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SEVENTH BIENNIAL REPORT

of the

State Water Conservation Commission

and the

TWENTY-FOURTH BIENNIAL REPORT

of the

STATE ENGINEER

of

North Dakota

WATER CONSERVATION COMMISSION
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To June 30, 1950

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SEVENTH BIENNIAL REPORT

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State Water Conservation Commission

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TWENTY-FOURTH BIENNIAL REPORT

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STATE ENGINEER

of

North Dakota

To June 30, 1950

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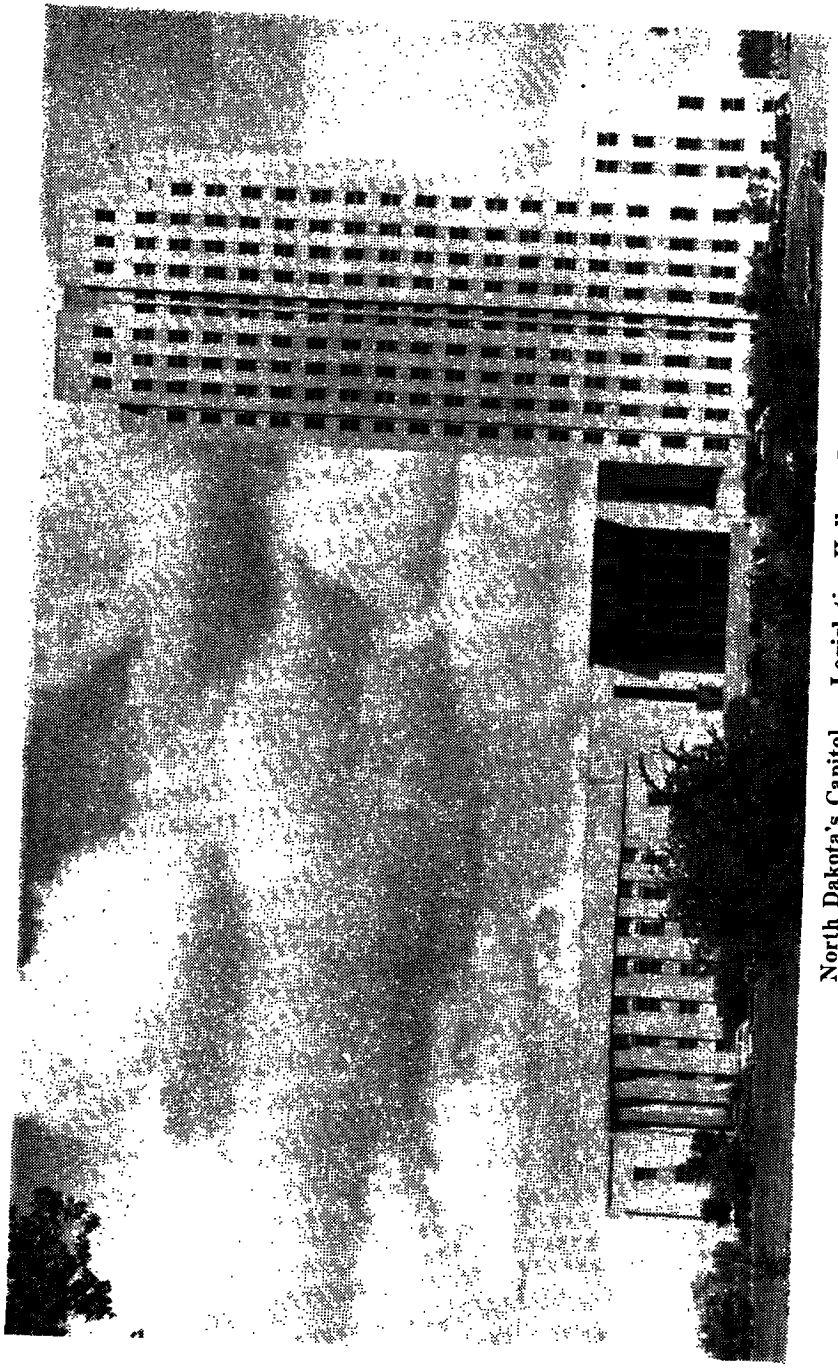


North Dakota's Capitol — Legislative Halls at Left

LETTER OF TRANSMITTAL

Honorable Fred G. Aandahl
Governor of North Dakota

Sir:

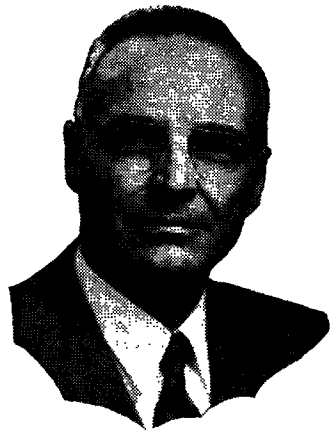
In compliance with provisions of law, we transmit herewith for your information and consideration the Seventh Biennial Report of the activities of the State Water Conservation Commission and the Twenty-Fourth Biennial Report of the State Engineer, from October 1, 1948, to June 30, 1950.

Respectfully submitted,

STATE WATER CONSERVATION COMMISSION

S. W. THOMPSON, Vice Chairman
EINAR H. DAHL
CURTIS OLSON
EARLE F. TUCKER
A. M. CHRISTENSEN
MATH DAHL

J. J. Walsh
Secretary and Chief Engineer, State Engineer



GOVERNOR FRED G. AANDAHL, Ex-officio Chairman of the State Water Conservation Commission, stated:

"This water development program will have as far reaching influence upon the future economy and prosperity of the area as the original Homestead Act."

ANTIQUITY OF IRRIGATION

"And a river went out of Eden to water the garden; and from thence it was parted and became into four heads." Genesis 2:10.

"And thus saith the Lord, ye shall not see wind,

"Neither shall ye see rain, yet that valley shall be filled with water, that ye may drink, both ye and your cattle, and your beasts." Kings, 3:16-17.

NORTH DAKOTA CONSTITUTION DECLARES:

Sec. 210—"All flowing streams and natural water courses shall forever remain the property of the state for mining, irrigating and manufacturing purposes."

Garrison Dam Sketch with Water Control Structures Location

ORGANIZATION AND PERSONNEL

The State Water Conservation Commission of seven members was created by the 1937 legislature. The Governor was made ex-officio chairman and authorized to appoint the other members. Amendments to the law were made by the 1939 legislature, reducing the membership to five. Other amendments increasing the scope of the commission's activities were made at later sessions.

The Commission was enlarged again by the 1949 legislative session to seven, consisting of the Governor, Commissioner of Agriculture and Labor, and five other members to be appointed by the Governor. The two new members are Math Dahl and A. M. Christensen. Mr. Tucker was reappointed on July 8, 1949, to a six-year term, terminating July 1, 1955.

The Commission is presently composed of the following members:

	Term Began	Term Ends
Governor Fred G. Aandahl, ex-officio chairman	Jan. 2, 1945	Jan. 2, 1951
C. Norman Brunsdale, Governor-elect and ex-officio chairman	Jan. 2, 1951	
Sivert W. Thompson, Vice-Chairman, Devils Lake	April 3, 1939	June 30, 1953
Einar H. Dahl, Watford City	April 3, 1939	June 30, 1953
Curtis Olson, Valley City	Jan. 1, 1948	June 30, 1951
Earle F. Tucker, Bismarck	May 1, 1948	July 1, 1955
A. M. Christensen, Minot	May 27, 1949	June 30, 1955
Math Dahl, ex-officio as Commissioner of Agriculture and Labor	May 27, 1949	
J. J. Walsh, Secretary and Chief Engineer, State Engineer		

POWERS AND DUTIES, STATE WATER COMMISSION

Powers and Duties of the Commission. The commission shall have full and complete power, authority, and general jurisdiction:

1. To investigate, plan, regulate, undertake, construct, establish, maintain, control, and supervise all works, dams, and projects, public and private, which in its judgment may be necessary or advisable:

a. To control the low-water flow of streams in the state;

b. To impound water for the improvement of municipal and rural water supplies;

c. To control and regulate flood flow in the streams of the state to minimize the damage of such flood waters;

Garrison dam bridge was built for construction purposes. It carries both railroad, truck and passenger cars for hauling materials and construction workers.

d. To conserve and develop the waters within the natural water-shed areas of the state and, subject to vested and riparian rights, to divert the waters within water-shed area to another water-shed area and the waters of any river, lake or stream into another river, lake or stream.

e. To improve the channels of the streams for more efficient transportation of the available water in the streams;

f. To provide sufficient water flow for the abatement of stream pollution;

g. To develop, restore and stabilize the waters of the state for domestic, agricultural and municipal needs, irrigation, flood control, recreation, and wildlife conservation, by the construction and maintenance of dams, reservoirs and diversion canals;

h. To promote the maintenance of existing drainage channels in good agricultural lands and to construct any needed channels;

i. To provide more satisfactory subsurface water supplies for the smaller villages of the state;

j. To finance the construction, establishment, and maintenance of public and private works, dams, and irrigation projects, which in its judgment may be necessary and advisable;

k. To provide for the storage, development, diversion, delivery, and distribution of water for the irrigation of agricultural land;

l. To provide for the drainage of lands injured by or susceptible of injury from excessive rainfall or from the utilization of irrigation water and, subject to the limitations prescribed by law, to aid and cooperate with the United States and any department, agency, or officer thereof, and with any county, township, drainage district or irrigation district of this state, or of other states, in the construction or improvement of such drains;

m. To provide water for stock; and

n. To provide water for the generation of electric power and for mining and manufacturing purposes;

2. To define, declare, and establish rules and regulations:

a. For the sale of waters and water rights to individuals, associations, corporations, and political subdivisions of the state, and for the delivery of water to users;

b. For the full and complete supervision, regulation, and control of the water supplies within the state; and

c. For the complete supervision and control of acts tending to pollute watercourses, for the protection of the health and safety of all the people of the state;

3. To exercise full power and control of the construction, operation, and maintenance of works and the collection of rates, charges, and revenues realized therefrom;

4. To sell, lease, and otherwise distribute all waters which may be developed, impounded, and diverted by the commission under the provisions of this chapter, for the purpose of irrigation, the development of power, and the watering of livestock, and for any other private or public use; and

5. To exercise all express and implied rights, power, and authority, that may be necessary, and to do, perform, and carry out all of the expressed purposes of this chapter and all of the purposes reasonably implied incidentally thereto or lawfully connected therewith.

6. To acquire, own and develop lands for irrigation and water conservation and to acquire, own and develop dam sites and reservoir sites and to acquire easements and rights-of-way for diversion and distributing canals.

7. To cooperate with the United States and any department, agency or officer thereof in the planning, establishment and maintenance of dams, reservoirs, diversion and distributing canals, for the utilization of the waters of the state for domestic and municipal needs, irrigation, flood control, water conservation, generation of electric power and for mining, agricultural and manufacturing purposes, and in this connection the State Water Conservation Commission is hereby authorized, within the limitations prescribed by law, to acquire, convey, contribute or grant to the United States real and personal property, including land or easements for dams and reservoir sites and rights-of-way and easements for diversion and distribution canals.

THE STATE ENGINEER

The State Water Conservation Commission appoints the State Engineer, who shall be a qualified and experienced hydraulic engineer and also shall be an experienced irrigation engineer. He shall serve as secretary and chief engineer of the commission.

He is required to make a formal printed report to the Governor for the biennium preceding each legislative session. He passes on applications for permits to appropriate water, records the permit when granted, and issues certificate of construction of irrigation works or dams when completed, examines and approves plans and specifications for dams or

irrigation works, inspects dam sites and construction works, and collects state fees for same as required by law.

His records are open to public inspection during business hours. He is the custodian of General Land office maps, field notes and records of surveys of land turned over by the government to the state.

He shall make such rules and regulations necessary to carry into effect the duties devolving upon his office, relating to applications for permits to appropriate water, for the inspection of works, for the issuance of licenses, and for the determination of rights to the use of water.

He cooperates with Federal agencies in making hydrographic surveys and investigation of each stream system and source of water supply in the state, and shall obtain and record all available data for the determination, development and adjudication of the water supply of the state, and other duties pertaining thereto.

He cooperates with the U. S. Geological Survey in making topographic maps and surveys.

EARLY HISTORY OF IRRIGATION

Irrigation, the watering of land by artificial means, to increase crop production, has been used since ancient times in arid and semi-arid countries.

The water supply may be either surface flow from reservoirs created by damming of streams and rivers or from direct stream diversion, or it may be pumped from underground strata.

Irrigation is an historic practice, recorded in the Nile valley in Egypt as early as 2,000 B.C., and practiced in adjacent areas, particularly in Babylonia, Palestine, and India. Large irrigation works were in operation in Tunisia, Algeria and Morocco. Probably the earliest irrigation was practiced in China.

On the American continent, also, the practice of irrigation goes back to immemorial times. At the time of the Spanish conquest, irrigation practice was found well developed, and irrigation structures existed then which dated back to the first traditions of the native population.

In Peru are remains of irrigation structures of undoubted antiquity and of a quality comparable with the best of the present day. In Chile, similar remains are found. In Argentina, there are remains of vast irrigation structures. In fact, along the Atlantic and Pacific drainages of South America, where the climate made it desirable, great irrigation structures were built. In some places stupendous irrigation canals may be traced—400 to 500 miles long. There is evidence to show, also, that

on the American continent refinements of irrigation were practiced, superior to any others known.

After the discovery of America, the zealous Catholic missionaries established missions in various parts of the two American continents. These priests were chiefly from southern Europe and well acquainted with irrigation. Whenever a mission was established in an arid section, a small irrigation system was also built for the support of the mission. Remains of these mission irrigation systems are found in various parts of America, notably in California.

Large scale irrigation was first practiced in the United States by the Mormons in Utah. From their success grew the prevalence of present day irrigation in western United States, principally west of the 100th Meridian, where it is essential to sound, stable agriculture.

Early in the spring of 1847, a party of pioneers, under the leadership of Brigham Young, set out from their winter camp, near what is now Council Bluffs, to find in the far west a place where their people could settle. On July 24, this party of pioneers entered the Great Salt Lake Valley, chosen as the place of settlement, and on that day planted potatoes in what is now the business section of Salt Lake City, and gave the soil a good soaking of water brought from the neighboring City Creek through a plow furrow that served as a ditch.

This was the birth of modern irrigation in the United States.

In 1902 the U. S. Reclamation Service was created, now designated as the Bureau of Reclamation. During these 48 years, the Bureau of Reclamation has constructed irrigation features to serve more than 5,000,000 acres of arid and semi-arid land in the western states. As an integral part of its program, the Bureau has constructed hydro-electric power plants with an installed capacity of approximately 3,000,000 kilowatts.

A federal investment of about $1,500,000,000 has been made to construct existing reclamation projects in the area in which it operates—the 17 western states.

Many dams are now built as multiple-purpose structures, including irrigation, flood control, improvement of navigation and generation of hydroelectric power.

According to the 1940 census more than 20,000,000 acres of land were under irrigation at that time in the 17 western states. Of this, 3,791,000 were served by the Bureau of Reclamation and Indian Office works, and the remainder by private developments.

The most enlightened peoples have always practised and do now practise irrigation, if climatic conditions make it desirable. It is difficult for an unintelligent or shiftless people to become good irrigators.

ACTIVITIES OF WAR DEPARTMENT CORP OF ARMY ENGINEERS PROJECTS UNDERWAY

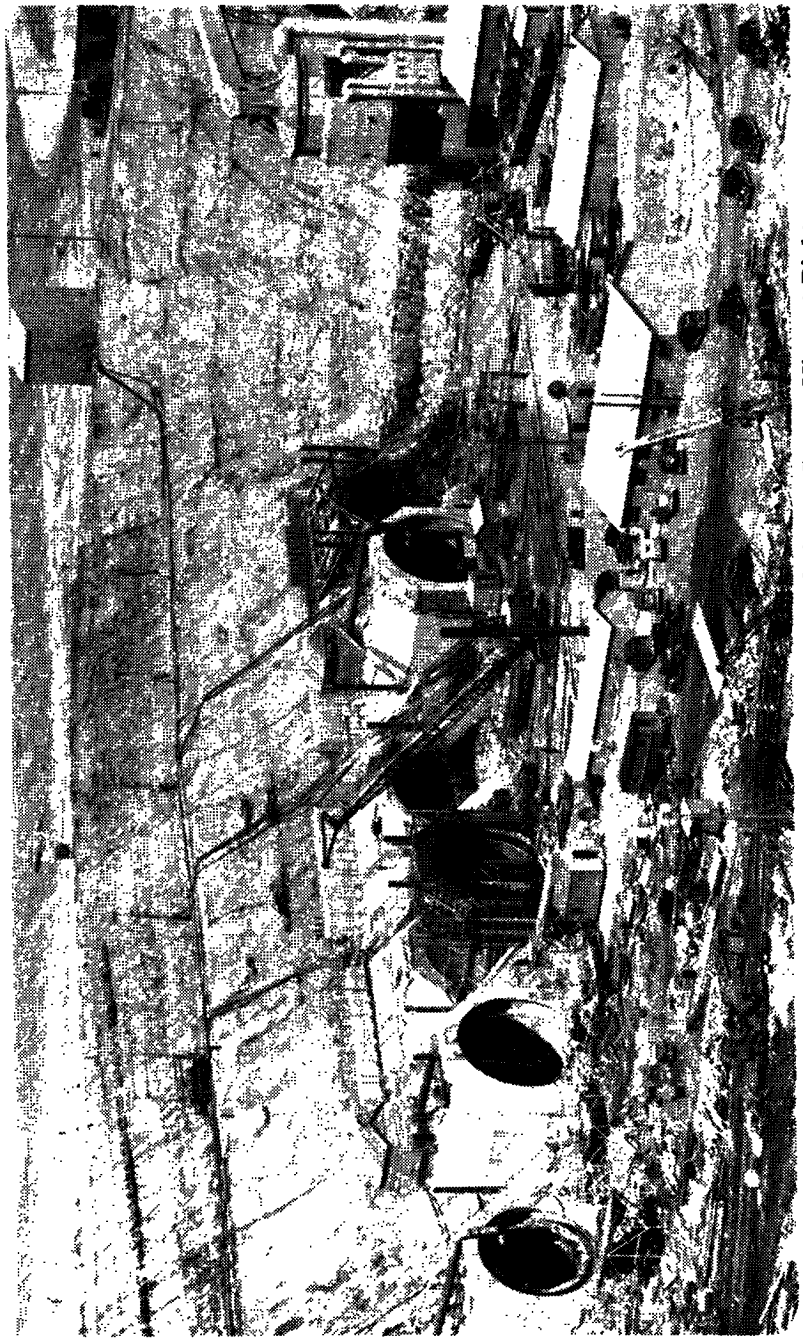
Garrison Dam and Reservoir

Progress is being made on the Garrison Dam and Reservoir Project now under construction by the Corps of Engineers, Department of the Army. The project is under the immediate supervision of Col. F. M. Albrecht, District Engineer, Garrison District at Fort Lincoln. Brig. Gen. S. D. Sturgis, Jr., Division Engineer Missouri River Division, Omaha, Nebraska, is in charge of all projects being constructed by the Corps of Engineers, of which Garrison is the key unit, under the Pick-Sloan comprehensive plan for the conservation of water resources of the Missouri Basin.

The Garrison dam and reservoir is a multi-purpose project for flood control, hydro-electric power, irrigation, navigation, water supply, and sanitation. The reservoir will extend upstream about 200 miles to the Montana state line, and have a capacity of 23,000,000 acre-feet and an area of 390,000 acres at maximum normal operating pool. The dam will be a rolled earth-fill structure over two miles long, rise 210 feet above the stream bed and contain about 70 million cubic yards of material. The spillway located in the east abutment, will be of the concrete chute-type, controlled by 28 tainter gates 40 feet wide by 29 feet high. The outlet works, in the west abutment, will consist of an intake tower, eight tunnels, stilling basin, and tailrace. Three tunnels, one 26 feet and two 22 feet in diameter, will serve for reservoir regulation and flood control operation. The other five, all 29 feet in diameter, will serve for power generation. Th powerhouse will have an initial capacity of 240,000 kilowatts with provision for ultimate capacity of 400,000 kilowatts. Approximate reservoir storage allocations will be 4,900,000 acre-feet of dead storage below elevation 1775, 13,850,000 acre-feet of multiple-purpose storage between elevations 1775 and 1838, and 4,250,000 acre-feet of flood control storage between elevation 1838 and maximum normal operating pool elevation 1850.

The project is scheduled for completion in 1955, at an estimated cost of $202,000,000, all of which is to be borne by the federal government. Additional appropriations of approximately $122,000,000 will be required to complete the project.

The reservoir, in conjunction with other projects in the comprehensive Missouri basin plan, will provide complete protection in the Missouri valley from floods equal to those of record on the main stem, will effect important reductions in flood stages of the lower Mississippi river and benefit navigation on the Missouri and Mississippi rivers by release of stored flood waters during low flow periods. It will contribute to the development of irrigation by making possible release of a portion



Garrison Dam Tunnel Outlets in Process of Completion — Cement Mixer at Right

of Fort Peck reservoir storage capacity to irrigation service and, possibly, by a direct diversion from Garrison reservoir to the eastern Dakotas. Diversion will also provide additional water for domestic water supply and sewage dilution along the James, Sheyenne and Red rivers and for restoration of Devils Lake. Recreational opportunities will be made available in a region which is now particularly devoid of facilities of this type. Production of low-cost power will result in widespread benefits.

Oahe Dam and Reservoir

Oahe dam, like Garrison, is a multiple-purpose project for flood control, hydro-electric power, irrigation, and navigation. The reservoir will extend about 250 miles upstream from the dam to a point near Bismarck. The dam will be a rolled earth fill structure about 9,300 feet long and 242 feet high above the river bed. The spillway will be an uncontrolled chute-type located on the west bank about one mile from the dam abutment. The reservoir will have a capacity of 22,500,000 acre-feet at maximum normal operating pool elevation of 1617 m.s.l. No completion date has been established for the project, on which construction work has just been initiated. Total cost is estimated at $234,400,000.

