
Boat Ramps	No.	53	2	55	69	14
Additional Reservoir Storage 4/	AF	141,170	113,700	254,870		

TABLE IV-7-3c ANNUAL WATER USE

RED RIVER BASIN

2020 TIME FRAME

	Units	2000 Developed Supply	Recommended Plan	2020 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	23,848		23,848	50,830	26,982
Other Public	AF	485		485	475	
Rural Water Supply						
Rural Water Systems	AF	3,950		3,950	3,405	
(self-supplied)						
Domestic	AF	2,365		2,365	1,910	
Livestock	AF	3,835		3,835	4,965	1,130
Irrigation						
Land Irrigated	(Ac)	(45,000)		(45,000)	(146,319)	(101,319)
Water Required 2/	AF	69,458		69,458	241,347	171,889
Industrial (self-supplied)	AF	4,255		4,255	5,245	990
Thermoelectric Power (coal conversion)	AF	275		275	275	
TOTAL AF		108,471		108,471	308,452	200,991
Recreation 3/						
Boating/Waterskiing	Ac.	11,316	56	11,372	18,227	6,855
Boat Ramps	No.	55		55	77	22
Additional Reservoir Storage 4/	AF	254,870	70,800	325,670		

1/ Unmet need by water-use category is indicated only where the gross requirement from the Future Without Plan (Table III-1-8) exceeds the developed supply. Total unmet need is the sum of all indicated unmet need.

2/ A farm efficiency factor of 60 percent necessitates the diversion of 1.45 acre-feet of water per acre of land irrigated via ground-water sources and two acre-feet via surface water.

3/ Recreation pertains only to boating/waterskiing, and the number of boat ramps; other benefits will occur but could not be measured.

4/ Net gain in storage; does not reflect gross storage.

TABLE IV-7-4a ANNUAL WATER USE

DEVILS LAKE BASIN

1990 TIME FRAME

	Units	1980 Developed Supply	Recommended Plan	1990 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	2,090	183	2,273	2,635	362
Other Public	AF	45		45	40	
Rural Water Supply						
Rural Water Systems	AF	160		160	155	
(self-supplied)						
Domestic	AF	1,400		1,400	1,320	
Livestock	AF	670		670	765	95
Irrigation						
Land Irrigated	(Ac)	(4,000)		(4,000)	(31,875)	(27,875)
Water Required 2/	AF	6,108		6,108	60,964	54,856
Industrial (self-supplied)	AF	390		390	400	10
Thermoelectric Power (coal conversion)	AF					
TOTAL AF		10,863	183	11,046	66,279	55,323
Recreation 3/						
Boating/Waterskiing	Ac.	39,327	62	39,389	53,091	13,702
Boat Ramps	No.	12		12	14	2
Additional Reservoir Storage 4/	AF		900	900		

TABLE IV-7-4b ANNUAL WATER USE

DEVILS LAKE BASIN

2000 TIME FRAME

	Units	1990 Developed Supply	Recommended Plan	2000 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	2,273		2,273	3,620	1,347
Other Public	AF	45		45	45	
Rural Water Supply						
Rural Water Systems	AF	160		160	155	
(self-supplied)						
Domestic	AF	1,400		1,400	1,260	
Livestock	AF	670		670	865	195
Irrigation						
Land Irrigated	(Ac)	(4,000)		(4,000)	(42,150)	(38,150)
Water Required 2/	AF	6,108		6,108	80,620	74,512
Industrial (self-supplied)	AF	390		390	405	15
Thermoelectric Power (coal conversion)	AF					
TOTAL AF		11,046		11,046	86,970	76,069
Recreation 3/						
Boating/Waterskiing	Ac.	39,339		39,389	63,710	24,321
Boat Ramps	No.	12		12	16	4
Additional Reservoir Storage 4/	AF	900		900		

TABLE IV-7-4c ANNUAL WATER USE

DEVILS LAKE BASIN

2020 TIME FRAME

	Units	2000 Developed Supply	Recommended Plan	2020 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	2,273		2,273	6,115	3,842
Other Public	AF	45		45	35	
Rural Water Supply						
Rural Water Systems (self-supplied)	AF	160		160	140	
Domestic	AF	1,400		1,400	1,120	
Livestock	AF	670		670	920	250
Irrigation						
Land Irrigated	(Ac)	(4,000)		(4,000)	(62,700)	(58,700)
Water Required 2/	AF	6,108		6,108	119,933	113,825
Industrial (self-supplied)	AF	390		390	425	35
Thermoelectric Power (coal conversion)	AF					
TOTAL AF		11,046		11,046	126,688	117,952
Recreation 3/						
Boating/Waterskiing	Ac.	39,389		39,389	84,946	45,557
Boat Ramps	No.	12		12	19	7
Additional Reservoir Storage 4/	AF	900		900		

1/ Unmet need by water-use category is indicated only where the gross requirement from the Future Without Plan (Table III-1-9) exceeds the developed supply. Total unmet need is the sum of all indicated unmet need.