Red River of the North

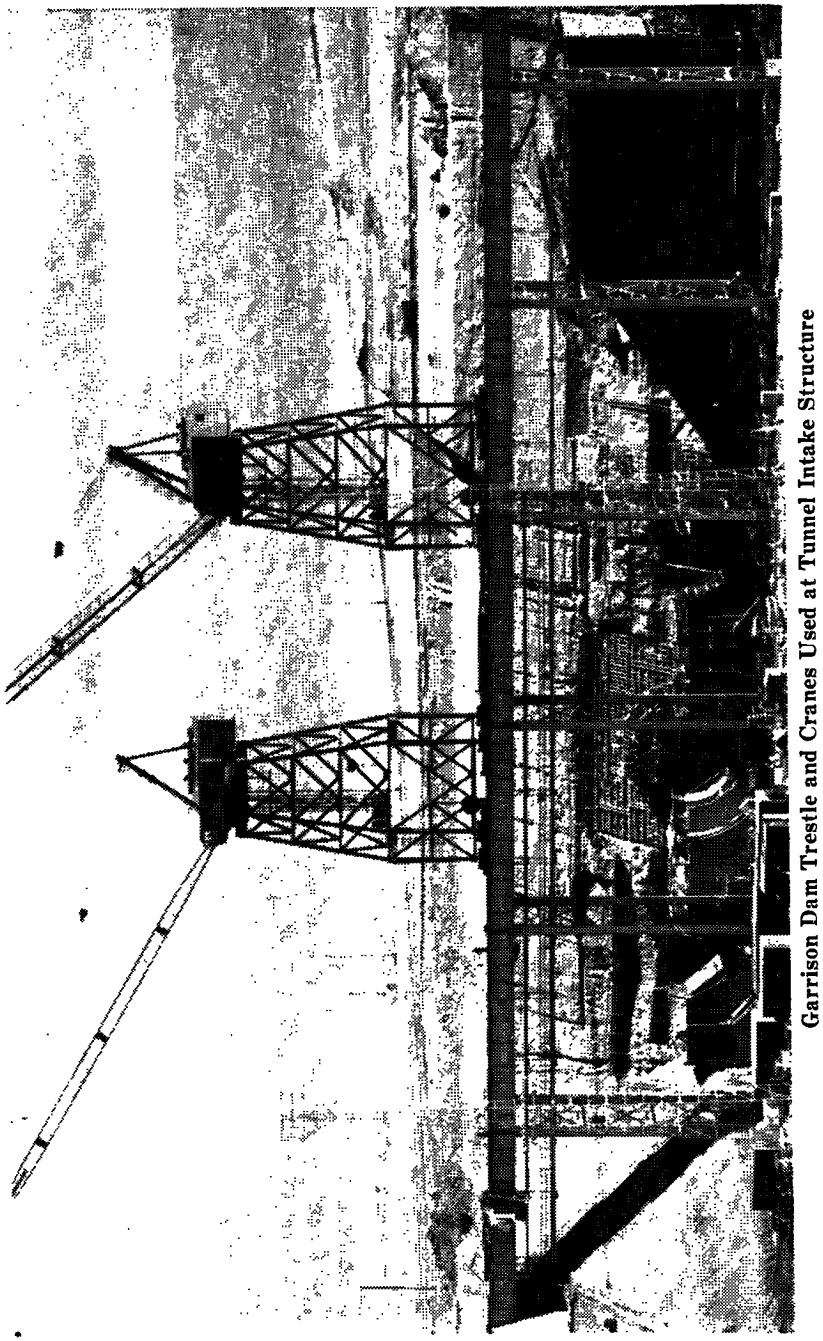
The Red river of the north project, authorized by the Flood Control act of 1948, lies in western Minnesota and eastern North Dakota. Work in North Dakota lies almost entirely in the valley of the Red river, either on that river itself or on its major tributaries immediately above their mouths.

The Red river of the north is formed by the confluence of the Ottertail and Bois de Sioux rivers at the twin cities of Wahpeton, North Dakota, and Breckenridge, Minnesota. It flows 400 miles to the international boundary in a tortuous northerly course through the broad flat bed of glacial Lake Agassiz. The flat slope and poor drainage, coupled with melting of winter-long accumulations of snow have resulted in severe floods of long duration, with increasing frequency during recent years.

The portions of the project in or adjacent to North Daota consist of channel improvements, levees and flood walls as follows:

Unit	Type	Estimated (1949) Federal Cost
Sheyenne river	38.3 miles of channel improvement	$ 866,400
Rush river	26.9 miles of channel improvement	555,200
Maple river	32.4 miles of channel improvement	1,134,000
Bois de Sioux and Red rivers at Wahpeton-Breckenridge	13.9 miles of channel improvement	487,300*
Red river at Grand Forks—East Grand Forks	21.9 miles of channel improvement, levees and flood wall	2,230,700*
Red river at Fargo-Moorhead	29 miles of channel improvement, levees and flood wall	1,466,200*
Total in North Dakota		$6,739,800

*Includes the Minnesota portion of the unit



Garrison Dam Trestle and Cranes Used at Tunnel Intake Structure

Channel improvements consist of clearing, straightening and enlarging. The earth levee at Grand Forks will be about 6,700 feet long, that at East Grand Forks will be 9,600 feet in length, including a 1,600-foot concrete flood wall section. The levee at Fargo will be about one mile in length, including a 900-foot section of floodwall. The Moorhead levee will be about 1,800 feet in length.

Planning is underway on all of the above features and funds have been available for initiating construction on the Sheyenne river unit, but due to lack of required assurances of local cooperation, construction has not been started. The project as a whole will be completed in about five years, dependent upon receipt of sufficient funds.

Baldhill Dam and Reservoir

Baldhill dam and reservoir, located in east central North Dakota on the Sheyenne river about 16 miles above Valley City, was authorized by the Flood Control act of 1944.

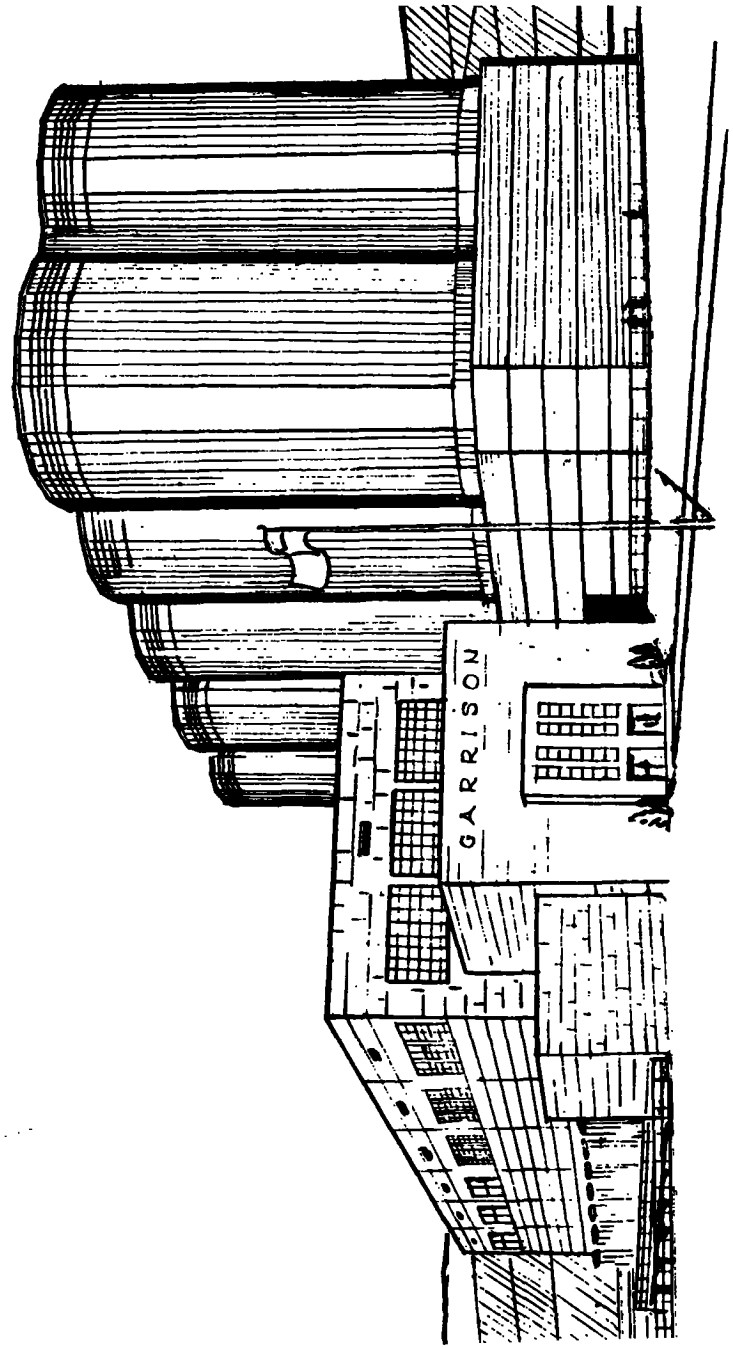
Baldhill dam was constructed for flood control and water utilization. The project comprises an earth fill dam with concrete spillway and control works. The dam has a total length of about 1,650 feet with a concrete gravity ogee control works about 140 feet in length, surmounted by three 40-foot Tainter gates, with two 3-foot diameter conduits in the piers for low water control. The earth dam and control works have been completed. Acquisition of remaining lands in the upstream portion of the reservoir and clearing thereon, and construction of operators dwelling and service buildings are the principal remaining items to be accomplished. The project can be completed by the spring of 1951 if sufficient funds are received. Present estimate of cost is $2,694,500.

Congress named the reservoir behind the dam, Lake Ashtabula, an Indian name meaning "Fish River."

Mandan

This project is located in the west central part of the state on both banks of the Heart river, approximately six miles above its confluence with the Missouri river, in Morton county. It was authorized by the Flood Control Act of 1946.

Municipal areas in Mandan have been inundated 24 times since 1881. Floods have caused extensive and repeated damage to domestic, business, industrial, railroad and civic properties. Severe losses have been suffered through traffic delays on U.S. Highway 10 and the Northern Pacific Railroad, both of which are transcontinental routes and pass through Mandan. The project, sufficiently completed during the 1949 construction season to be placed in emergency operation, consists of relocating and raising of approximately 23,000 lineal feet of levee, constructing 287 lineal feet of concrete cantilever type flood wall, reinforcing approximately 5,500 feet of railroad embankment to be utilized as levee, placing



Sketch of Power Tunnels Surge Tanks and Hydroelectric Generating Plant at the Garrison Dam in North Dakota

riprap protection on 600 lineal feet of stream bank, raising two highway bridges and adding one 75-foot span, constructing one stop log structure, and providing appurtenant drainage facilities to discharge sewage and storm flow during periods of flood. The federal and non-federal costs of the project will be approximately $551,700 and $93,100 respectively. The project will be completed during the 1950 construction season.

Homme Dam and Reservoir

Homme dam and reservoir is located in the northeast corner of North Dakota on the south branch of Park river, about four miles upstream from the city of Park River. The project was authorized by the Flood Control Act of 1944.

Homme reservoir has been designed to provide protection from spring overflow and a dependable stream flow for water supply and sewage dilution purposes. The dam consists of an earth-fill structure 865 feet long with a controlled concrete conduit five feet in diameter under the dam and a concrete overflow spillway about 150 feet in length adjacent to the dam. The reservoir has a storage capacity of about 3,650 acre-feet below spillway crest. Pool clearing and construction of the earth dam and control works have been completed. The concrete spillway is under construction and will be completed by the fall of 1950. The present estimated cost is $1,339,000.

AUTHORIZED PROJECTS

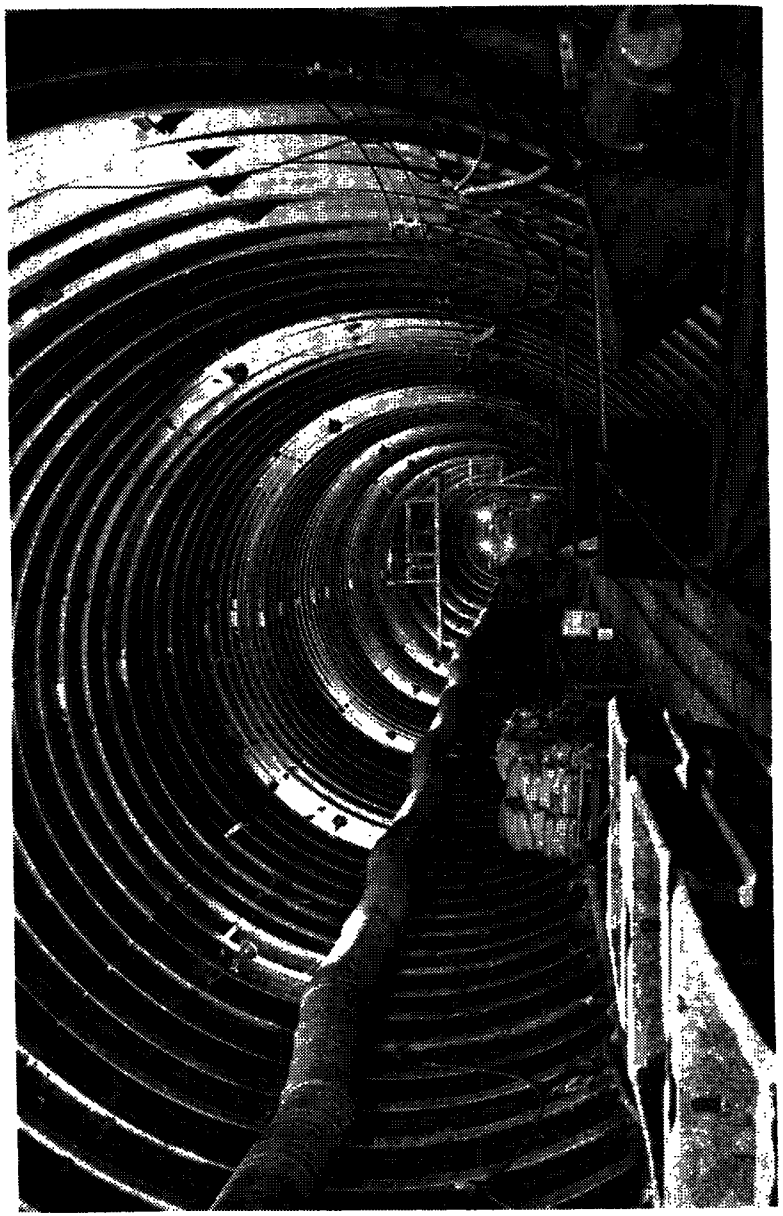
Diversion Into the Dakotas

This project, which will be located in central North Dakota, east of Garrison dam, was authorized by the Flood Control act of 1944.

The plan contemplates diversion of water from Garrison reservoir into Snake creek and Turtle Lake basin. Auxiliary reservoir will be created by a dam across the Snake creek arm of the reservoir. This reservoir will fill when the main reservoir is high and gates will hold the water available for pumping over the divide to the east. When the main reservoir is not high enough to fill the Snake creek reservoir by gravity, it will be filled by pumping. At the east end of the Snake creek and Turtle Lake basin, near Prophets mountain, a second pumping plant will lift the water 45 to 55 feet, from which point it will flow by gravity through canals and drop structures to the headwaters of James and Sheyenne rivers and be diverted into Devils lake. The estimated federal cost of the work is $35,000,000.

Pembina and Tongue River Reservoirs

These projects, located in the extreme northeast corner of North Dakota, were authorized by the Flood Control act of 1944. Restudy of the projects was authorized by senate commerce committee resolution



Garrison Dam 36 ft. Diameter Tunnel in Process of Construction

adopted February 28, 1945. The projects are inactive and no work will be undertaken pending completion of the restudy.

Jamestown Dam and Reservoir

This project, located in east central North Dakota on James river approximately one mile north of Jamestown, was authorized in the Flood Control act of 1944. It is now being planned by the Bureau of Reclamation.

Marmarth

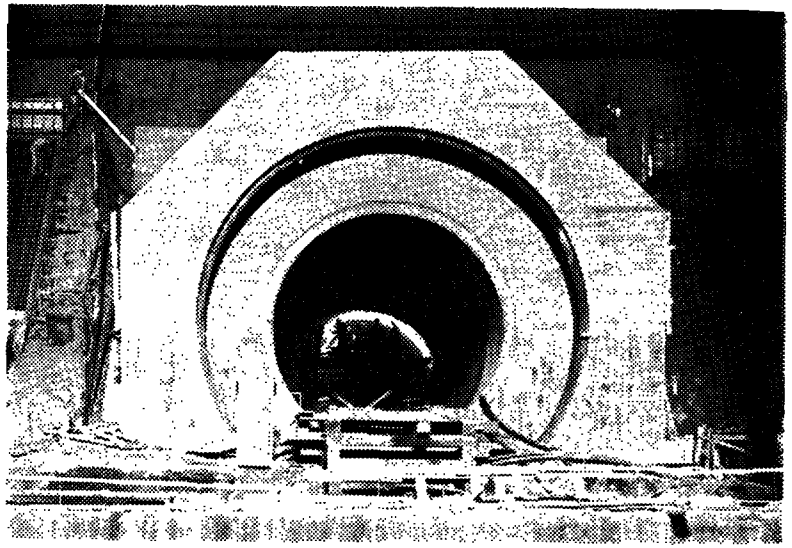
This project, located in southwest North Dakota on the Little Missouri river, was authorized by the Flood Control act of 1936. It consists of levees to protect the city of Marmarth from floods on Little Missouri river and on Little Beaver creek, which is tributary to the Little Missouri at Marmarth. It remained inactive for several years because of lack of necessary local cooperation, but in 1946 the city requested that it be reactivated and offered to furnish the necessary local cooperation. A new report, recommending an expanded and enlarged project, was prepared and submitted to Congress. The original project will remain inactive pending action by Congress on this report.

Beulah

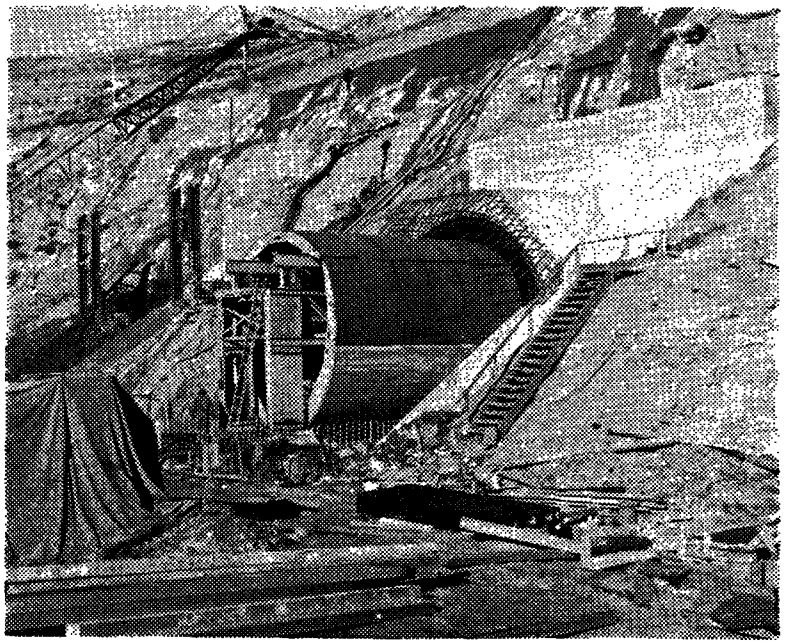
This project, located in west central North Dakota, was authorized by the Flood Control act of 1944. Past floods from two coulees which drain through the town have inundated the major portion of Beulah and have caused damage to utilities, business and city property and the Northern Pacific Railroad. The project plan provides for protection against floods from the two coulees by increasing the capacity of existing drainage channels through which the coulees drain into Knife river. The project is inactive owing to lack of local cooperation and its authorization will expire on December 9, 1952, under the terms of Section 3 of the 1944 Flood Control act, if local cooperation requirements have not been met by that time.

Hazen

This project is also located in west central North Dakota and was authorized by the Flood Control act of 1944. The city of Hazen lies on an alluvial plain between the Knife river and Antelope creek, a tributary, about two miles above their confluence. Past floods on Antelope creek have inundated the major portion of Hazen and caused extensive damage to municipal, business, and private property and to Northern Pacific Railroad facilities in the town. The project plan provides for the protection of Hazen by the construction of levees along the north and west sides of the town, together with appurtenant drainage and bridge work. Local interests have not furnished the necessary assurances of local cooperation, and the project is in an inactive status. The five-year period, established by Section 3 of the Flood Control act of December 22, 1944, will end on March 30, 1953, and the project authorization will expire at that time if local cooperation requirements have not been met.



Floodlights enabled the photographer to take this night picture of the upstream portal of tunnel No. 7, recently completed. This tunnel is 22 ft. in diameter and required 10,947 cubic yards of concrete in the 3½ ft. thick lining.



Form for 3½ ft. Concrete Lining, Garrison Tunnel

DEVELOPMENT OF WATER CONSERVATION IN NORTH DAKOTA

More than one-half of North Dakota is in the arid zone, where rainfalls are irregular and during some years insufficient to mature crops. Farming and ranching during dry periods is a precarious mode of making a living. The uncertain economy of the western half of the state culminated in the drought of the thirties with searching winds and years of watching an unrelenting sky for rain, almost completely bankrupting the area.

This was, however, nothing new in the history of the state. Climatic irregularities, most of the time with disastrous results, had been experienced with marked regularities ever since man inhabited the region. Official records during the later decades showed that the original pattern is part and parcel of this area.

The North Dakota constitutional convention in 1888, after being warned by Major J. W. Powell, director of the U. S. geological survey, adopted the following as part of the constitution:

"All flowing streams and natural water courses shall forever remain the property of the state for mining, irrigating and manufacturing purposes."

In 1905 the legislature created the office of state engineer and vested in him the authority to grant water rights—the right to appropriate the waters of streams and rivers for beneficial use.

In 1917 the law was enacted providing for the establishment and maintenance of irrigation districts.

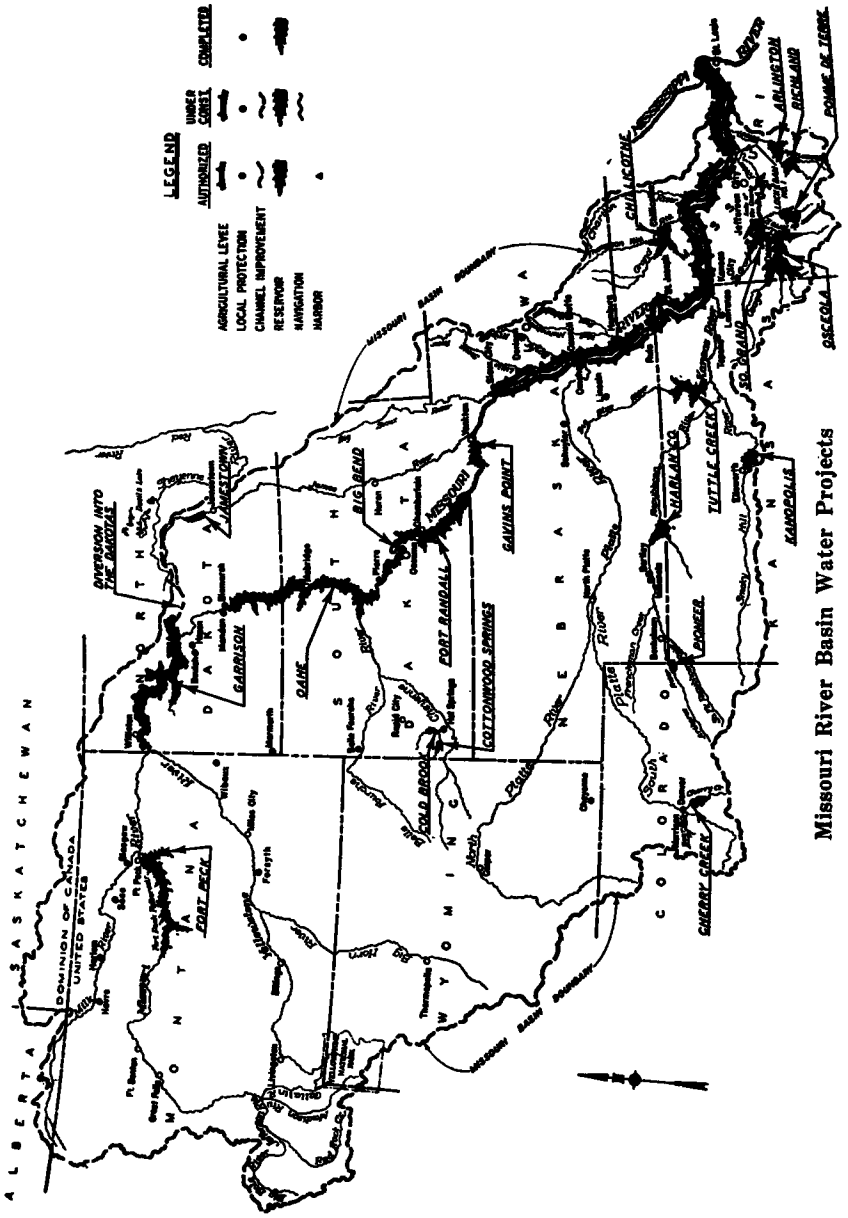
The North Dakota State Water Conservation Commission was created by the 1937 legislature. This act was reenacted in 1939.

The state water commission is composed of seven members of which the governor is ex-officio chairman.

After its creation in 1937, the commission, in cooperation with the North Dakota Rural Rehabiliattion Corporation, established the Lewis and Clark project in McKenzie county and the Sioux irrigation project near Cartwright, in the same county. Several small irrigation projects were also established in cooperation with the Rural Rehabilitation Corporation in Sioux county for the purpose of making irrigated gardens available to drought-stricken farmers.

Thereupon the Bureau of Reclamation moved into North Dakota and reestablished the Buford-Trenton project west of Williston in Williams county.

By 1940, the water commission was so well organized that it could "step out" with an investigational program that embraced about 15



Missouri River Basin Water Projects

dams, most of them in the western part of the state. Four of these dams are already completed—the Baldhill and Homme dams in the eastern half of the state, constructed by the army engineers, and the Heart Butte and Dickinson dams on the Heart river, in the Slope area, by the Bureau of Reclamation.

The Garrison dam, one of the key structures of the Pick-Sloan Missouri river development program, is under construction by the Corps of Engineers and more than 30 per cent completed. Engineers estimate its cost at $202,000,000. The present program calls for completion by 1955.

Appropriations made by the legislature have enabled the state water commission to aid many worthy water conservation projects and to cooperate in the planning and construction of the Missouri basin development as authorized by congress.

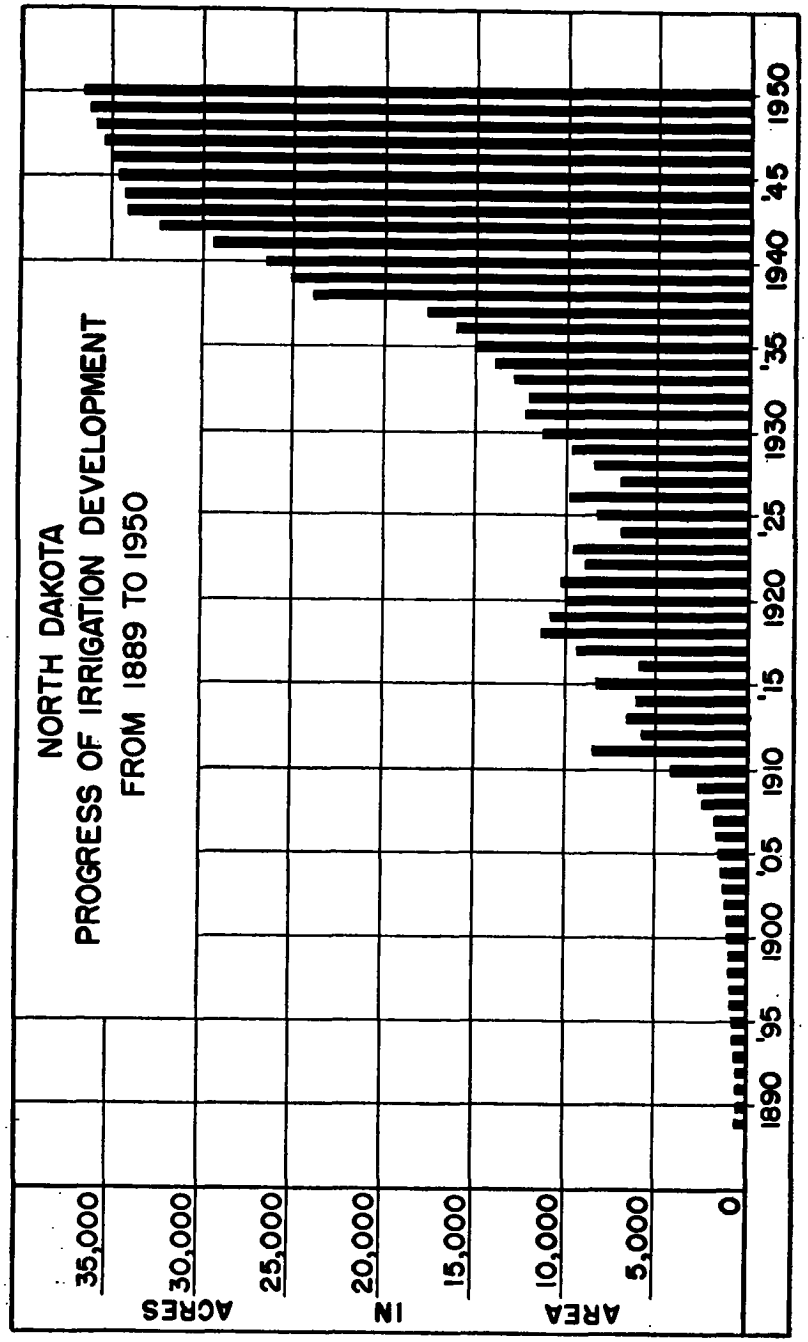
The commission is the official state agency charged with the repair and maintenance of small dams located in the various sections of the state.

The commission is cooperating on a 50-50 basis with the U. S. geological survey on three phases of surveys, investigation and assembling data for the water development plan. These include topographic mapping surveys; hydrographic stream-flow measurements and underground water surveys. Underground water surveys and investigations are being conducted to make available datum on underground water for municipalities and communities.

Other appropriations for cooperative purposes with federal departments include preliminary and detailed field surveys and investigations. Similar work is being carried on by engineers of the water commission. The result is a state-wide study and investigation of North Dakota's potential water resources.

Water conservation works in North Dakota are progressing at a rapid pace since the 1937 legislature created the State Water Conservation Commission during the drought period of the 1930's. Few, if any, visualized at that time how far advanced project planning and dam construction would be today for the conservation of water and the number of storage dams constructed and under construction. The commission is proud of the splendid cooperation received from federal departments that have resulted in the building of the great engineering works being constructed by the Corps of Army Engineers and the Bureau of Reclamation. These structures will forever remain a monument in our history of water development in North Dakota.

The Missouri river basin development plan envisions the ultimate developments of all natural resources, including full water development and utilization of all potential works for the storage of surplus water and natural stream flows, including domestic, municipal, industrial, irrigation, power, conservation of wildlife, recreation, navigation and



other multiple purposes. Development of water resources in North Dakota include storage works for irrigation, water for domestic, municipal, power development, restoration of Devils Lake, wildlife refuges, recreation and other uses. Members of the Commission are greatly concerned with the allocation and division of waters in the drainage basins of the Missouri, Souris, and the Red river of the North. At present, a compact commission is negotiating for allocating the Yellowstone river basin waters between Wyoming, Montana and North Dakota, and the International Joint Commission have directed their engineering committee to submit to the Commission a report on the present needs and future requirements of the Souris and Red rivers for the Dominion of Canada and the United States, before ratification. The Commission will submit their findings to the Water Commission for their consideration and approval.

(See 3-page N. D. Water Development map folded in this report.)

ACTIVITIES OF NORTH DAKOTA STATE WATER CONSERVATION COMMISSION ENGINEER INVESTIGATIONS AND SURVEYS

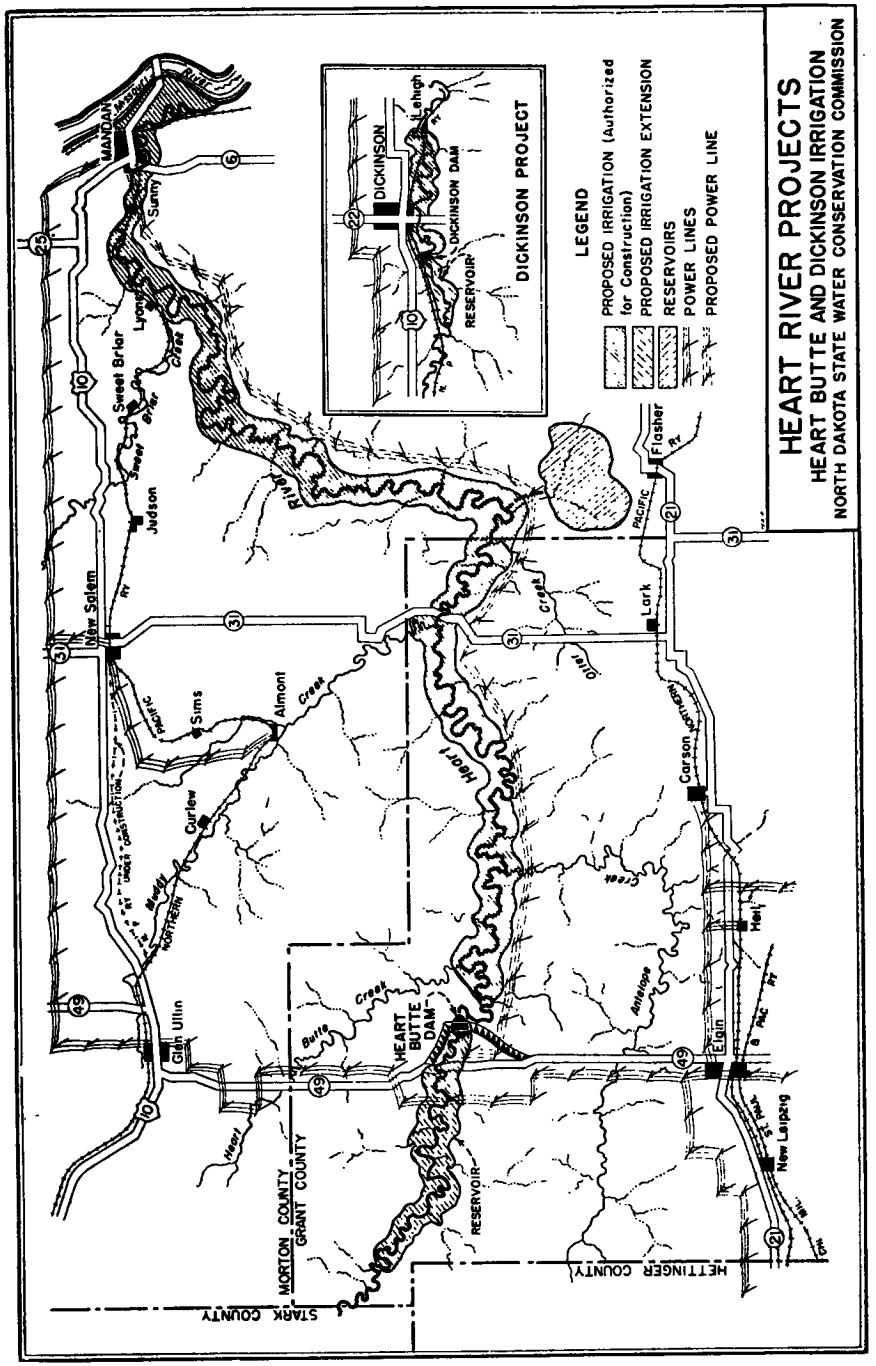
In June, 1948, the State Water Conservation Commission commenced making detailed topographic surveys of the bottom lands in the James river valley, south of Jamestown, mapping the area extending to LaMoure to determine the land susceptible to irrigation development. To date, approximately 23,500 acres have been mapped. The mapping information data, showing contours and elevations gathered in this program, is of great importance and value in future planning and for potential irrigation developments. The amount of work completed is listed as follows: Mapping 23,500 acres extending over 60 river miles, 45 miles of levels were run for vertical control and 24 sheets completed on a scale of 1 in. equals 400 feet.

CEDAR RIVER

Work on surveys on the Cedar and Cannonball rivers was resumed early in the spring of 1950 to extend the Water Commission river surveys of the mapped area during 1945-47, when 104,460 acres were mapped. This is a detailed topographic survey of river bottom area to determine the irrigable lands. Maps made from these surveys are of great value in classifying lands and for planning and designing of irrigation works by both federal and state agencies. Before commencing mapping operations, 111 miles of levels were run and 10 triangulation stations were set to establish vertical and horizontal controls, 104,460 acres being previously mapped on a scale of 1 inch equals 400 feet.

GARRISON DIVERSION

During the latter part of 1948, survey parties from the State Water Conservation Commission ran 25 miles of levels for vertical controls and completed 1,000 acres of topographic mapping on a scale of 1 inch equals 400 feet, covering spot check areas east of Underwood and north



of Washburn, these maps to be available in planning irrigation development from the Garrison reservoir by the Bureau of Reclamation.

Other surveys during the period include survey of

HEART RIVER TRANSMISSION LINE

During the spring and summer of 1949 a survey party of the State Water Conservation Commission, in cooperation with the Bureau of Reclamation, ran 41 miles of location surveys for the Heart river transmission line.

RUSH LAKE, SNOWFLAKE CREEK—PROJECT NO. 463

The State Water Conservation Commission at the request of local parties conducted an investigation and made surveys of Snowflake Creek, the main outlet channel of Rush Lake, in Cavalier county in the spring of 1949 to determine whether or not it is feasible to drain off the excess waters and maintain uniform lake levels. This information has been made available to local authorities, the Soil Conservation Service and the Corps of Engineers, for use in their basin-wide study of the Red river drainage problem.

LAKE JUANITA—PROJECT NO. 443

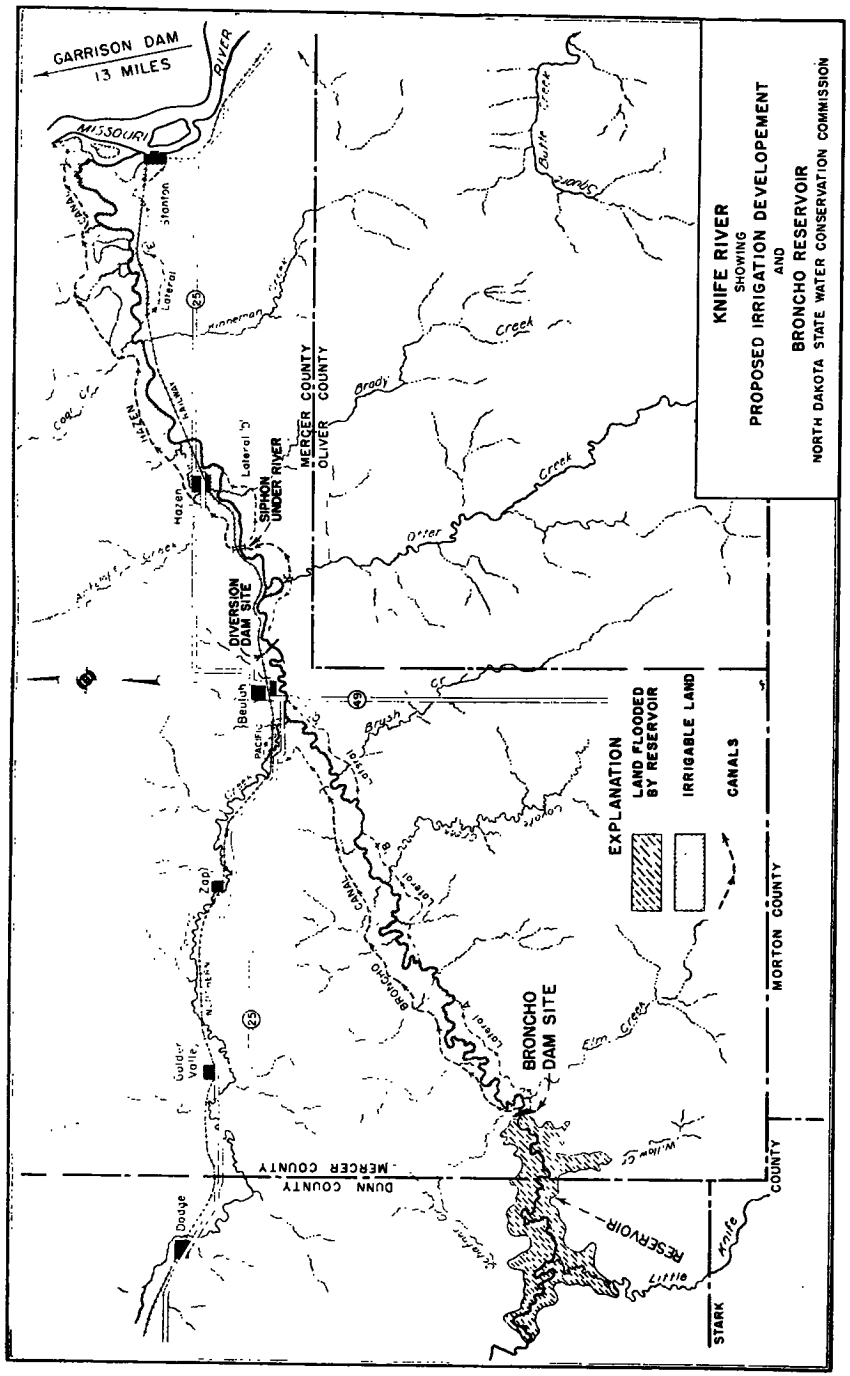
At the request of local Lake Juanita citizens, investigations, surveys, mapping and establishing levels were conducted by the Water Commission engineers in cooperation with the State Game and Fish Department to determine the feasibility of raising the level of the lake to provide a local recreational area and for the propagation of a wildlife refuge. These surveys have been made available to local parties and state and federal agencies interested in this project.

LAKE METIGOSHE

At the request of the State Historical Society and owners of property around the lake, surveys were made to determine whether there are additional storage areas available for maintaining uniform water surface levels at Lake Metigoshe and the feasibility of constructing works to control the excess inflow on some of the main channels and small lakes through regulation and release of water during critical dry periods.

GOLDEN LAKE

During the summer of 1949, at the request of local organizations, the State Water Conservation Commission conducted surveys at Golden lake in Steele county in order to determine the feasibility of restoring Golden lake to approximately its original levels by diverting water from Beaver creek into Golden lake through a series of canals, culverts and natural water courses. Topographic maps and surveys and estimated costs of constructing the diversion works have been made available to local organizations in charge of planning the project.