2/ A farm efficiency factor of 60 percent necessitates the diversion of 1.45 acre-feet of water per acre of land irrigated via ground-water sources and two acre-feet via surface water.

3/ Recreation pertains only to boating/waterskiing, and the number of boat ramps; other benefits will occur but could not be measured.

4/ Net gain in storage; does not reflect gross storage.

TABLE IV-7-5a ANNUAL WATER USE

SOURIS RIVER BASIN

1990 TIME FRAME

	Units	1980 Developed Supply	Recommended Plan	1990 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	7,825		7,825	9,105	1,280
Other Public	AF	240		240	245	5
Rural Water Supply						
Rural Water Systems	AF	895		895	1,565	670
(self-supplied)						
Domestic	AF	3,215		3,215	3.025	
Livestock	AF	2,445		2,445	2,530	85
Irrigation						
Land Irrigated	(Ac)	(6,000)		(6,000)	(16.775)	(10,775)
Water Required 2/	AF	10,152		10,152	27,838	17,686
Industrial (self-supplied)	AF	335		335	345	10
Thermoelectric Power (coal conversion)	AF	995		995	995	
TOTAL AF		26,102		26,102	45,648	19,736
Recreation 3/						
Boating/Waterskiing	Ac.	22,049	150	22,199	31,310	9,111
Boat Ramps	No.	66	1	67	86	19
Additional Reservoir Storage 4/	AF		450	450		

TABLE IV-7-5b ANNUAL WATER USE

SOURIS RIVER BASIN

2000 TIME FRAME

	Units	1990 Developed Supply	Recommended Plan	2000 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	7,825		7,825	12,390	4,565
Other Public	AF	240		240	300	60
Rural Water Supply						
Rural Water Systems	AF	895		895	1,760	865
(self-supplied)						
Domestic	AF	3,215		3,215	2,885	
Livestock	AF	2,445		2,445	2,870	425
Irrigation						
Land Irrigated	(Ac)	(6,000)		(6,000)	(66,217)	(60,217)
Water Required 2/	AF	10,152		10,152	122,858	112,706
Industrial (self-supplied)	AF	335		335	355	20
Thermoelectric Power (coal conversion)	AF	995		995	995	
TOTAL AF		26,102		26,102	144,413	118,641
Recreation 3/						
Boating/Waterskiing	Ac.	22,199		22,199	34,837	12,638
Boat Ramps	No.	67		67	96	29
Additional Reservoir Storage 4/	AF	450		450		

TABLE IV-7-5a ANNUAL WATER USE

SOURIS RIVER BASIN

2020 TIME FRAME

	Units	2000 Developed Supply	Recommended Plan	2020 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	7,825		7,825	20,045	12,220
Other Public	AF	240		240	230	
Rural Water Supply						
Rural Water Systems	AF	895		895	1,955	1,060
(self-supplied)						
Domestic	AF	3,215		3,215	2,595	
Livestock	AF	2,445		2,445	3,050	605
Irrigation						
Land Irrigated	(Ac)	(6,000)		(6,000)	(165,100)	(159,100)
Water Required 2/	AF	10,152		10,152	312,897	302,745
Industrial (self-supplied)	AF	335		335	380	45
Thermoelectric Power (coal conversion)	AF	995		995	995	
TOTAL AF		26,102		26,102	342,147	316,675
Recreation 3/						
Boating/Waterskiing	Ac.	22,199		22,199	38,806	16,607
Boat Ramps	No.	67		67	110	43
Additional Reservoir Storage 4/	AF	450		450		

1/ Unmet need by water-use category is indicated only where the gross requirement from the Future Without Plan (Table III-1-10) exceeds the developed supply. Total unmet need is the sum of all indicated unmet need.

2/ A farm efficiency factor of 60 percent necessitates the diversion of 1.45 acre-feet of water per acre of land irrigated via ground-water sources and two acre-feet via surface water.

3/ Recreation pertains only to boating/waterskiing, and the number of boat ramps; other benefits will occur but could not be measured.

4/ Net gain in storage; does not reflect gross storage.