KNIFE RIVER
SHOWING
PROPOSED IRRIGATION DEVELOPEMENT
AND
BRONCHO RESERVOIR
NORTH DAKOTA STATE WATER CONSERVATION COMMISSION
GARRISON DAM
13 MILES
MISSOURI
RIVER
Stanton
Hazen
Beulah
Zap
Golden Valley
Dodge
DIVERSION DAM SITE
SIPHON UNDER RIVER
MERCER COUNTY
OLIVER COUNTY
DUNN COUNTY
MERCER COUNTY
MORTON COUNTY
STARK COUNTY
BRONCHO DAM SITE
RESERVOIR
Little Knife
Brady Creek
Otter Creek
Brush Creek
Elm Creek
Willow Cr
Cedar Cr
Coal Cr
Lateral "A"
Lateral "B"
Lateral "C"
Lateral "D"
Lateral "E"
Lateral "F"
Lateral "G"
Lateral "H"
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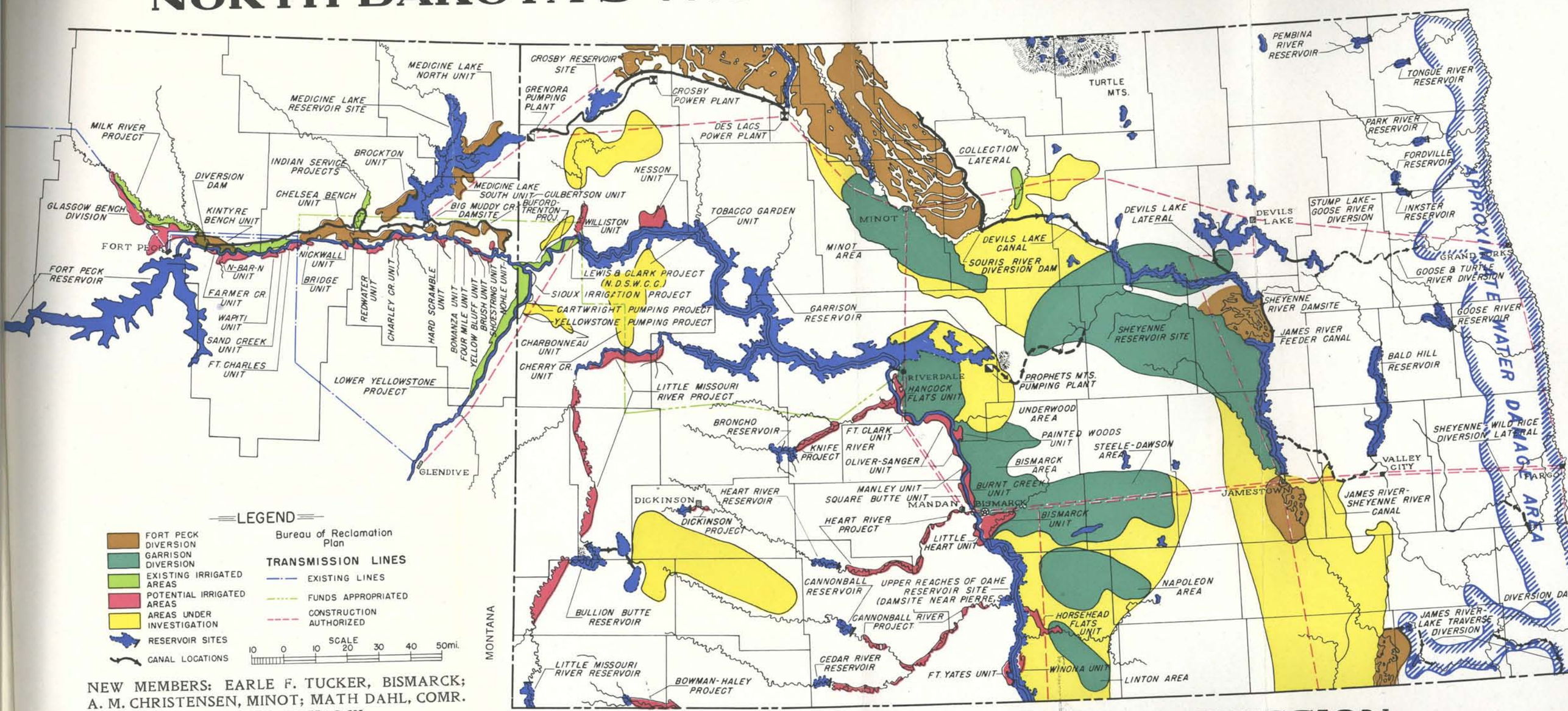
Lateral "HH"
Lateral "II"
Lateral "JJ"
Lateral "KK"
Lateral "LL"
Lateral "MM"
Lateral "NN"
Lateral "OO"
Lateral "PP"
Lateral "QQ"
Lateral "RR"
Lateral "SS"
Lateral "TT"
Lateral "UU"
Lateral "VV"
Lateral "WW"
Lateral "XX"
Lateral "YY"
Lateral "ZZ"
EXPLANATION
LAND FLOODED BY RESERVOIR
IRRIGABLE LAND
CANALS

NORTH DAKOTA'S WATER DEVELOPMENT PLAN



NEW MEMBERS: EARLE F. TUCKER, BISMARCK; A. M. CHRISTENSEN, MINOT; MATH DAHL, COMR. AGRICULTURE & LABOR, BISMARCK

NORTH DAKOTA WATER CONSERVATION COMMISSION

MEMBERS WATER COMMISSION: GOVERNOR FRED G. AANDAHL, EX-OFFICIO CHAIRMAN; ~~KENNETH W. SIMONS, BISMARCK,~~ VICE-CHAIRMAN; SIVERT W. THOMPSON, DEVILS LAKE; EINAR H. DAHL, WATFORD CITY, CURTIS OLSON, VALLEY CITY, J. J. WALSH, BISMARCK, SEC. AND CHIEF ENGINEER, STATE ENGINEER

MANDAN DEVELOPMENT FARM

The State Water Conservation Commission assisted the Bureau of Reclamation in surveying and laying out of the main irrigation and lateral ditches on the Mandan development farm on the Heart river, and in conducting surveys for preparing and leveling land for irrigation which is being operated by the Bureau in cooperation with the State Training School, demonstrating the value of irrigation in the production of stable crops and irrigated pasture.

BALDHILL FISH PONDS

During the fall of 1948, in cooperation with the Federal Wildlife Service and the State Game and Fish Department, a survey party from the State Water Conservation Commission surveyed and mapped the site for the proposed Fish Rearing Ponds below Baldhill dam on the Sheyenne river in Barnes county. This work included a detailed topographic map showing the layout and plan for the rearing ponds.

Other miscellaneous surveys were made in McKenzie and Hettinger counties to assist farmers in laying out their irrigation systems.

Drainage and irrigation surveys were made on the Lewis and Clark, Fort Clark and Sioux irrigation districts, the Burlington Disabled War Veterans rehabilitation project and the Eaton flood irrigation district.

CHAPTER 63

Senate Bill No. 71

(Committee on Appropriations)

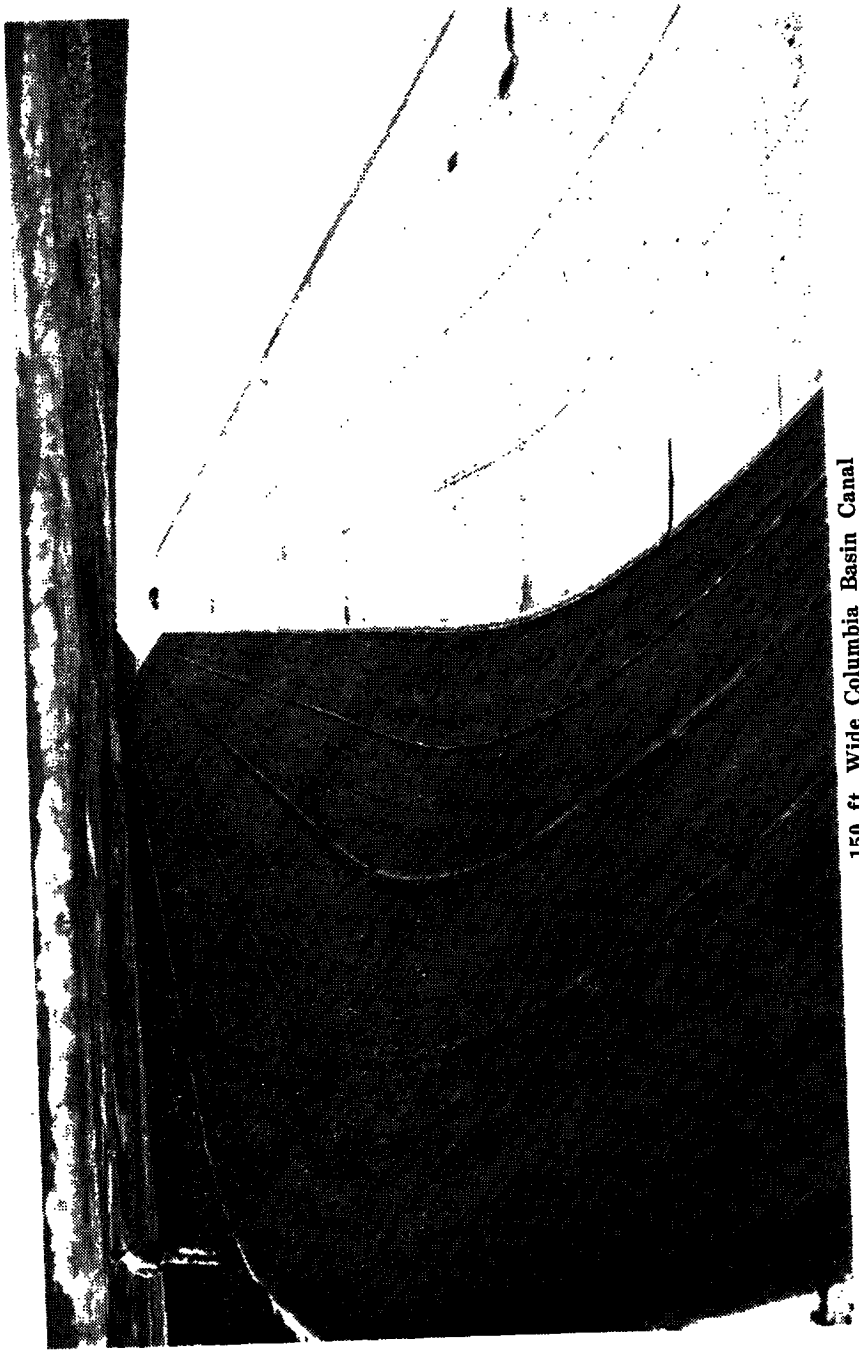
WATER CONSERVATION COMMISSION ADMINISTRATIVE FUND

AN ACT

Making an appropriation into the "Administrative Fund" for the State Water Conservation Commission for general administration expenses, maintenance of existing dams and drainage channels, construction of needed drainage channels, planning and surveying projects, expenses of State Compacts and for the preparation of water conservation and irrigation projects for post-war construction and development.

Be It Enacted by the Legislative Assembly of the State of North Dakota:

Section 1. APPROPRIATION.) There is hereby appropriated into the "Administrative Fund" of the State Water Conservation Commission out of any moneys in the State Treasury, not otherwise appropriated, the sum of $606,400.00, or so much thereof as may be necessary for the payment of all general administration expenses of said commission, compensation of state engineer and expenses of all of its employees, for partial guarantee of construction bonds, maintenance of existing dams,



150 ft. Wide Columbia Basin Canal
Missouri-Souris Canal to be 200 ft. Wide and Carry 23 ft. Depth Water

administrative expenses of state compacts and for the payment of costs of planning, surveying and preparing water conservation and irrigation projects, for construction, for post-war projects for the purpose of cooperating with the Bureau of Reclamation, the Corps of United States Army Engineers, the Soil Conservation Service, and any other federal agency, in planning the development of water resources of this State for the beneficial use thereof, which may be matched either in whole or in part by Federal or State agencies and governmental subdivisions of the State, for the biennium beginning July 1, 1949, and ending June 30, 1951, to-wit:

Commissioners—Per Diem & Expenses	$ 4,000.00
Administration	30,000.00
Maintenance of Existing Dams	100,000.00
International & Interstate—Commissioners' Conference Expenses	12,000.00
Topographic & Conservation, Cooperation with U.S. Geological Survey	30,000.00
Hydrographic Surveys, Cooperation with U.S. Geological Survey	20,000.00
Salary—State Engineer	5,400.00
Construction and Reconstruction Drains or Irrigation	150,000.00
Engineering & Geological Surveys & Demonstrations	30,000.00
Cooperation with U.S. Departments, Small Projects and for Organizing Conservation & Irrigation Districts	135,000.00
Other Investigations, Surveys, etc.	90,000.00
TOTAL	$606,400.00

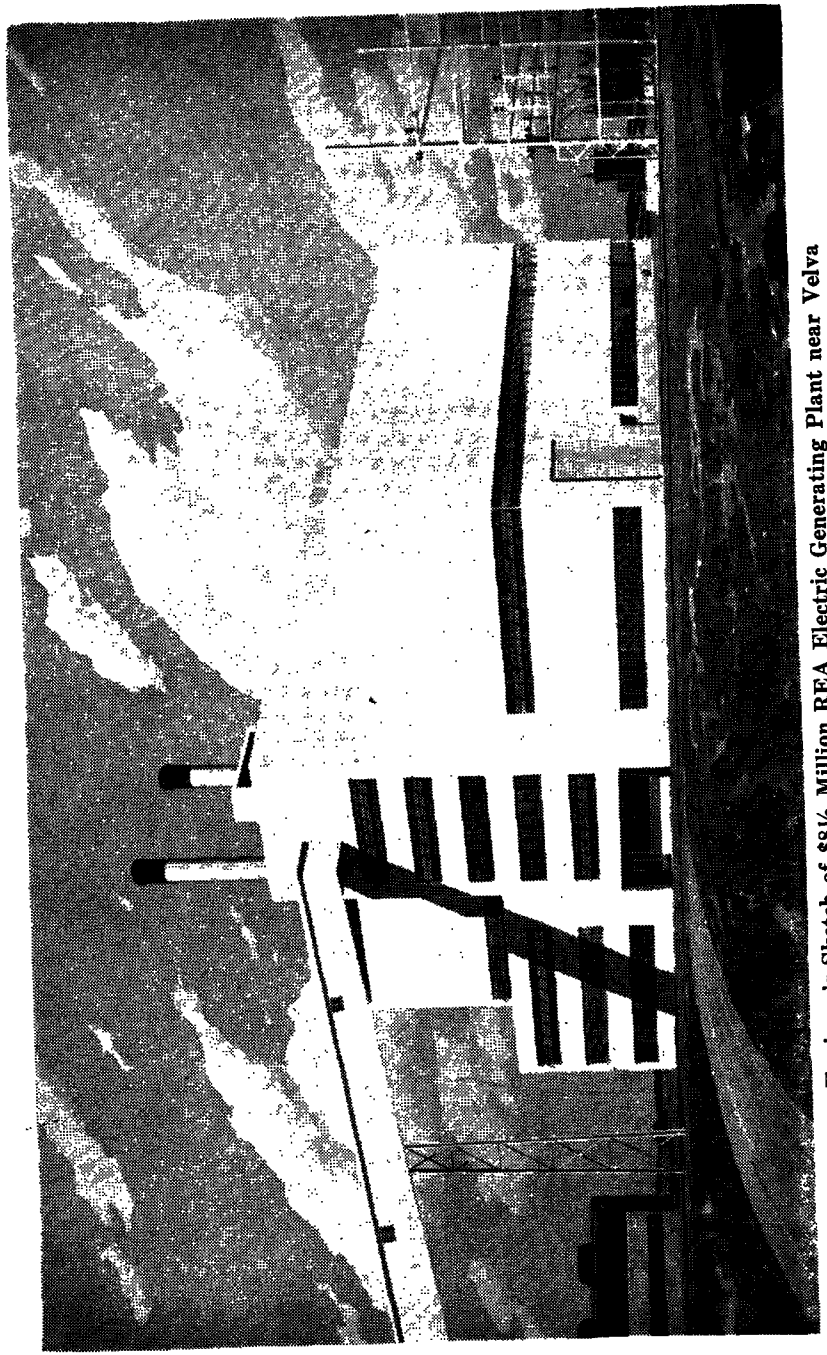
Approved February 23, 1949.

ONE MILLION TONS QUARTZITE ROCK FOR GARRISON DAM CLOSURE

A rock deposit of hard quartzite sufficient for quarrying has been found in southwestern North Dakota between Elgin and New Leipzig. It is planned to use one million tons of this rock for the closure of the Garrison dam, which is now planned for 1953. This rock must be quarried in from two and a half tons to ten tons each to prevent it being rolled down stream by the force of the waters of the Missouri river. Many trainloads will be lined up ready for depositing from the construction bridge and forcing the river waters into the diversion canal and through the eight tunnels, where it can be controlled by gates.

SANISH AND VAN HOOK CONSOLIDATE NEW TOWNSITE SELECTED

Because the rising waters of the Garrison reservoir would inundate portions or all of present townsites, the towns of Sanish and Van Hook, in Mountrail county appointed committees to represent them in selecting



Engineer's Sketch of $8½ Million REA Electric Generating Plant near Velva

a new joint townsite between the present locations, and will be aided in moving and securing of city water and other needed facilities by the Corps of Engineers. It will be necessary to re-route the Soo-line railway grade. A new bridge across the Missouri river is to be located on high approach about a mile south of the present site of Sanish, and will be approximately one mile long, to serve eastern McKenzie county people.

NEW BRIDGE PLANNED TO REPLACE SANISH BRIDGE

The Corps of Engineers have released tentative plans for the replacement of the present Sanish bridge across the Missouri river. It is to be located 4300 feet south of the present bridge, on high ground, and will be 4,200 feet long, and will carry Highway No. 23.

The steel from the Elbowoods bridge will be used for the center span of the new bridge, with new deck truss spans at both ends. It will be 47 feet above the maximum operating level of the Garrison reservoir.

The piers will be of solid reinforced concrete, and the highest will rise 140 feet above the river bottom, and will be carried on steel piles driven to suitable foundation or bed rock.

The east approach is in the first small valley south of the present Sanish bridge. Approaches will require heavy grading and a cut through the bluff will reach a depth of more than 100 feet.

Present plans call for completion of the bridge in 1954.

GARRISON HYDRO-ELECTRIC POWER AVAILABLE 1955

Power from the Garrison dam will be available about 1955, engineers of the Bureau of Reclamation announced.

In the meantime, an $8,000,000 REA cooperative steam plant is being built near Voltaire, N. D. to supply power within the next year or two for the central part of the state. Additional power will be available from government, public utilities and other sources.

Bureau engineers report that work is going ahead on the Minot-Devils Lake, Jamestown, Bismarck power loop which will transmit power 650 miles from the steam power plant as above.

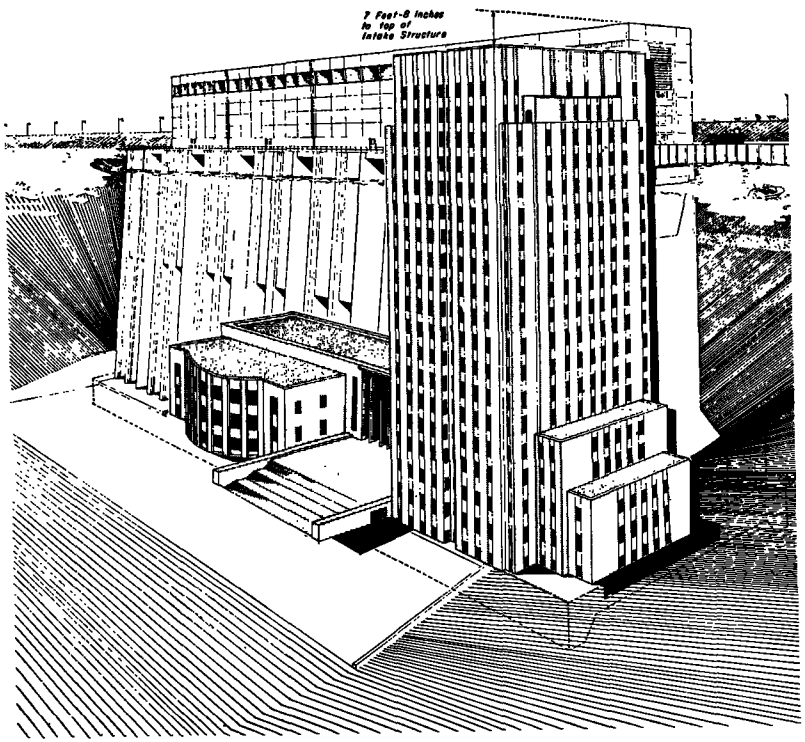
Contracts have also been let for construction of a power line spur from Jamestown to Edgeley and to Forman. A three-way contract providing for mutual use of lines and emergency assistance has been signed by the Bureau, the coops. and the Ottertail Power Co.

In addition, construction of the 155,000 volt line from Ft. Peck to the Garrison dam has been completed. Several sub-stations along this route will be finished not later than October, 1950. The Montana-Dakota Utilities Co. is using portions of this line to transmit its own power at the present time.

DAM INTAKE STRUCTURE DWARFS STATE CAPITOL

The Garrison dam intake structure will be higher and longer than the state capitol. It is being constructed on the upper side of the dam and will hold the gates regulating the flow of water through the eight tunnels, under the dam.

This intake structure will be 259 feet high; the capitol is 241 ft. high. The structure is 501 ft. long, while the capitol's length is 389. The contract for the intake structure is for $15,125,830.



Garrison Dam Intake Structure
Capitol Imposed to Contrast Size

THE BUREAU OF RECLAMATION

Bruce Johnson, Bismarck, district manager, is in charge of investigations on the Missouri-Souris project in the North Dakota division of the Bureau of Reclamation. Kenneth F. Vernon is Regional Director, Billings, Montana.

Missouri-Souris Diversion Project: The Missouri-Souris diversion plan is to divert water from the Missouri river below Fort Peck reservoir in Montana into North Dakota, onto Devils lake, the Sheyenne and James rivers. As planned, the proposed project provides for a diversion dam below Fort Peck, including a canal, storage reservoir, pumping and power plants to irrigate approximately 160,000 acres in Montana and about one million acres in North Dakota. Return flows will be collected and returned to the Souris river and diverted by canal to the Sheyenne river, where water will be used for irrigation, restoration of Devils lake, diversion into the headwaters of the James river for irrigation and municipal purposes and regulation and control of stream flows in the Sheyenne and Red rivers.

HEART RIVER UNIT

Construction work on the Heart Butte dam was completed by the Bureau of Reclamation in December, 1949, and the Dickinson dam will be nearly completed in August, 1950. These two structures will provide flood control, conserve water for city and domestic uses, and also make available water for irrigation purposes.

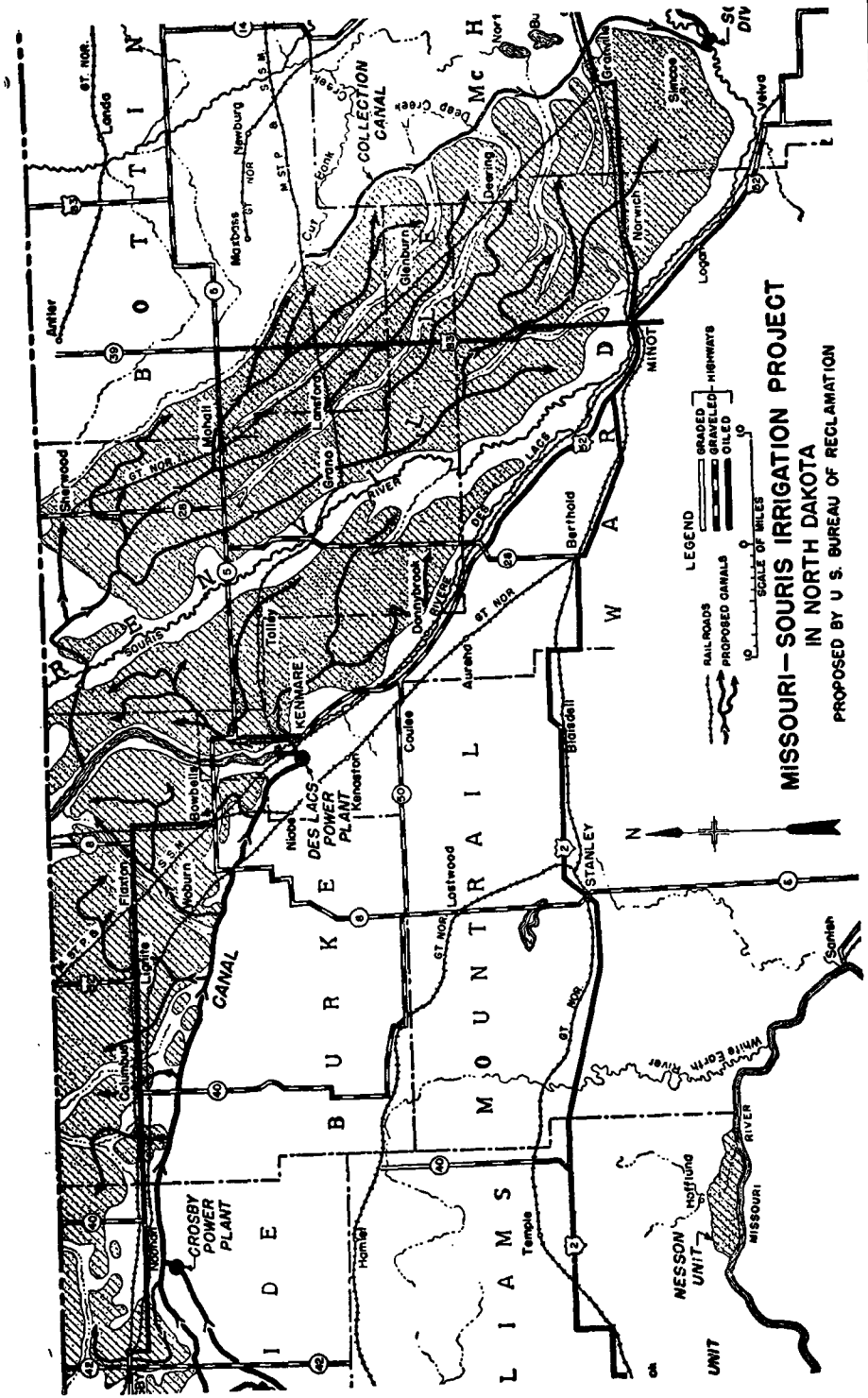
The Heart river irrigation district has been formed to use water from the Heart river reservoir to irrigate approximately 14,000 acres. At the present time, the district is negotiating with the Department of the Interior on a repayment plan before work on the construction of the irrigation system begins. At Dickinson, there has been executed a repayment contract with the Bureau of Reclamation for supplying municipal water to the city. Future plans include the irrigation of approximately 1,000 acres of land to be supplied from the Dickinson reservoir.

THE FORT CLARK UNIT

All preconstruction work has been completed on the Fort Clark Unit of the Missouri river. Here it is proposed to pump water from the Missouri to irrigate some 2,039 acres of land. An irrigation district has been organized, and the Bureau of Reclamation has presented the district with a draft of a repayment contract. The board of directors has approved the contract and the Secretary of the Interior has approved it as to form. An irrigation district election will be held on the question whether or not to accept the contract. Upon acceptance of the repayment contract, the Bureau will proceed with construction.

CARTWRIGHT IRRIGATION DISTRICT

Progress is being made in planning construction of above irrigation district in McKenzie county under the supervision of the Bureau of



Reclamation. The irrigation district has been organized and preconstruction surveys have been completed. This project is located south of Cartwright on the east side of the Yellowstone river and will provide for irrigation of 920 acres of land.

LOWER YELLOWSTONE PUMPING PROJECT

The Lower Yellowstone Pumping project is an organized irrigation district and is now attached to the Sidney unit of the Yellowstone division to be constructed by the Bureau of Reclamation. The lands to be irrigated on this project are located in North Dakota, the water to be supplied from the Yellowstone river. The work includes enlargement of the present pumping facilities in Montana, and the construction of the main canal and laterals. The project, as originally planned, was to irrigate approximately 1800 acres.

JAMESTOWN DAM

The Bureau of Reclamation has been charged with the construction of the Jamestown dam, located approximately two miles above Jamestown. This structure is to provide storage of flood waters and regulation of stream flows for protecting the City of Jamestown. During 1950, Jamestown was subjected to damage from floods from both the Pipestem and James rivers. Estimates show that the damage to the city was approximately 2½ million dollars. Congress has recently authorized $750,000 for starting construction work of the dam.

SHEYENNE AND JAMES RIVERS DIVERSION

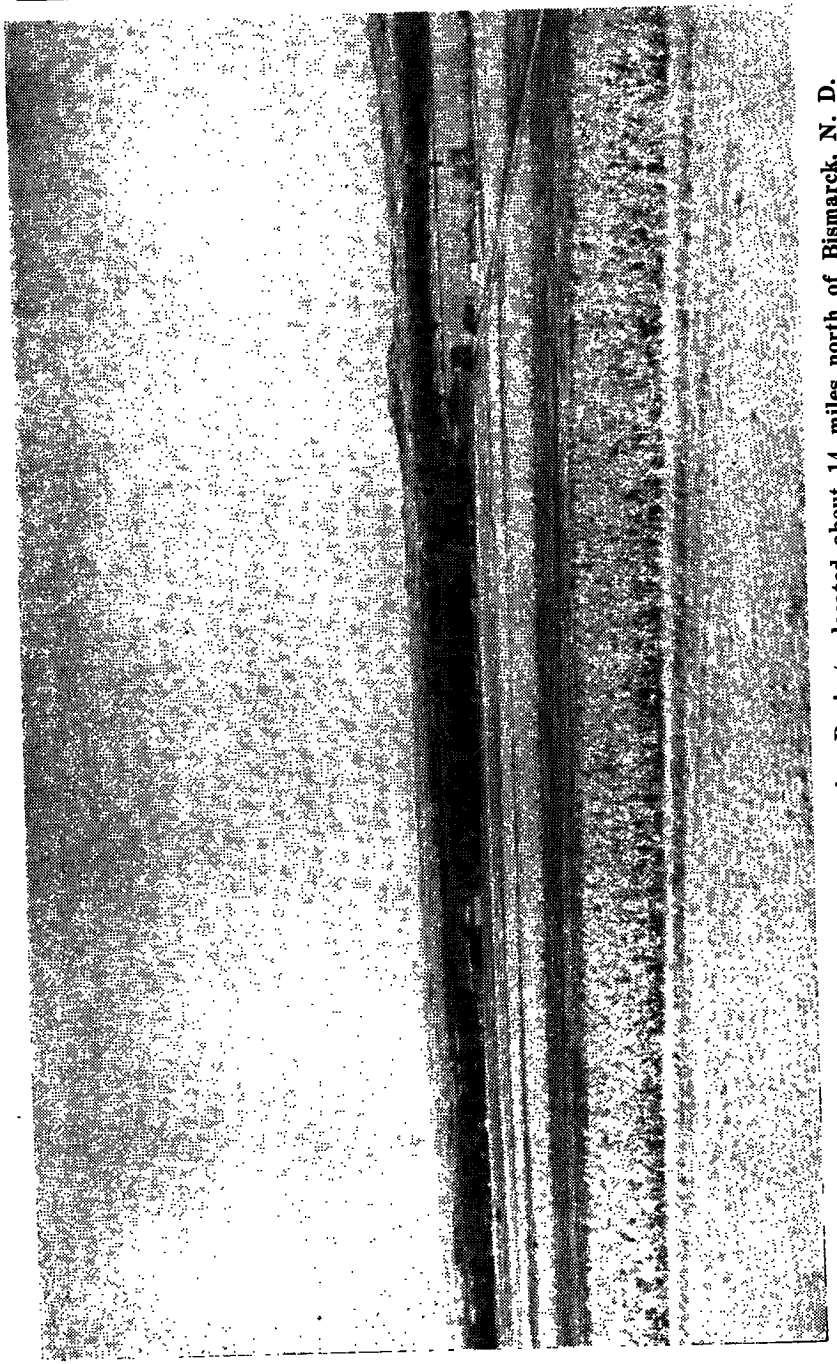
Return flows from the Missouri-Souris area are to be diverted into the Sheyenne river reservoir from which water is to be diverted to restore Devils lake and provide municipal water for 19 cities along the Sheyenne and Red rivers. Water is also to be diverted south from the Sheyenne dam into the James river valley to irrigate approximately 55,000 acres of the New Rockford unit, to be re-regulated by Jamestown reservoir and for the irrigation of 22,000 acres of the Jamestown unit and 30,000 acres in the Oakes unit.

OTHER BUREAU PROJECTS

Other work of the Bureau of Reclamation includes development of irrigation on tributary streams including the Knife, Heart and Cannonball rivers. This work will include pumping units, power lines and irrigation distribution systems. Continuing surveys and investigations are being made on the Little Missouri river and diversion and use of water from the Garrison reservoir. The Bureau plans to complete construction of the lateral and drainage ditches this year on the lower division of the Buford-Trenton project, located near Williston.

INVESTIGATIONS—BUREAU OF RECLAMATION NORTH DAKOTA

Cannonball Division: Semidetailed land classification was completed on Thunderhawk unit and a reconnaissance of lands above the dam was made. Several alternate sites for Thunderhawk dam were selected.



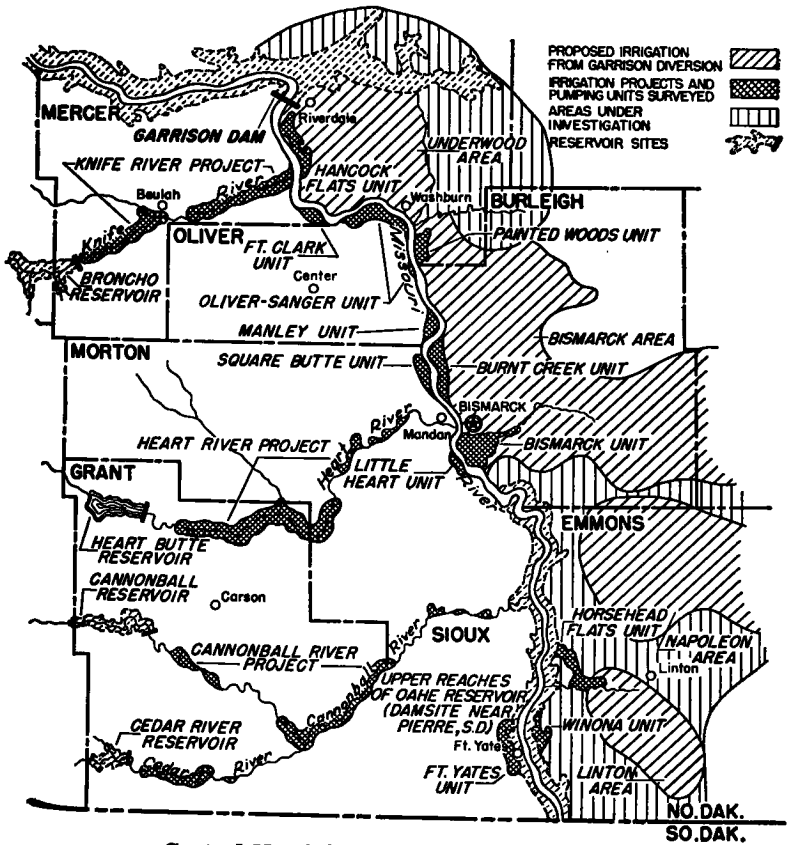
Wogansport Unit of Missouri River Pumping Projects, located about 14 miles north of Bismarck, N. D.

Garrison Division: Detailed land classification on the block and spot-check areas in the Coleharbor unit were classified in detail. A general summary of this work is being prepared.

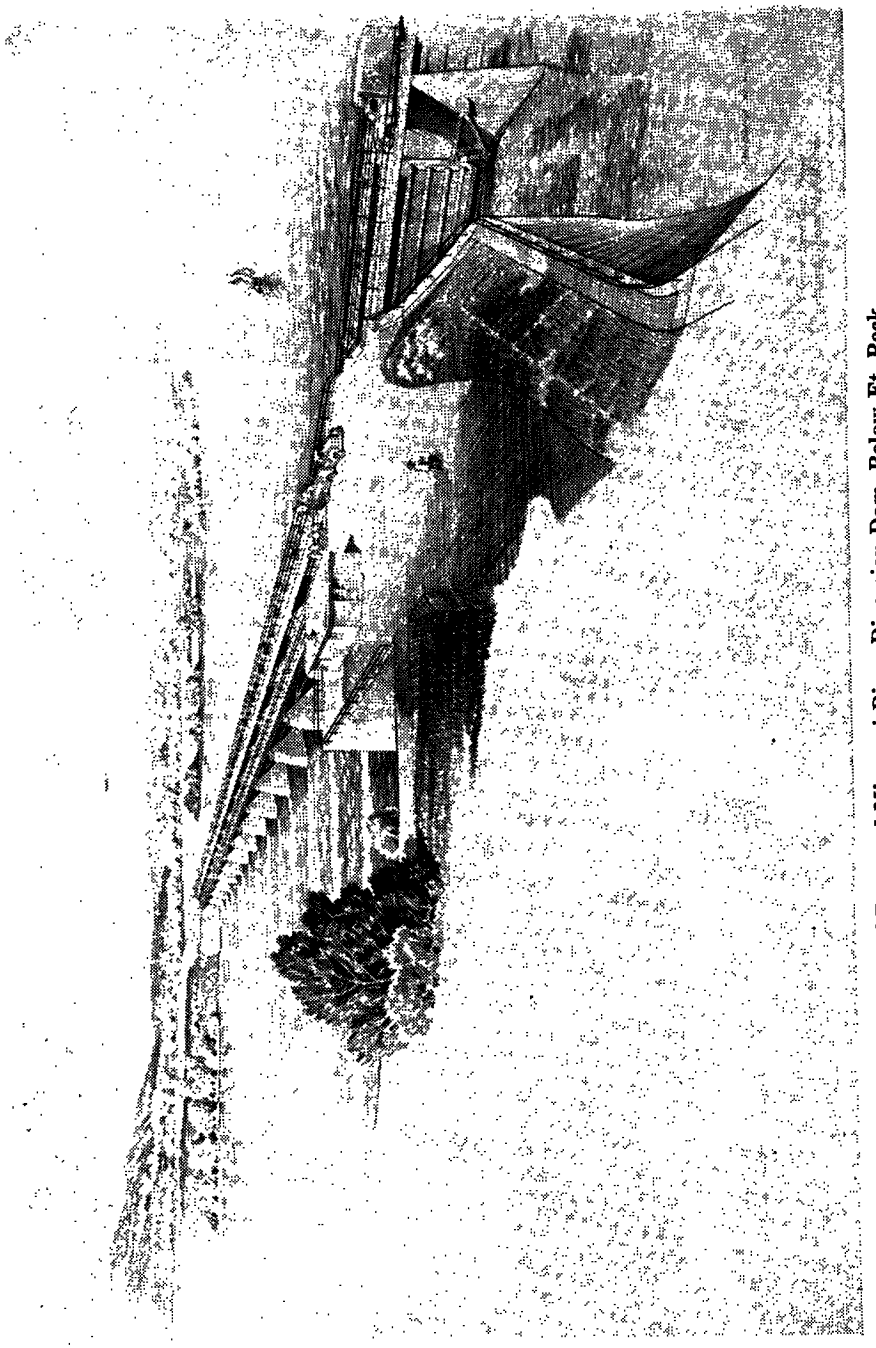
Knife Division: Detailed land classification was to be revised. Foundation drilling and material exploration at Broncho dam site were to be resumed.

Missouri-Souris Division-Crosby-Mohall Unit: Land classification, economic studies, surveys, and estimates were to be completed on the Bowbells block area and a detailed report prepared. Operation of Bowbells development farm was to continue.

Work continued on the Crosby-Mohall unit, including continued investigations of the entire unit, compiling data for the Bowbells block report, and continued operation of the Bowbells development farm. In the area west of Des Lacs river, the semidetailed land classification was completed



Central North Dakota Irrigation Projects



Sketch of Proposed Missouri River Diversion Dam, Below Ft. Peck

on 493,000 acres. On the Bowbells block area, land classification was completed, and infiltration and drainage studies received special attention.

Missouri-Souris-Devils Lake Unit: An analysis of quality of water in Devils Lake was to be made. Sheyenne canal was to be surveyed. Operation studies were to be made of Devils lake and Sheyenne reservoir.

A water sampling program was started on Sheyenne and Red rivers in cooperation with the State of North Dakota. Field work on location of Sheyenne canal were completed. The operating schedule for raising the water level of Devils lake and Sheyenne reservoir was started.

Missouri-Souris-Jamestown Unit: Preconstruction surveys were to continue at Jamestown dam and reservoir, and surface exploration was to be undertaken to locate a possible buried channel between the James river and Pipestem creek. Land resource studies of the Jamstown unit were to continue.

North Dakota Pumping Division-Painted Woods Unit: Work was to continue on economic studies and surveys on the pumping plants and lateral systems.

Drainage requirements and land classification have been reviewed, and a program of development of ground-water sources for irrigation in lieu of pumping from the Missouri river has been started.

North Dakota Pumping Division: Pumping plant studies will be made to determine the best type and location for plants. Water requirements and economic studies will be made. Studies will be made of Hancock Flats, Oliver-Sanger, and Square Butte units.

PROPOSED IRRIGATION PROJECTS

WILLISTON PUMPING IRRIGATION UNIT

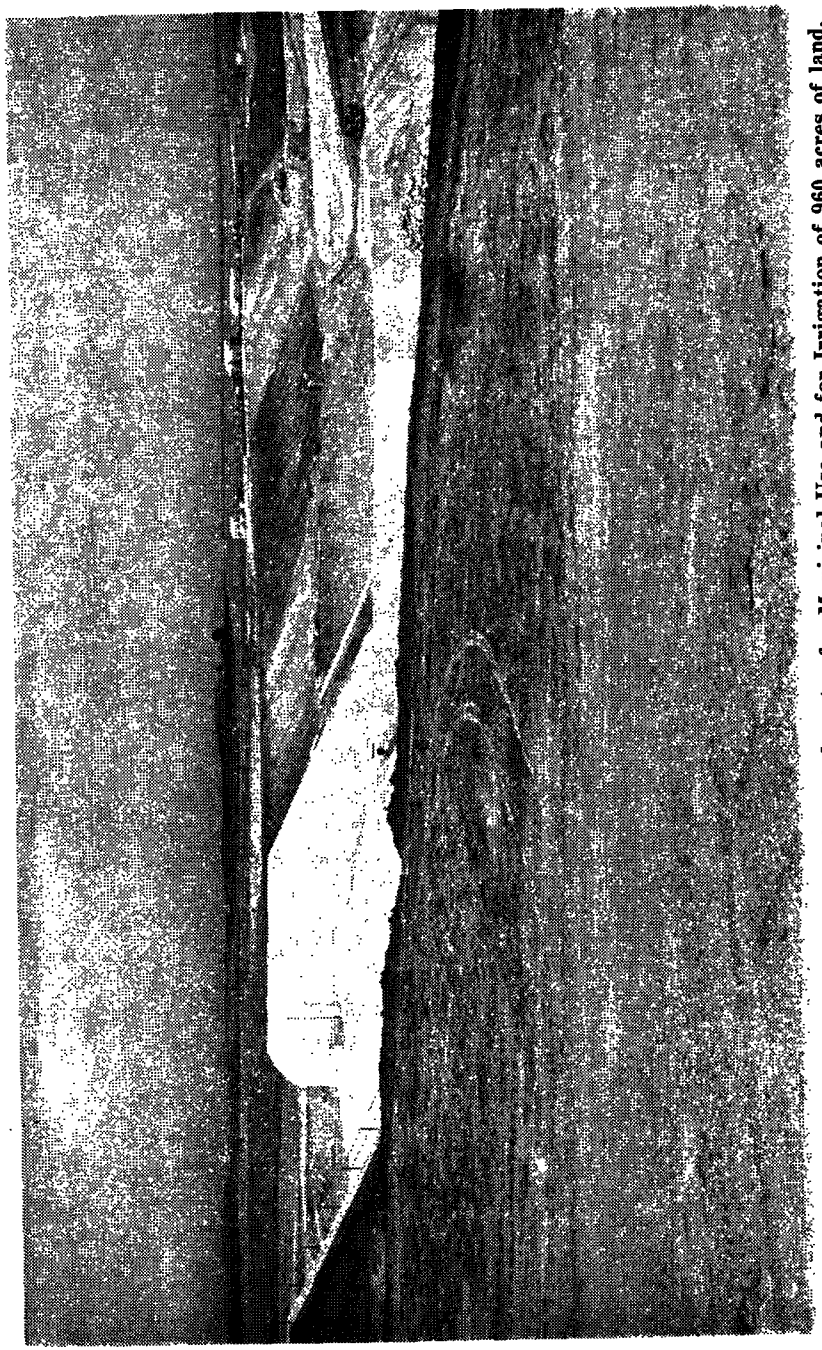
Included in the plans of the Bureau of Reclamation is the construction of a pumping irrigation project of approximately 7,000 acres in the valley of Little Muddy Creek and on the benchlands to the west, practically surrounding the city of Williston, in Williams County, North Dakota.

THE NESSON VALLEY PROJECT

Located about 26 miles east of Williston, in Williams and south of Ray in Mountrail counties, is what is called the Nesson Valley Pumping Project, of about 9,600 acres. This has been surveyed and lands classified, and is included in the construction plans of the Bureau of Reclamation for the development of the Missouri river diversion areas.

UNDEVELOPED MISSOURI RIVER PROJECTS

In addition to the Williston Pumping unit, Nesson valley project, and the recently organized Fort Clark irrigation district, some other projects are included in the Missouri river development plan. These extend from below the Garrison reservoir to the South Dakota state line, and range in size from approximately 2,000 to 9,000 acres. They



Dickinson Dam and Spillway which will impound water for Municipal Use and for Irrigation of 960 acres of land.

include the following projects: Manhaven, Hancock Flats, Oliver-Sanger, Painted Woods, Manley, Wogansport, Square Butte, Burnt Creek, Little Heart, Horsehead Flats, Winona and Bismarck projects.