TABLE IV-7-6a ANNUAL WATER USE

STATEWIDE

1990 TIME FRAME

	Units	1980 Developed Supply	Recommended Plan	1990 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	58,620	251	58,871	70,190	11,319
Other Public	AF	1,785		1,785	1,900	120
Rural Water Supply						
Rural Water Systems (self-supplied)	AF	5,675		5,675	6,285	660
Domestic	AF	13,440		13,440	12,660	
Livestock	AF	23,140		23,140	24,220	1,060
Irrigation						
Land Irrigated	(Ac)	(183,000)	(45,100)	(228,100)	(346,890)	(119,975)
Water Required 2/	AF	315,186	90,200	405,386	617,197	227,876
Industrial (self-supplied)	AF	11,195		11,195	12,430	1,235
Thermoelectric Power (coal conversion)	AF	1,036,845		1,036,845	1,051,840	14,995
TOTAL AF		1,465,886	90,451	1,556,337	1,796,722	257,485
Recreation 4/						
Boating/Waterskiing	Ac.	413,468	2,311	415,779	557,940	142,161
Boat Ramps	No.	269	7	276	331	55
Additional Reservoir Storage 5/	AF		335,920	335,920		

TABLE IV-7-6b ANNUAL WATER USE

STATEWIDE

2000 TIME FRAME

	Units	1990 Developed Supply	Recommended Plan	2000 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	58,871	1,400	60,271	88,824	28,553
Other Public	AF	1,785		1,785	2,300	515
Rural Water Supply						
Rural Water Systems (self-supplied)	AF	5,675		5,675	8,895	3,390
Domestic	AF	13,440		13,440	12,065	
Livestock	AF	23,140		23,140	27,455	4,315
Irrigation						
Land Irrigated 2/	(Ac.)	(228,100)	(102,100)	(330,200)	(479,605)	(215,290)
Water Required 2/	AF	405,386	204,200	609,586	853,858	403,432
Industrial (self-supplied)	AF	11,195		11,195	12,710	1,515
Thermoelectric Power (coal conversion)	AF	1,036,845	10,000	1,046,845	1,106,835	59,990
TOTAL AF		1,556,337	215,600	1,771,937	2,112,942	501,710
Recreation 4/						
Boating/Waterskiing	Ac.	415,779	1,290	417,069	611,406	194,537
Boat Ramps	No.	276	4	280	361	81
Additional Reservoir Storage 5/	AF	335,920	502,800	838,720		

TABLE IV-7-6c ANNUAL WATER USE

STATEWIDE

2020 TIME FRAME

	Units	2000 Developed Supply	Recommended Plan	2020 Developed Supply	Future Without Gross Requirement	Unmet Need 1/
Municipal	AF	60,271	3,300	63,571	134,080	70,509
Other Public	AF	1,785		1,785	1,760	10
Rural Water Supply						
Rural Water Systems	AF	5,675		5,675	8,375	3,265
(self-supplied)						
Domestic	AF	13,440		13,440	10,845	
Livestock	AF	23,140		23,140	28,940	5,800
Irrigation						
Land Irrigated 2/	(Ac)	(330,200)	(256,100)	(586,300)	(745,034)	(405,919)
Water Required	AF	609,586	512,200 3/	1,121,786	1,325,180	752,544
Industrial (self-supplied)	AF	11,195		11,195	13,295	2,100
Thermoelectric Power (coal conversion)	AF	1,046,845	56,100 3/	1,102,945	1,151,835	48,890
TOTAL AF		1,771,937	571,600	2,343,537	2,674,310	883,118
Recreation 4/						
Boating/Waterskiing	Ac.	417,069	56	417,125	687,566	270,441
Boat Ramps	No.	280		280	406	126
Additional Reservoir Storage 5/	AF	838,720	460,700	1,299,420		

1/ Statewide unmet need by water-use category and time frame is the sum of the indicated unmet need for that category from the five river basins (Table IV-7-1a through IV-7-5c). Total statewide unmet need is the sum of all indicated statewide unmet need for each time frame.

2/ A farm efficiency factor of 60 percent necessitates the diversion of 1.45 acre-feet of water per acre of land irrigated via ground-water sources and two acre-feet via surface water.

3/ Requires diversion of water from Lake Sakakawea.

4/ Recreation pertains only to boating/waterskiing, and the number of boat ramps; other benefits will occur but could not be measured.

5/ Net gain in storage; does not reflect gross storage.

PART FIVE

GENERAL STUDY CONCLUSIONS

In review of the goals and objectives and the various alternatives that ultimately became elements of the plan recommendations, it is possible to draw some general, statewide conclusions about water resource management in North Dakota. Each of the following conclusions is based not only on written aspects of this plan but on the perceptions that were gained in the many public meetings held across the State.

- North Dakotans recognize that water resource development is an essential component of stable economic growth but they are cautious and want adequate safeguards to protect and preserve the resource for future generations.

- The Missouri River and mainstem reservoirs are viewed as a great and relatively untouched resource. Every area across the State emphasized the need to reserve sufficient water from this source to satisfy North Dakota's future needs.