POWER LINE CONSTRUCTION

Government REA loans had enabled rural organizations to wire and equip a large number of farms in the state, with connecting lines to power centers. Garrison hydroelectric power may not be available before 1955. Appropriations of about $2,250,000 was made for 1950, and contracts authorized for an additional $2,000,000 in 1951 for power transmission line construction in North Dakota. And, an additional $8,500,000 was appropriated for a loan to REA cooperatives to build a steam generating power plant at a coal mine near Voltaire, North Dakota, to provide REA lines with power, pending the availability of Garrison power, and to be used as a stand-by plant for possible future needs.

FLOOD CONTROL

The control of floodwaters is one of the phases of the big water development plans for North Dakota. During years of excessive precipitation and snow run-offs, the Red River valley has suffered crop and property damage running into millions of dollars from floodwaters. The State Water Conservation Commission has been authorized by the legislature to cooperate with local and government agencies for the organization of drainage districts and the construction of local drainage ditches. This program has done much to alleviate the situation.

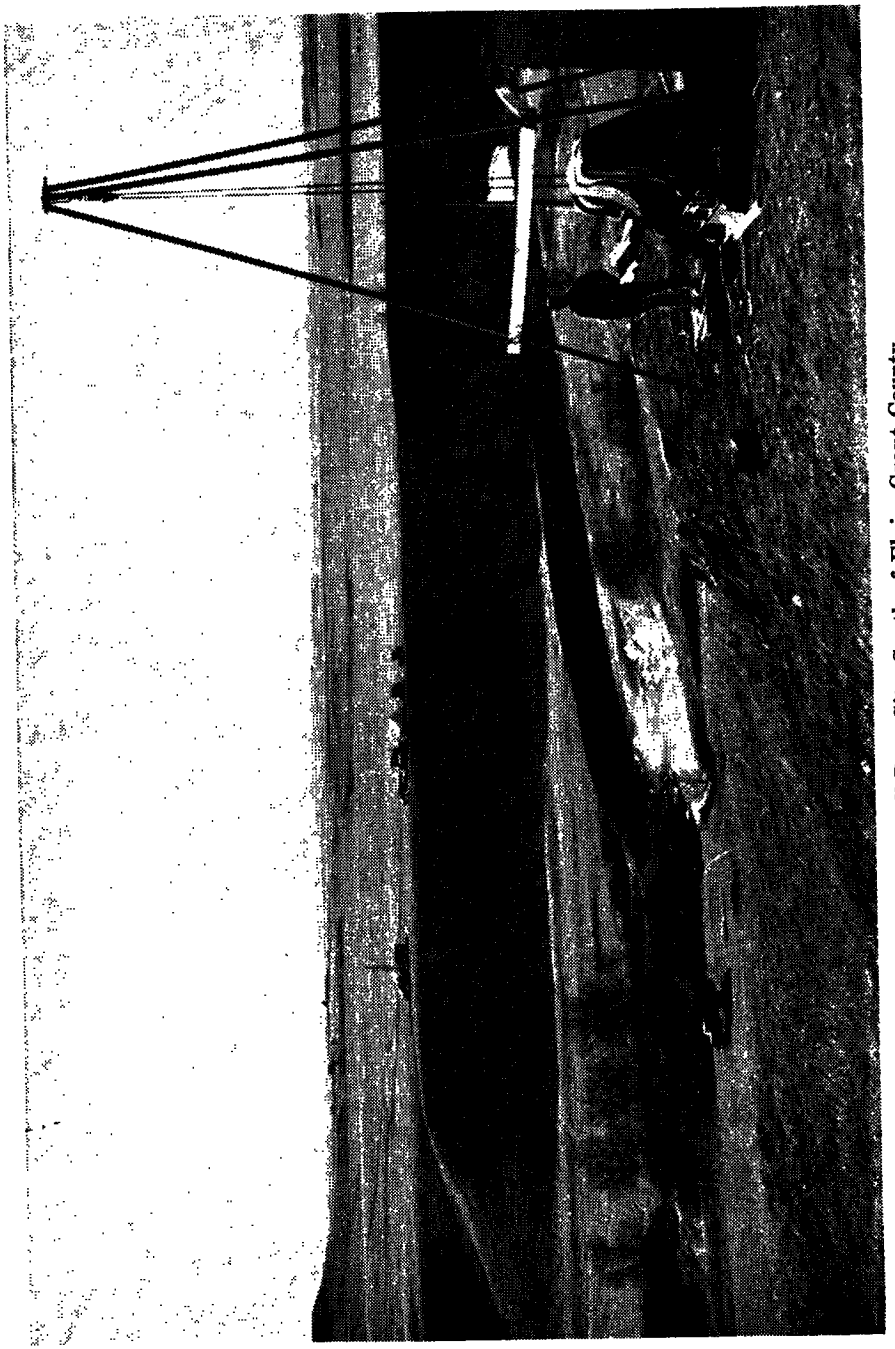
The Corps of Army Engineers after conducting a survey of the Red River drainage area in North Dakota and Minnesota recommended to congress control measures, including dams and reservoirs along the tributaries in a six to ten year construction program, with an estimated cost of six to ten million dollars, in addition to the Bald Hill dam and reservoir and the Park River dam and reservoir previously authorized. Work has started on the valley program.

SNOW REMOVAL OPERATIONS IN THE SOUTHWEST MOTT AREA

Following the spring blizzard in April, 1950, the State Water Conservation Commission furnished equipment and personnel in cooperation with the State National Guard for snow removal operations in the Mott area at the request of the governor. Heavy snowfall and blizzards in this area blocked all state and county roads to such an extent that all traffic in the area was stalled, causing great hardship on the people affected. During this period, the crew from the State Water Commission opened approximately 35 miles of secondary road, making it possible for the farmers to haul feed and provisions from town for domestic and livestock uses.

1950 FLOODS BREAK RECORDS, CAUSE MUCH LOSS

The snow run-off in the spring of 1950 was the heaviest in the memory of man and caused much damage and property loss in different areas over



View of Cannonball Dam Site, South of Elgin, Grant County

the state. At the request of Governor Aandahl, the President allocated $250,000 for North Dakota flood relief from his emergency fund. Government weasels and jeeps were shipped in to several key points to aid in the distribution of food to distressed communities where the deep snow and excessive floodwaters prevented getting needed supplies. Some food and stock feeds were transported by plane for emergency relief in some areas. Repair of washed out bridges and approaches was a heavy drain on county road and bridge funds. Many branch railroad lines were badly damaged, requiring suspension of train service in some instances as long as 60 days. Some damage on main lines required only temporary delays of main line trains. Surveys made of the damage in North Dakota by floodwaters varied, some estimates being as high as eighteen million dollars over the state. The flood damage on the Red river valley, especially from Grand Forks to Grafton and Pembina and on to the city of Winnipeg in Manitoba, was especially severe.

IRRIGATION PROJECTS, LOANS FOR FINANCING

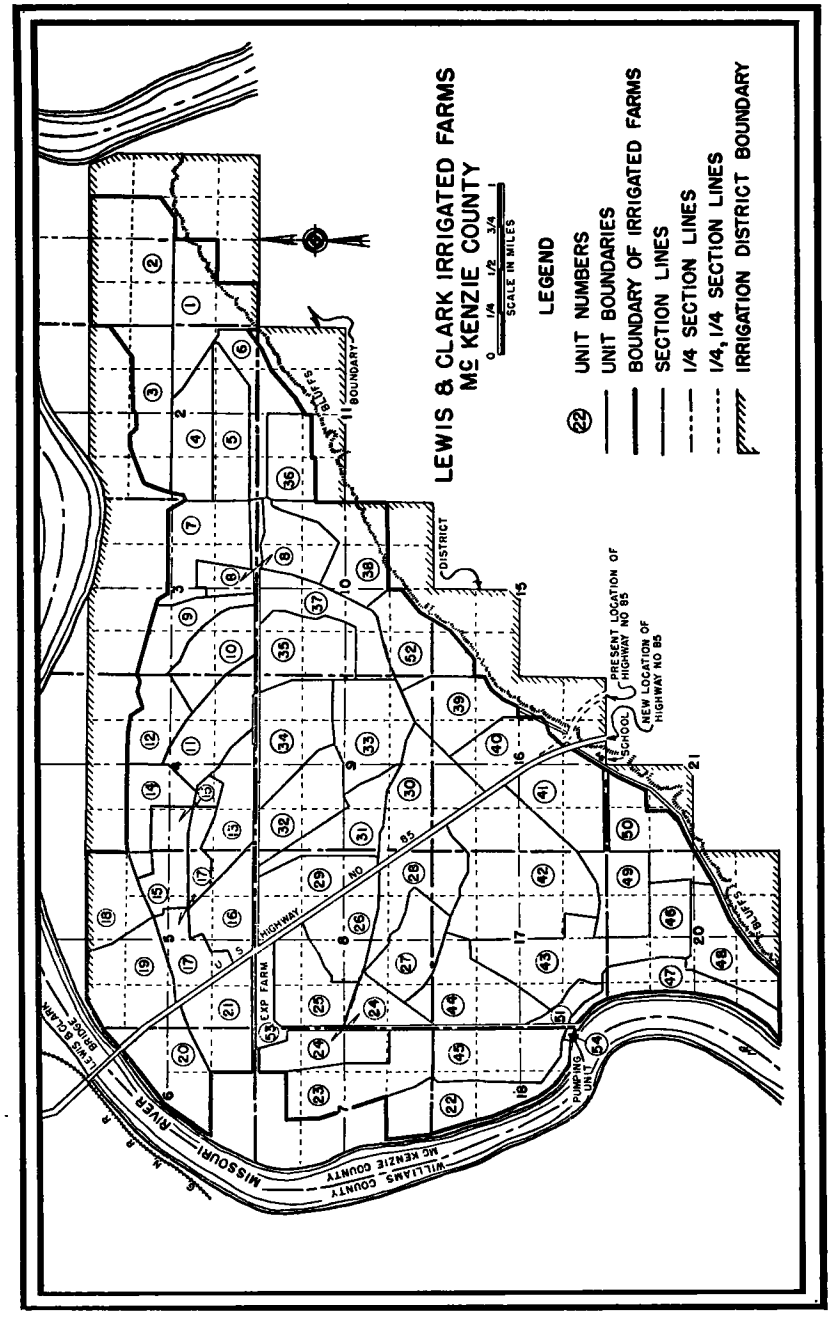
The Farmers Home Administration has government funds available to help finance by long-term, low-interest loans to farmers or groups of farmers to install water facilities on their farms for small irrigation projects or other water facilities needed to make the farm more profitable. This would enable either an individual or a group of farmers to install small irrigation projects and pay for same over a period of years from the increased income. Loans to individuals are usually limited to $5,000, but irrigation district groups of farmers can finance systems costing less than $50,000. and spread payments over twenty years or even more. This should materially aid farmers desiring to install sprinkler irrigation pumps and equipment. Loans are even made to tenant farmers where they hold a long-term lease to the land, and can be made only when no other source of credit for this type of loan is available.

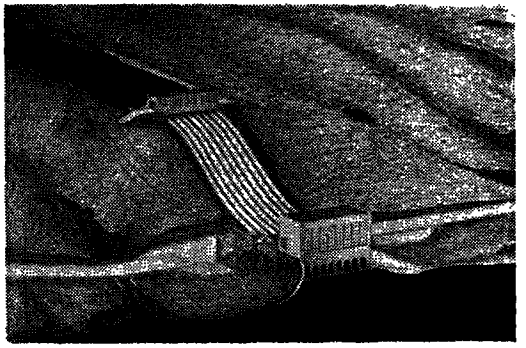
IRRIGATION POTENTIAL IN NORTH DAKOTA

Governor Fred G. Aandahl, at a meeting held in Flaxton, stated that increasing irrigation is a movement to meet the needs of a nation expanding in population; that irrigation will provide a sustaining livelihood for a part of the nation's population and help provide the country with needed foodstuffs now in short supply.

He predicted that particularly in the Missouri-Souris area that the change will not be a wholesale shifting over from dryland farming to an irrigation economy in the region. He said the coming of more irrigation would bring a gradual change to new high-yielding crops which would supplement the present dryland farming and increase the income and stability.

He emphasized that if North Dakota could add 20,000 to 30,000 acres of land under irrigation each year for a period of years, that the development could achieve a steady, sound, constructive program for the region.





Proposed Grenora, N. D. Pumping Plant

On the Missouri-Souris million-acre irrigation project, plans include what will be the largest pumping plant in the world. Eight large electric motors will pump the water up about 100 feet over the divide and into the main canal. This canal will be 200 feet wide at the top, 150 feet at the bottom, and built to carry 23 feet of water, enough to carry an ocean-going Liberty Ship.

IRRIGATION RETURNS ON LOWER YELLOWSTONE

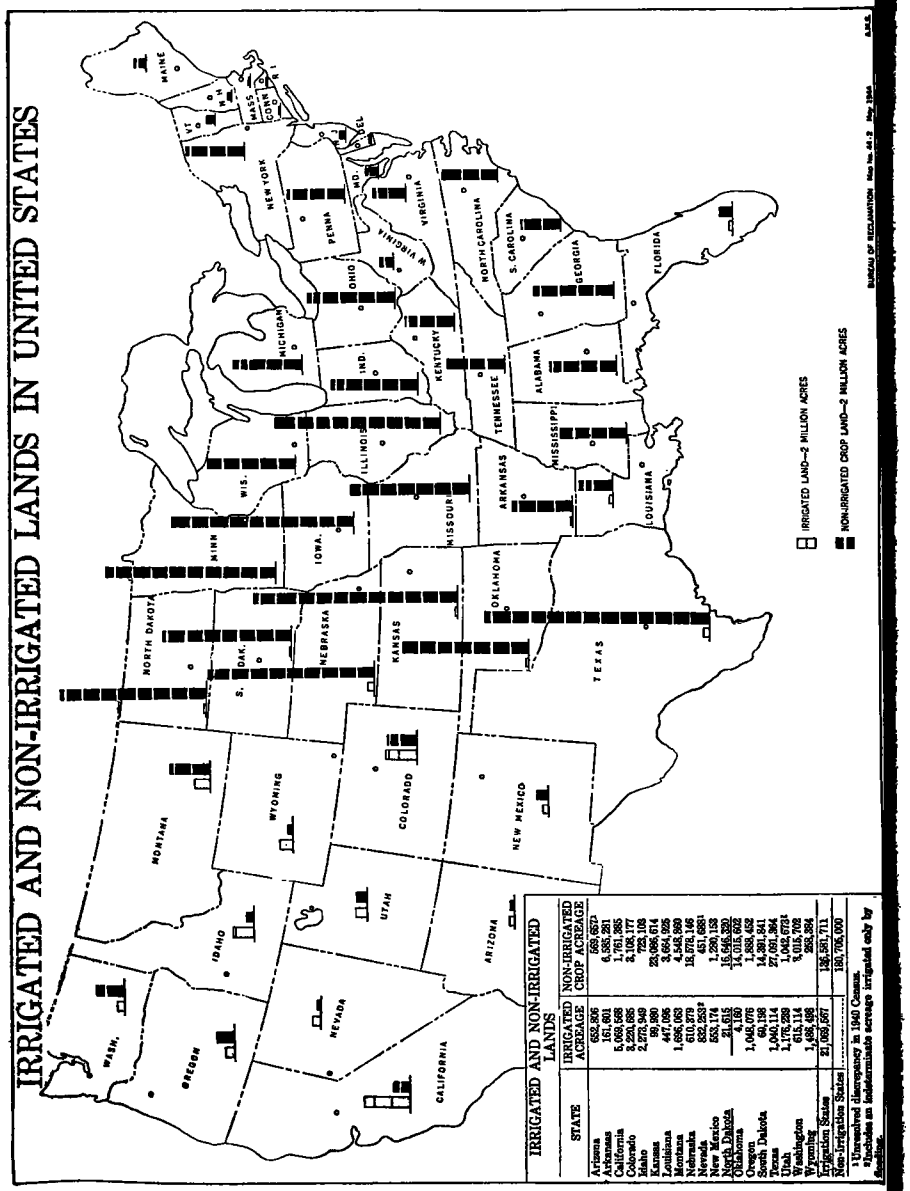
Forty years of experience on the Yellowstone Irrigation District, about 20,000 acres of which is in McKenzie County, North Dakota, gives a reliable index as to what can be expected of irrigated lands in North Dakota. In 1947 the average returns per acre on this irrigated tract with ideal production conditions and world war high prices was $80.17, with some returns from sugar beet fields averaging as high as $124 per acre. In 1949 reduced yields and lower prices made the average gross returns per acre $54.33. However, this was two and a half times the gross returns under dry land farming.

YIELDS UNDER IRRIGATION

On the Lewis & Clark Experiment Farm
Arlon G. Hazen, Superintendent

High value crops for cash income and high yielding crops for livestock feed must have preference under irrigation because of the limited acreage, the expense, and the amount of labor required to produce a crop under irrigation. Most irrigated, family size units, range between 100 and 160 acres of irrigable land. It has been demonstrated that a farmer can make a comfortable living for himself and family from this acreage providing he plans his farming operations well and makes the best possible use of the land each year.

The results tabulated are not conclusive since they represent only the 1948 and 1949 seasons. They are, however, highly significant and the procedure will give reliable information when an average of several seasons results are accumulated.



STATE	IRRIGATED ACREAGE	NON-IRRIGATED CROP ACREAGE
Arizona	652,205	599,672
Arkansas	161,601	6,585,281
California	5,059,688	1,761,285
Colorado	2,220,085	2,108,177
Idaho	2,273,949	723,108
Kansas	89,880	23,066,614
Louisiana	447,095	2,564,925
Montana	1,697,059	3,454,869
Nebraska	610,979	18,678,146
Nevada	832,583[2]	451,693[1]
New Mexico	553,174	1,289,133
North Dakota	21,615	15,546,320
Oklahoma	4,150	14,015,602
Oregon	1,040,976	1,866,642
South Dakota	7,268	14,281,841
Texas	1,040,114	27,091,364
Utah	1,176,289	1,045,673[1]
Washington	615,114	9,015,702
Wyoming	1,488,495	868,384
Irrigation States	21,059,577	136,581,711
Non-Irrigation States	.....	180,706,000

[1] Unexplained discrepancy in 1940 Census.
[2] Includes an indeterminate acreage irrigated only by flooding.

CROP YIELD SUMMARY, 1948, 1949

(See p. 33 Irr. Trials in Western North Dakota)

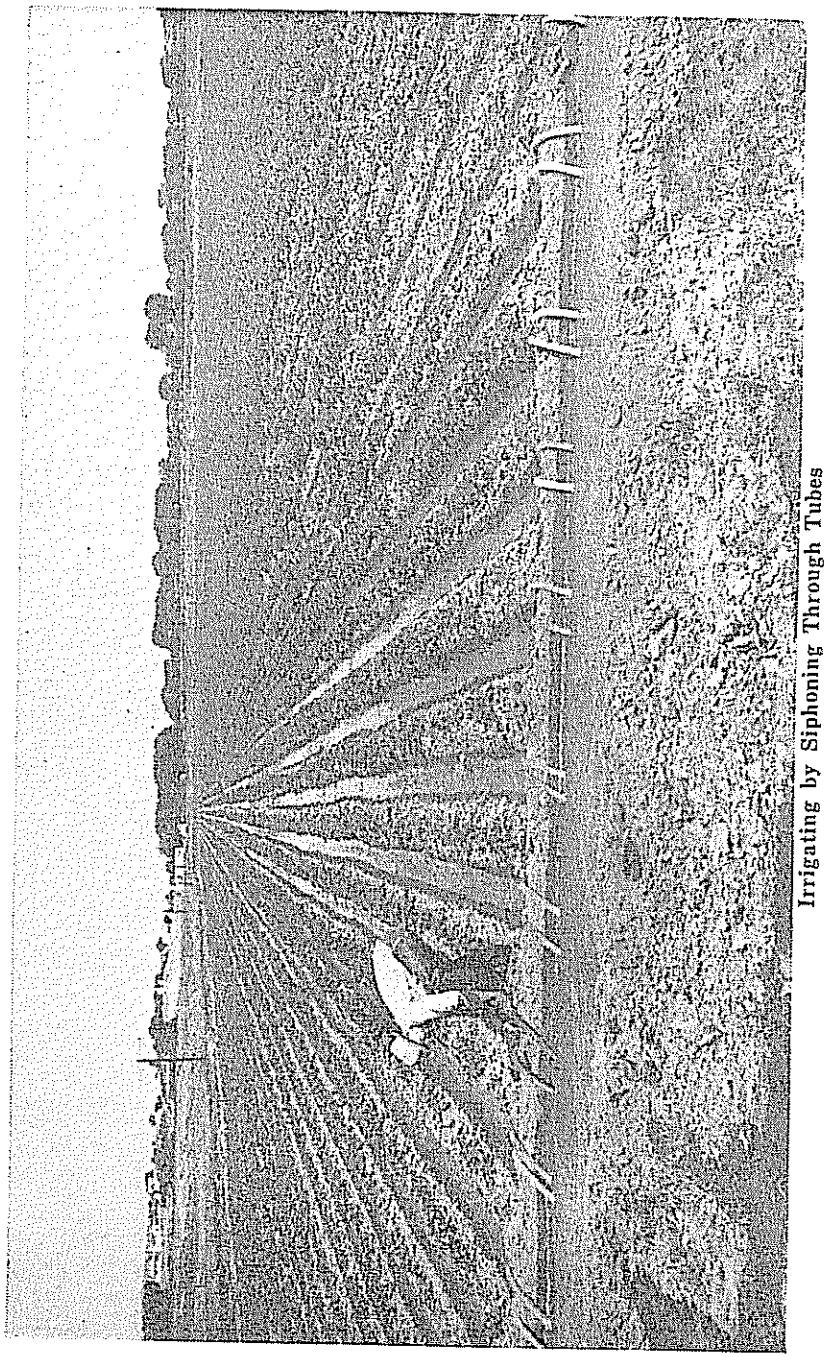
	Year	Rainfall inches	Irrigation inches	Yield per acre bu.
Potatoes	1948	7.55	0.00	241.4
		7.55	3.00	258.0
	1949	5.50	0.00	49.4
		5.50	14.9	219.9
		5.50	17.7	272.1
Oats	1948	7.55	0.00	65.0
		7.55	2.75	84.1
		7.55	7.48	17.6
	1949	4.95	0.00	20.2
		4.95	7.35	96.9
		4.95	15.15	100.5
Barley	1948	7.40	0.00	46.0
		7.40	2.50	56.7
		7.40	6.60	55.1
	1949	4.95	0.00	20.4
		4.95	7.10	56.3
		4.95	16.90	57.5
Corn	1948	7.55	0.00	46.8
		7.45	1.50	57.5
		7.45	3.84	63.5
	1949	5.50	0.00	54.3
		5.50	3.90	56.1
		5.50	6.93	58.3
		5.50	10.69	55.5
Sugar Beets	1948	7.55	0.00	13.7
		7.55	2.75	15.2
		7.55	12.56	18.0
	1949	Stand uneven—no test made.		

WORLD ACREAGES UNDER IRRIGATION

As given by the Encyc. Brit. Vol. 12, p. 262:

		acres			acres
1.	India,	55,000,000	13.	Siam	2,000,000
2.	U.S. of America	24,000,000	14.	Morocco	1,500,000
3.	Russia in Europe	8,000,000	15.	Australia	1,000,000
4.	Japan	7,000,000	16.	China	1,000,000
5.	Egypt	6,000,000	17.	South Africa	800,000
6.	Mexico	5,700,000	18.	Peru	800,000
7.	Italy	4,500,000	19.	Canada	400,000
8.	Spain	3,500,000	20.	Algeria	400,000
9.	France	3,150,000	21.	Phillipines	250,000
10.	Java	3,000,000	22.	Hawaii	200,000
11.	Chili	3,000,000	23.	British Columbia	100,000
12.	Argentina	2,000,000	24.	Cuba	50,000

India is now ahead of the combined acreages of the six next nearest nations that have given irrigation the most attention. Torrential rains flood many areas which at other seasons of the year experience extremely dry weather which kills crops and causes famine. Multitudes have died



Irrigating by Siphoning Through Tubes

of hunger in many years when the rainfall was ample but did not come in the crop growing season. Two comparatively recent years of terrible summer droughts and famine caused the death of more than one and a half million people. For more than a decade India has by its irrigation works prevented the recurrence of famine, which was so common for past generations.

NORTH DAKOTA FARM LANDS

According to a recent study by the Bureau of Agricultural Economics, individual farmer owners hold 70 per cent of the farm land, with an average of 244 acres per farm.

In North Dakota, about 41 million acres of land were in farms in 1945. Of this, 89 per cent was owned by individuals, four per cent by corporations, six per cent by the government and a little less than one per cent by Indians. Ninety per cent of the owners are men.

About eight per cent of owners in North Dakota held units of 1,000 acres or more, 20 per cent 500 to 999 acres, 44 per cent 220 to 499 acres and 22 per cent 140 to 219 acres.

The North Dakota State Department of Agriculture reports the total acreage into crops for 1949 was 16,705,814. The largest acreage cropped was in 1945 and totaled 17,311,190 acres.

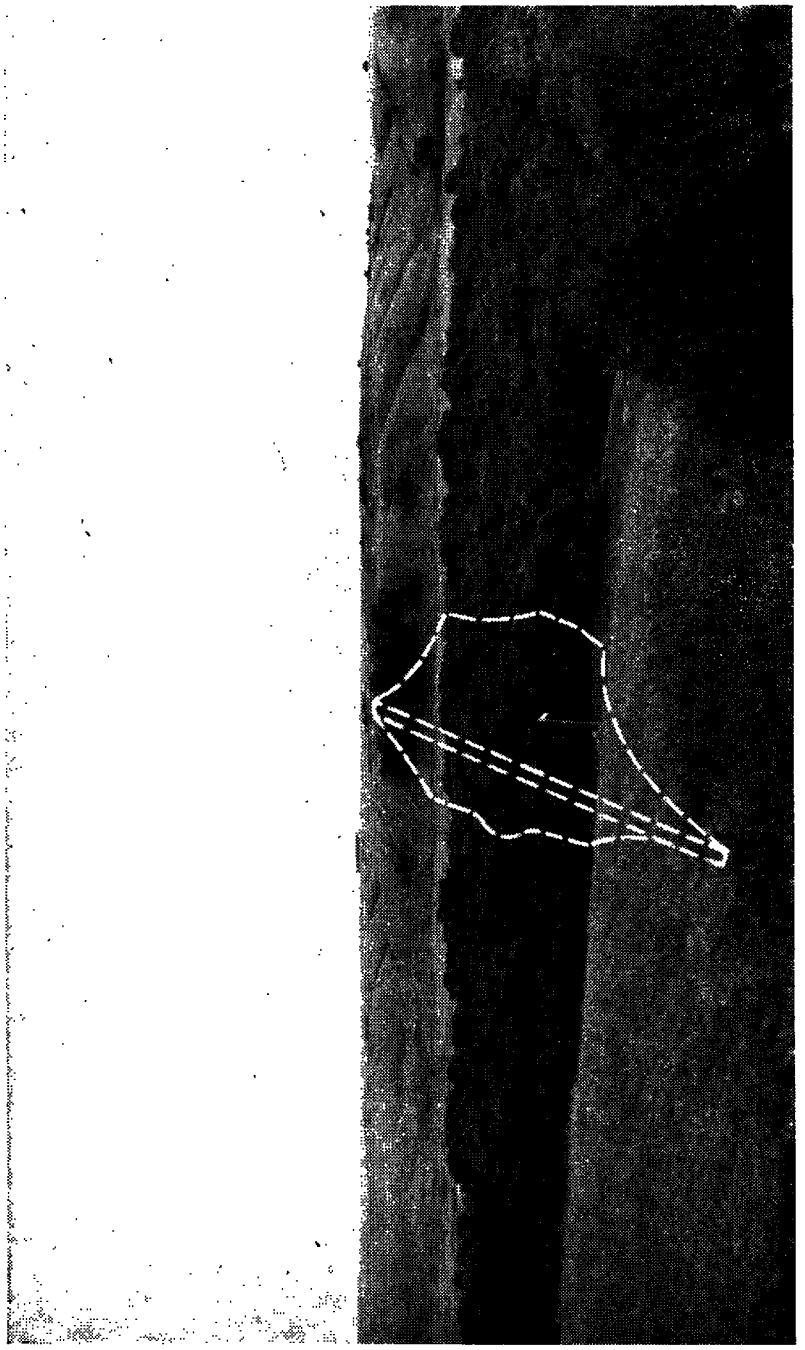
$30,000 ALLOTTED SOIL SURVEYS

The State Water Conservation Commission set aside $30,000 to match a like amount of government funds for soil survey work on the Missouri-Souris project, the work to be done under the direction of Dean H. L. Walster of the Agricultural College and cover a two-year period. The Department of Agriculture is furnishing four trained men from the bureau of plant industry, to work with four men from the Agricultural College force, in cooperation with engineers of the bureau of reclamation.

The College was without funds it could use for this purpose and appealed to the Water Commission for assistance. A study will be made of the possibility of reclaiming fertility to saline and alkaline soils and whether underground drainage difficulties in the Bowbells area would prevent the use of these lands for irrigation. If not, whether other possible irrigated areas can be found in the Missouri-Souris project to offset the land found unsuitable for irrigation. Preliminary surveys indicated that this could be done.

SPRINKLER IRRIGATION MAY AID MISSOURI-SOURIS AREAS. BY BUREAU OF RECLAMATION

A revised bulletin under above head was printed and distributed among its employees and others interested in December, 1949, which discusses advantages and disadvantages of irrigation by this method, and possible uses where it may be more advantageous than gravity irrigation.



Site of Sheyenne River dam and reservoir, near New Rockford, North Dakota

The bulletin comments that intensive and widespread interest in the use of sprinkler systems has continued. Many irrigation farmers wish to install sprinklers in order to improve their irrigation application, conserve water, and because of more convenient working hours, and where irrigation by sprinklers is the only feasible method because of special conditions of soil, topography, or crop requirements, and to minimize seepage.

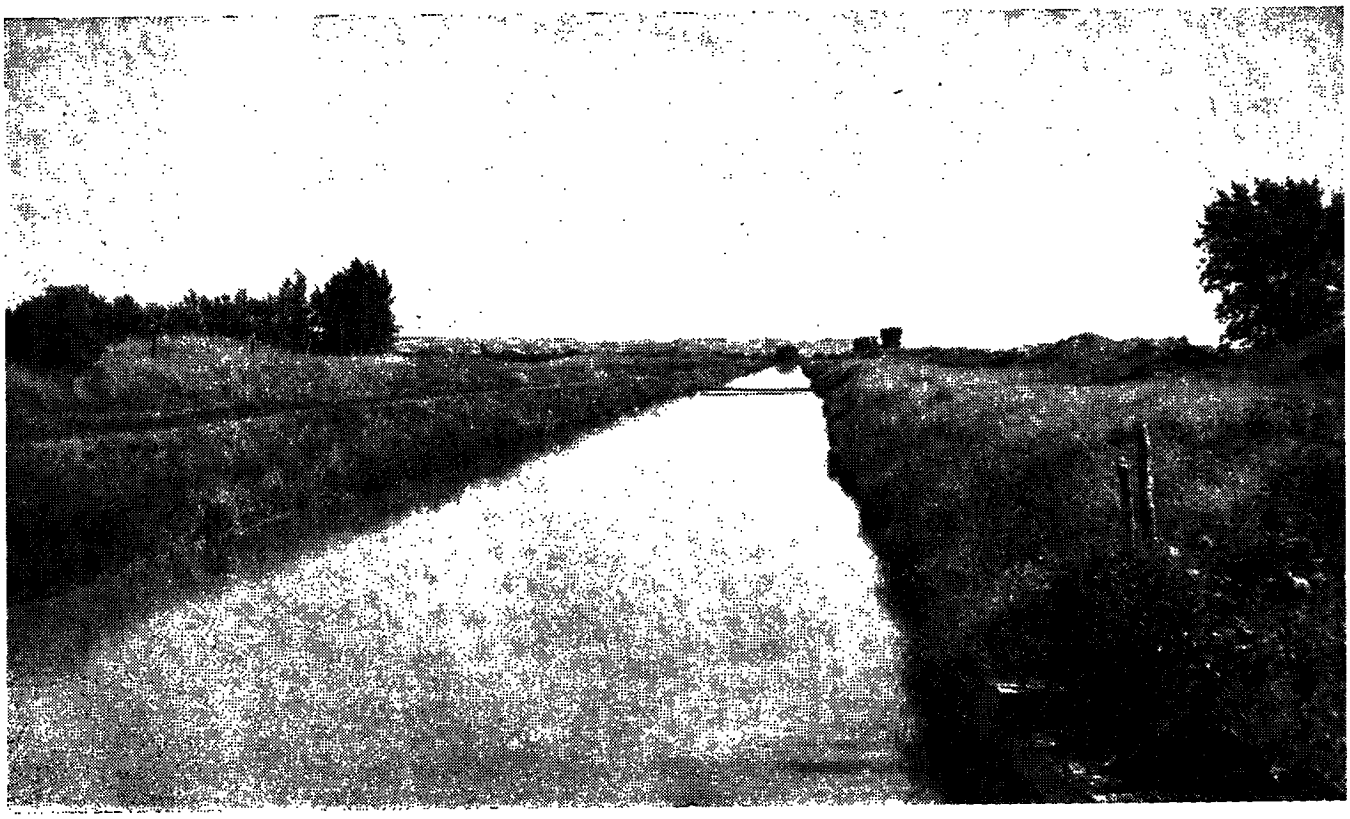
It states, that sprinkler irrigation has a real and significant place in bringing improved use of project resources and increased financial success, where conditions do not lend themselves to surface methods of application, but that attempts to use sprinklers on inadequate information may result in unsuccessful installations and loss.

Sprinkler irrigation is a means of conserving water and thus increase the area that can be developed. The possibility of increasing crop production by sprinkler irrigation is great.

The bulletin states "Of the many thousands of acres of land in the Missouri-Souris project in North Dakota, large portions may be irrigated by sprinklers that cannot be successfully irrigated by surface methods. Also, much larger acreages of the land may be irrigated by sprinkling than by surface methods. This land is in a glaciated area topographically and partly unsuited to surface irrigation."

DEVILS LAKE WILL BE GREAT RECREATION CENTER

One of the most attractive developments, recreation-wise, is the restoration of Devils Lake. From a chemical-filled body of near stagnant receding water to a beautiful fish-inhabited lake, gives a world of recreational possibilities which will make it a center of attraction for people traveling many miles. Since 1867 this lake has had a gradual recession. Return flow waters from the Missouri-Souris project are to be diverted to Devils Lake which will freshen the waters and at the proposed water level of 1425 feet will have an area of about 52,000 acres.



Main Canal on Lower Yellowstone Irrigation District irrigating about 20,000 acres in North Dakota and 38,000 acres in Mont.

LOWER YELLOWSTONE IRRIGATION DISTRICTS 1 and 2
In Montana and North Dakota
45,026 Acres
Livestock Inventories
1948 and 1949

	December 31, 1948			December 31, 1949		
	Number	Value	Total value	Number	Value	Total value
Horses-Mules	275	$ 33.30	$ 9,159.00	272	$ 26.43	$ 7,189.00
Cows	1,710	113.14	193,475.00	2,305	106.35	245,138.00
Cattle, Feeders	7,113	131.03	932,010.00	4,047	106.30	430,201.00
Cattle, Dairy	1,427	141.58	202,035.00	1,468	111.86	164,215.00
Purebred Sires	64	292.84	18,742.00	98	247.70	24,275.00
Grade Sires	12	124.58	1,495.00	8	140.63	1,125.00
Sheep, Farm Flock	8,251	8.46	69,820.00	1,891	13.90	43,529.00
Sheep, Feeders	103,204	14.69	1,515,843.00	82,053	14.87	1,220,515.00
Hogs	2,436	30.64	74,635.00	2,173	17.80	38,679.00
Turkeys	497	8.02	3,989.00	106	4.73	501.00
Chickens	24,327	1.08	26,166.00	26,818	.93	24,874.00
Other Fowl	.....	.....	344.00	.....	.....	426.00
Bees, hives	838	.....	12,633.00	833	.....	12,970.00
Totals	.....	.....	$3,060,346.00	.....	.....	$2,196,399.00

Hereford Steer Feeders from Yellowstone Irrigation District Top the Market

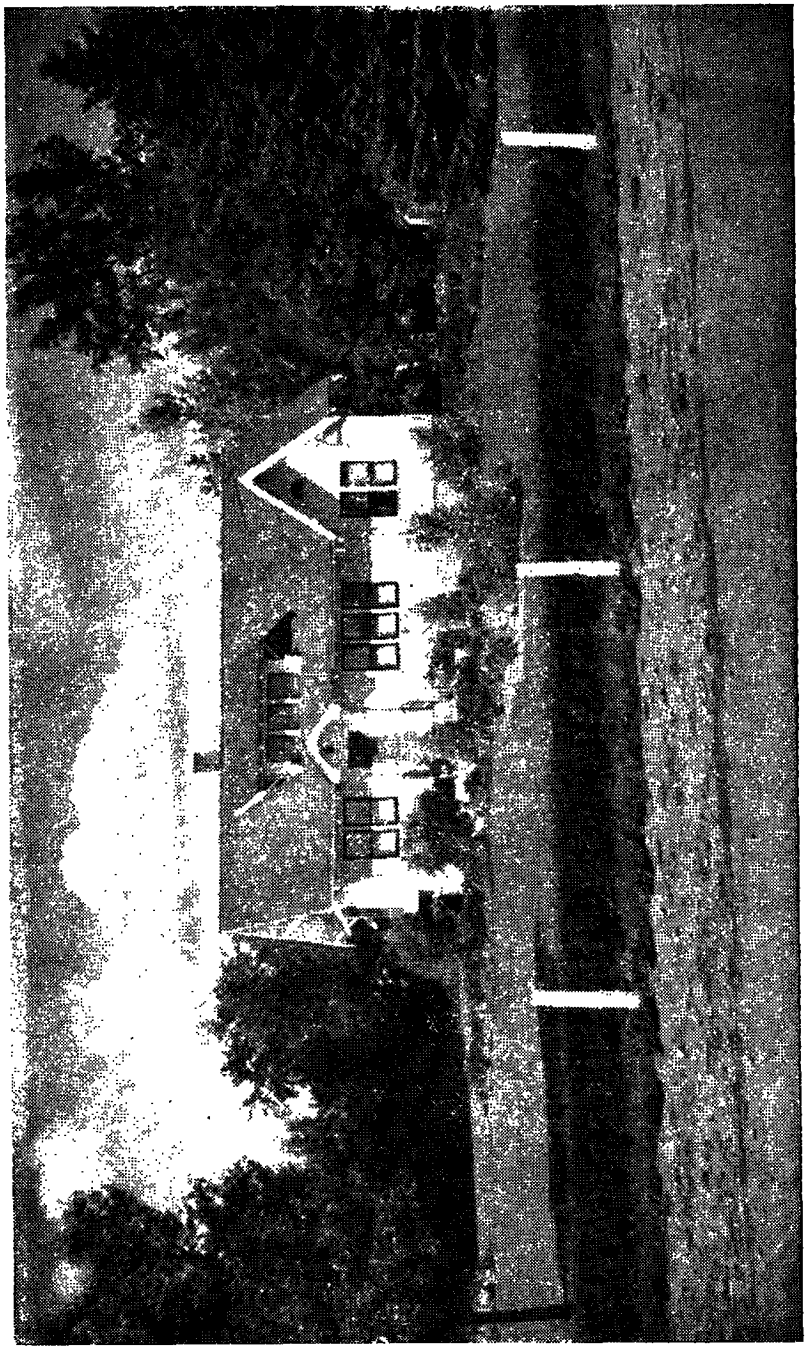
LOWER YELLOWSTONE IRRIGATION DISTRICTS 1 and 2

In North Dakota and Montana

45,026 Acres

Crop	1944 Av. Yield	1944 Acre Value	1944 Total	1945 Av. Yield	1945 Acre Value	1945 Total	1947 Av. Yield	1947 Acre Value	1947 Total	1949 Av. Yield	1949 Acre Value	1949 Total
CEREAL:												
Barley	41.2	$ 32.93		33.4	28.41		39.51	55.31		31.0	27.90	
Corn	34.9	34.91		19.4	19.44		35.17	52.76		34.36	29.21	
Oats	54.2	27.12		44.2	22.18		55.88	44.71		42.96	25.77	
Wheat	30.6	39.81		26.5	37.16		30.71	74.63		24.61	44.30	
Speltz	44.9	22.47		30.2	16.60		42.04	42.04		28.41	25.57	
Totals			512,460.00			408,226.00			$1,080,936.51			$ 686,950.40
SEED:												
Alfalfa	1.1	23.01		1.2	25.59		1.52	30.37		1.23	30.76	
Clover	3.1	13.14		3.2	19.29		4.00	24.00		2.19	15.79	
Flax	10.5	29.15		7.0	19.40		10.21	61.27		10.12	33.92	
Millet	15.0	11.25					17.42**	47.78**				
Soybeans	57.8	7.03										
Totals			9.433.00			14,003.00			74,733.60			18,561.35
FORAGE:												
Alfalfa	2.1	22.61		1.9	22.40		1.92	28.87		2.35	24.17	
Other Hay	1.2	7.17		3.6	6.41		1.00	5.98		1.18	3.54	
Corn Fodder	1.4	4.74		2.1	7.18		1.57	7.83		1.45	5.82	
Corn Sileage	6.6	13.17		5.2	10.46		6.72	20.15		5.10	12.75	
Sugar beet tops		2.22			1.95			5.62			4.20	
Natural Pasture		.50			.50			.50			.50	
Tame pasture		12.00			12.00			10.00			10.00	
Other pasture		2.00			2.00			2.00			2.00	
Totals			$ 291,422.00			259,809.00			$ 225,873.50			$ 319,820.50
VEGETABLES:												
Beans, commerce	9.7	35.84		11.1	65.76		9.5	45.04		9.06	51.21	
Potatoes, white	120.0	120.02		*88.8	53.31		65.55	59.00		210.0	110.75	
Gardens, truck		58.36			71.88			83.27			70.35	
Totals			99,491.00			52,551.00			74,610.90			125,384.95
Sugar beets	11.1	111.28	1,558,883.00	9.6	90.15	1,482,465.00	11.25	126.34	1,482,465.00	10.3	91.84	983,272.51
Additional revenues			460,256.00			463,260.00			498,037.25			266,619.73
TOTAL VALUE CROPS			2,931,996.00			2,680,320.00			$3,833,775.28			$2,666,195.73
AV. VALUE PER ACRE			62.69			57.13			80.19			54.33

*(Hail damage reduced yields and returns for 1945 on part of project) (**Peas)



Farm home of Nels Bach, on Lower Yellowstone Irrigation District.

LOWER YELLOWSTONE IRRIGATION IN MONTANA AND NORTH DAKOTA

Probably the best index as to what may be expected from irrigated lands in North Dakota is the Lower Yellowstone Irrigation District of 58,324 acres, of which about 20,000 acres is in McKenzie County, North Dakota, and the balance in Montana. The district has been in operation for 40 years, so has passed the experimental stage. It was constructed at a cost of $66. per acre, including the drainage system. Spread over a series of years, the average annual repayment charge is $1.60 per acre. In addition, the annual operation and maintenance charge varies some, but for three years has been $1.10 per acre. It must be remembered that the construction work was done when labor and materials were much less than today.

The principal crops are alfalfa, wheat, corn, barley, beans and sugar beets. Yields of alfalfa have commonly been three tons to the acre, but with favorable conditions have reached five to six tons. Yields of wheat have been 30 or more bushels: corn, 40 bushels; barley, 40 bushels; and sugar beets, 15 tons to the acre. Truck gardening pays well. Berries give good yields and hardy varieties of apples can be raised.

The returns per acre for 1949 crops of barley, corn, oats, wheat and speltz totaled $686,950.40, or 26 per cent of the gross income; of which wheat with $44.30 average gross per acre was the highest. Alfalfa, clover and flax seeds yielded $18,561.35, or 7 per cent of the gross returns, with a flax average of $33.92 per acre and alfalfa $30.76 being outstanding. Forage crops, consisting of alfalfa, hay, corn fodder, and silage, sugar beet tops and pasture yielded 14 per cent of the gross returns of $319,820.50, of which alfalfa hay was outstanding with $29.48 per acre average returns. In commercial vegetables, beans, potatoes and garden truck yielded 5 per cent of the total returns, with potatoes leading in per acre returns averaging $110.75, and beans $51.21. Sugar beets yielded 37 per cent of the gross returns of $983,272.51, averaging $91.84 per acre. Other returns include returns from stock feeding operations and grossed $266,619.73 or 10 per cent of the total of $2,666,195.73, or an over-all average of $54.33 per acre for the total irrigated acreage. Livestock feeding and finishing for market of 4,047 range cattle and 82,053 range sheep has grown to be one of the principal activities of the irrigated area, yielding 10 per cent of the total returns, or $266,619.73.