- Diversion of water from the Missouri River to areas of need within the State must be accomplished. It is recognized that federal financial assistance will be even further curtailed in the future and that a means to finance diversion projects at the State level must be devised.

- There is broad support for continued development of rural water supply systems in areas where water quality or availability is a problem.

- Water development features such as dams, canals, and pipelines should be implemented with a minimum of disruption to agricultural lands and should be environmentally sound.

- Collection and distribution of data concerning both surface and ground water availability and quality should be maintained and/or enhanced.

- Soil and water compatibility should be considered in granting water permits to assure long-term productivity. The criteria used to determine compatibility should be studied further.

- A need exists to improve the publics awareness of water resources and water resource management.

- Broad based interest exists in the development of irrigation to help stabilize and diversify the State's agricultural production. Many people have reservations about irrigation thinking that increased yields will further reduce market prices. Therefore, need exists to better educate the public on the virtues of irrigation including greater diversity in crops produced and more assured production even in dry years.

- Efficient use of water in existing and proposed irrigation developments is advocated with the suggestion that assistance be provided to renovate older systems and adopt improved irrigation techniques.

- Maintenance and improvement of water quality in streams and lakes is a statewide concern. It is recognized that land management practices have a direct impact on water quality, thus broad support exists for improved land management to aid in the control of non-point source pollution.

- Funding for lake restoration programs is essentially at a "demonstration" level. If the existing trend of accelerated lake eutrophication is allowed to continue, about half of the lakes currently managed as fisheries will be unsuitable within 15 to 20 years. Federal funding for restoration programs are not expected to increase, therefore, state and local entities must consider the assumption of this burden.

- Flooding is a long-standing problem in many areas across North Dakota and North Dakotans recognize that both structural and non-structural solutions for flood damage reduction must be pursued. Interest has been expressed in holding water on the land in contributing watersheds to minimize the need for large, flood water storage reservoirs.

- North Dakota's Flood Plain Management Act adopted in 1981 signifies a new and strong commitment by the State to pursue a comprehensive approach to flood plain management. A need exists to develop and disseminate flood plain information to the public and to local communities to facilitate participation in the National Flood Insurance Program. Flood prone communities must adopt and implement comprehensive flood hazard mitigation plans.

- North Dakota possesses invaluable fish and wildlife resources. Man's influence on the landscape has resulted in a loss of both numbers and diversity of species, thus it is important that "essential" habitat be secured if the quality of the resource is to be maintained or improved. In securing fish and wildlife habitat, more flexible programs like the State and Federal Water Bank are much preferred to permanent easement and fee title purchases.

- New acquisition of lands for fish and wildlife purposes are strongly questioned in most areas of the State since many acres have already been dedicated to habitat preservation. Strong sentiment was voiced that land currently dedicated should be managed more intensively to meet fish and wildlife needs. Improved cooperation/coordination between fish and wildlife authorities and landowners should be fostered.

- The demand for water related outdoor recreation exceeds available opportunities in many areas of the State. Broad support has been voiced for expedient implementation of outdoor recreation facilities that are either independent developments or components of multipurpose projects.

- Weather modification is a little understood program in most areas of North Dakota. Continued research conducted on existing operational projects is needed with scientific findings translated to more easily understood formats and presented to the public.

- Hydroelectric power generation is received favorably in North Dakota because it is viewed as a clean, renewable energy source. There is significant opposition, however, to further loss of Missouri River bottoms to the re-regulation reservoir necessitated by increased generating capacity at Garrison Dam. Smaller scale hydropower development seems to enjoy far greater support.

- Strong support does not currently exist for the preservation of instream flows for purposes of outdoor recreation, water quality and fish and wildlife.

- The Joint Powers Board concept is favored over Water Resources Districts based on hydrologic boundaries as the most effective mechanism for local water management activities.

- Dealing with the recurring, severe flooding in the Red River Valley requires a high level of coordination between North Dakota and Minnesota. Participants in the State Water planning process from that area strongly support the formal coordination activities of the Red River Water Resources Council and urge both State Legislatures to provide continued funding.

- It is imparative that the amount of water needed to satisfy both Indian and Federal Non-Indian water rights be quantified so the question of water availability can be resolved, thus relieving the uncertainty that exists in the State's water right system.

- Existing soil irrigability criteria used by the U.S. Bureau of Reclamation in determining project feasibility is considered by many to be too stringent for the conditions that exist in North Dakota. A research program was recently initiated to review factors that contribute to soil irrigability under conditions typical to North Dakota. The results of this research could be very significant to future irrigation development across the State and should be completed at the earliest possible date.

- Strong interest has been demonstrated for research which would evaluate the many values attributed to wetlands. Scientifically sound quantification of wetland values is needed to provide a <u>comprehensive</u> understanding of this resource element.