This irrigated area of about an area of two townships is raising as much feed and feeding as much stock ready for market as the average whole dry-farmed county in that area. At first the settlers thought a section of land, more or less, was necessary to make a comfortable living with some accumulation, but the average farm on the project at the present time is approximately 100 acres, which experience has proved to be large enough to keep the average family busy and enable them to make a comfortable income.

Farm home of Axel Danielson, on Lower Yellowstone Irrigation District.

IRRIGATION CROP RETURNS

No recent report of crop returns under irrigation in North Dakota and adjacent areas is available. The Bureau of Reclamation reported average gross returns per acre as shown below, and that in almost every case the amount exceeded the cost of constructing the irrigation features of the project.

Potatoes averaged $258.77 per acre, sugar beets $134.62; beans $63.80; and grains $35.83. Alfalfa hay and other feeds, vegetables and gardens, fruits, pasture and miscellaneous crops returns were very satisfactory.

The five high-yielding projects, of which the Yellowstone is partly in North Dakota, showed average gross yields per acre as follows:

Huntley Project, near Billings, Montana	$ 55.97
Shoshone, Wyoming	55.70
Lower Yellowstone	54.63
Buffalo Rapids, near Glendive, Montana	48.67
Milk River, near Chinook, Montana	48.55

On the Lower Yellowstone irrigation project, about 20,000 acre of which are in McKenzie County, North Dakota, high average gross yields on individual crops were as follows:

Potatoes	$109.86
Sugar beets	94.46
Gardens	65.67
Flax	58.06
Beans	55.38
Wheat	54.37

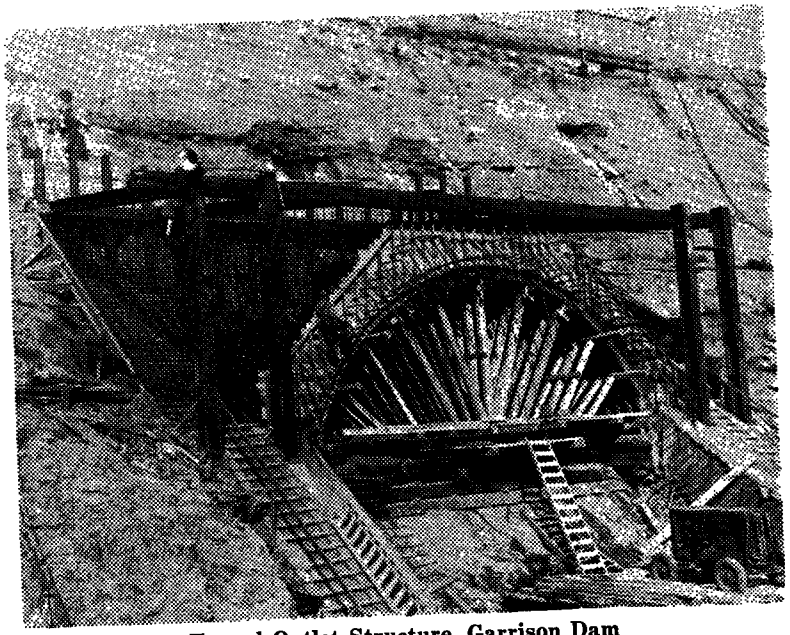
IRRIGATION AIDS FRUIT RAISING

The Lower Yellowstone Irrigation District is producing splendid crops of apples, crabapples, pears, cherries, plums, raspberries and strawberries. This indicates that with irrigation North Dakotans can produce most of the fruit juices needed for a balanced diet. A few small acreages in different communities are producing strawberries, raspberries and small fruits with sprinkler irrigation which for several years past have yielded more than a thousand dollars per acre.

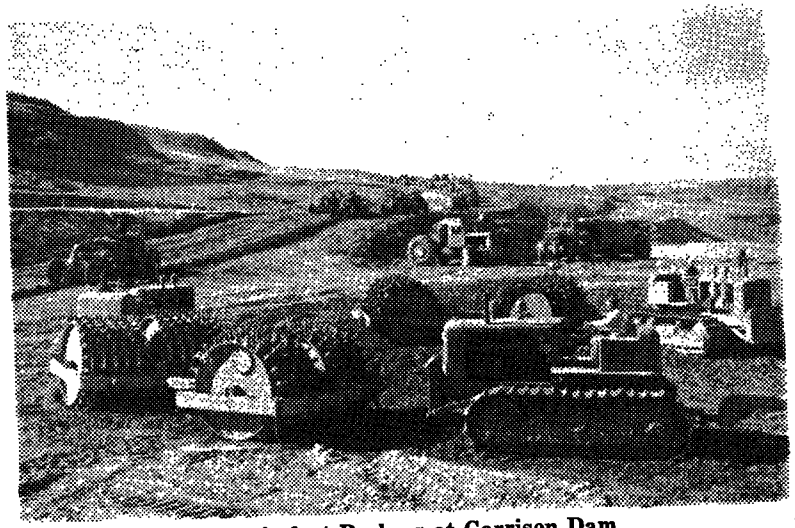
The Great Plains Field Station at Mandan have been demonstrating for years that it is possible to raise some wonderful fruit, mostly grafted on hardy native roots.

COOPERATING AGENCIES

State and national departments and agencies with which the work of the State Water Conservation Commission is coordinated have contributed generously to the work accomplished. On first glance it may appear to the reader that there is an over-lapping of effort but on further study it will be found that each department or agency has performed its particular part of the work which when coordinated with



Tunnel Outlet Structure, Garrison Dam



Sheep's-foot Packers at Garrison Dam

With a suitable mixture of excavated material mixed with water in right proportions, and ten or twelve passes of these sheep's-foot packers, heavily weighted, there is created an admixture impervious to moisture and almost equal to concrete, for the main enbankment.

the others covers all the phases of the planning, surveying, mapping, specifications, weather and stream-flow records required for estimates, and details which make up the complete and detailed plans. This Commission is deeply indebted to the different cooperating agencies for their very fine cooperation.

PROPOSED DAMS AND RESERVOIRS

With Approximate Figures

Name	Stream	Capacity acre-feet	Height of dam (ft.)
Cannonball	Cannonball river	300,000	125
Thunderhawk	Cedar creek	Not determined	
Broncho	Knife river	Not determined	
Crosby	Souris Canal	332,000	30
Des Lacs	Des Lacs river	Not determined	30
Velva	Souris river	Diversion dam	
Sheyenne	Sheyenne river	560,000	95
Jamestown	James river	Not determined	92

PROPOSED IRRIGATED PROJECTS

Name of Unit	Approx. acres	General Location
Heart river	13,100	Extending 60 miles west of Mandan
Cannonball and Cedar rivers	12,000	SW North Dakota—Solen to Elgin and to Thunderhawk dam on Cedar river
Knife river	15,380	Western N. Dak.—Beulah-Hazen-Stanton
Little Missouri	Not determined	Preliminary Studies and Investigations
Hancock Flats	5,400	30 miles NW of Washburn
Fort Clark	2,140	40 miles NW of Mandan
Oliver-Sanger	8,690	30 miles N of Mandan
Painted Woods	4,300	30 miles N of Bismarck
Manley	1,200	15 miles N of Mandan
Wogansport	1,750	12 miles N of Bismarck
Square Butte	2,040	8 miles N of Mandan
Burnt Creek	1,310	5 miles N of Bismarck
Bismarck	8,500	Adjoining Bismarck on south
Horsehead Flats	6,450	50 miles S of Bismarck
Winona	4,540	65 miles S of Bismarck
Missouri-Souris	1,000.000	Crosby-Minot area
New Rockford	55,500	New Rockford area
Jamestown	22,000	Jamestown area
Oakes	31,000	On James river near Oakes

POWER TRANSMISSION LINES

Part Under Construction

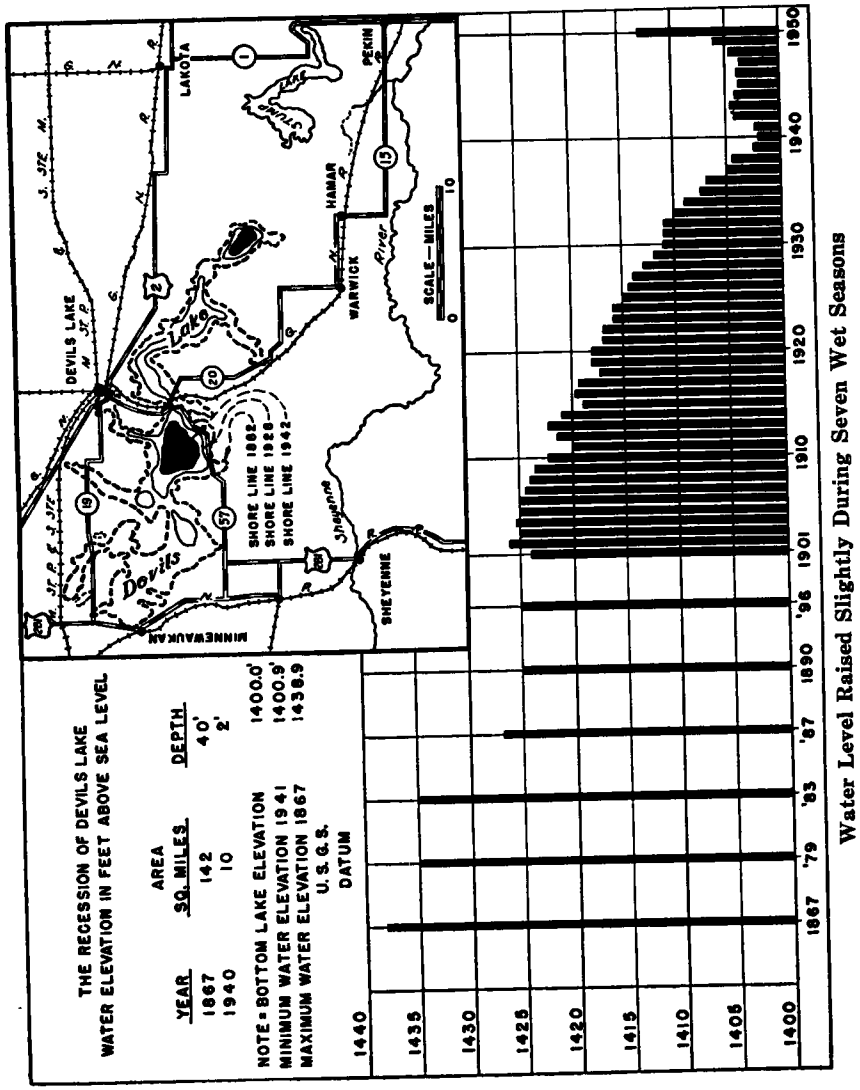
From	To	Voltage
Williston	Garrison	115,000
Bismarck	Heart river subunit	69,000
Minot	Garrison	115,000
Garrison	Bismarck	115,000
Washburn	Turtle Lake	69,000
Bismarck	Dawson	69,000
Bismarck	Jamestown	230,000
Jamestown	Fargo	115,000
Buffalo	Absaraka	69,000
Bismarck	Mobridge	230,000
Williston	Medicine Lake	115,000
Minot	Grand Forks	115,000
Devils Lake	Carrington	115,000
Carrington	Oakes	115,000
Oakes	Lisbon	69,000
Devils Lake	Grand Forks	69,000
Garrison	Bismarck #1	230,000
Jamestown	Fargo	230,000
Minot	Des Lacs	115,000
Grand Forks	Fargo	115,000
Minot	Garrison #2	115,000
Weaver	Cando	69,000
Des Lacs	Bowbells-Rugby	69,000
Souris Tap Line	N. of Newburg	69,000
Overly Tap Line		69,000
Minot	Carrington	69,000
Oakes	Wahpeton	69,000
Beulah	Heart River	69,000
Belfield	Richardton	69,000
Wahpeton	Fergus Falls	69,000
Fargo	Fergus Falls	230,000
Garrison	Bismarck #2	230,000
Bismarck	Jamestown #2	230,000

(See 3-page map folded in "Power Resources")

CONGRESSIONAL APPROPRIATIONS JULY 1, 1949

Garrison Dam	$27,500,000
Baldhill Dam	210,000
Homme Dam	475,000
Mandan Flood Control	36,000
Corps of Engineers projects	$28,221,000
For Construction:	
Missouri Diversion Dam	$ 200,000
Fort Clark Irrigation	137,270
Dickinson Project	871,300
Heart Butte Project	1,117,750
Cannonball Project	* 282,000
Transmission Lines	2,452,500
Preconstruction:	
Crosby-Mohall	$ 515,000
Devils Lake	35,000
Jamestown Project	150,000
Painted Woods	60,000
Cartwright Project	* 21,891
Sidney Unit in Mont.-No. Dak.	* 31,156
Investigations:	
Missouri-Souris	$ 71,500
North Dakota Pumping	9,500
Garrison Diversion	44,500
Little Missouri	38,000
Knife River	38,000
Cannonball	38,000
Power Studies	27,500
Contract Authority:	
Transmission Lines	$ 2,000,000
Missouri-Souris	4,364,000
Bureau of Reclamation Projects	$12,504,867

*Fiscal year allocations



Water Level Raised Slightly During Seven Wet Seasons

RECORD RISE IN LEVEL OF DEVILS LAKE

The level of Devils Lake has risen to an elevation of 1,413 feet above mean sea level, the highest elevation attained since 1927 according to information collected by the U. S. Geological Survey in cooperation with the North Dakota Water Conservation Commission.

Prior to the spring runoff this year, the Lake elevation was approximately 1,406 feet; hence a rise of about seven feet has occurred so far this year. This is by far the greatest change in elevation of the Lake surface recorded during any year since the records began in 1867, and the volume of water in the Lake has more than doubled since the thaw began this spring. The lowest elevation recorded was in 1940 when the level dropped to 1,401 feet, about 37 feet below the highest of record in 1867 when the water surface stood at an elevation of approximately 1,438 feet.

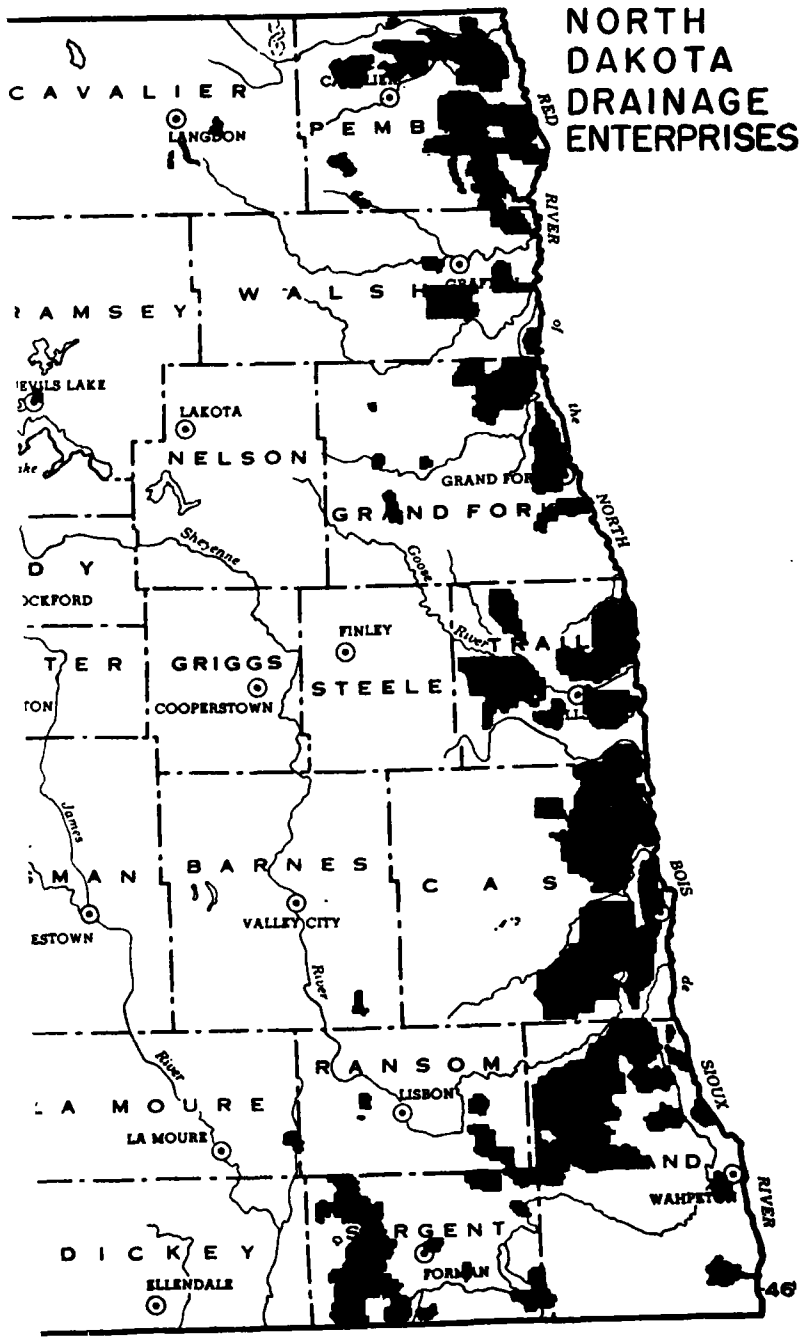
The flow in Mauvais Coulee, principal tributary to the Lake, has been higher this spring than previously known. The peak flow in this Coulee for the season was a little more than 600 cubic feet per second on June 7.

NORTH DAKOTA RURAL REHABILITATION CORPORATION

Since 1937, when the State Water Conservation Commission was organized, the North Dakota Rural Rehabilitation Corporation, has loaned the greater portion of funds used in the construction of the Lewis & Clark, the Sioux and the Grantier irrigation projects in McKenzie county, and in constructing and enlarging the intake for the Yellowstone Pumping Irrigation project.

FLOOD DAMAGE IN NORTH DAKOTA

North Dakota is subject to seasonal flood damage on its different streams. This some years is quite severe, with a heavy money loss and occasionally some loss of life. But the area which is subject to flood crop losses almost every year is the Red River Valley. This loss varies but with occasional crop losses which are quite severe. The government statistician estimated that the losses to crops from floodwaters in 1942-3 in the Red River Valley amounted to twenty three million dollars. The areas inundated are shown on the "North Dakota Drainage Enterprises" map accompanying this report. Since this map was made, state appropriations have aided counties and local drainage districts in the construction and cleanout of drainage ditches which have aided in the rapid drain-off of floodwaters. These drains were constructed largely by the Soil Conservation Service engineering staff under the supervision of the State Water Conservation Commission and the local county or drainage district. After completion of the Corps of Engineers basin-wide plan is in operation, the flood difficulties of the Red River Valley should be largely overcome. It is estimated that it may take ten years to complete construction planned.



DRAINAGE

Drainage activities in North Dakota went forward during the period October 1, 1948, to June 30, 1950, particularly in the counties of the Red River valley. Work is undertaken by the various counties with the U.S. Soil Conservation service supervising and assisting. The State Water Conservation Commission received an appropriation of $150,000 from the state legislature for the 1949-1951 biennium to assist financially in this work. In addition to expenditures from this appropriation, payments totaling $106,374.97 were authorized from the 1947-1949 drainage appropriations to pay for work under contract but incomplete at the close of the 1947-1949 biennium. This drainage construction and repair program includes excavation for the drain, either cleanout or new excavation, spoil bank leveling, obtaining easements, purchase of necessary material and supplies and incidental expenditures. Expenditures made are shown in the table that follows. The state expenditures were made from 1949-1951 appropriations for work contracted for since July 1, 1949, and from 1947-1949 appropriations for work under contract but incomplete on June 30, 1949. During the period covered by the report, approximately 2,000,000 cubic yards of earth were excavated for the drains and in addition installations of necessary bridges and culverts for farm crossings were made.

Under ruling formulated by the Commission, funds appropriated by the legislature for construction, reconstruction and cleanout of drains are available on a matching basis, the drainage districts to pay 60 per cent of the costs, the Commission to pay the balance of 40 per cent. A portion of these funds are also available to regular organized irrigation districts for repair and reconstruction of canals and protective works.

The following table shows the allocations of funds to counties by the State Water Conservation Commission for the 1949-1951 biennium:

County	Allocated
Cass	$ 20,000.00
Dickey	3,000.00
Grand Forks	8,000.00
Pembina	35,000.00
Ransom	8,000.00
Richland	8,000.00
Sargent	4,000.00
Traill	5,000.00
Walsh	5,000.00
Bottineau	14,000.00
Balance, unallocated	40,000.00
Total Appropriation	$150,000.00

SUMMARY OF DRAINAGE EXPENDITURES
OCTOBER 1, 1948 TO JUNE 30, 1950

County	State Share of Cost	County Share of Cost	Total Cost of Drain
Cass	$ 30,940.84	$ 46,411.31	$ 77,352.15
Grand Forks	5,641.93	8,462.89	14,104.82
Pembina	24,568.12	36,852.17	61,420.29
Richland	4,008.76	6,013.18	10,021.94
Sargent	688.22	1,032.33	1,720.55
Eaton Flood Irrigation Project	420.00	630.00	1,050.00
Traill	55,568.76	83,357.30	138,926.06
Walsh-Pembina	38,964.93	65,356.41	104,321.34
Lewis & Clark Project	5,730.62	843.24	6,573.86
Sioux Irrigation District	1,934.80	.....	1,934.80
Burlington Project	2,255.59	.....	2,255.59
	$170,722.57	$248,958.83	$419,681.40

1950 SNOW RUN-OFF EXCEEDED ALL RECORDS

Records of stream flow measurements for more than forty years were broken on many North Dakota streams by the 1950 snow run-off rush of water. This emphasized the need of keeping stream-flow records for many years so that engineers can have the extreme lows and highs of the stream on which they contemplate construction of dams and reservoirs to control floods, and provide irrigation water in periods of drouth. Some of the records broken by 1950 floods follow:

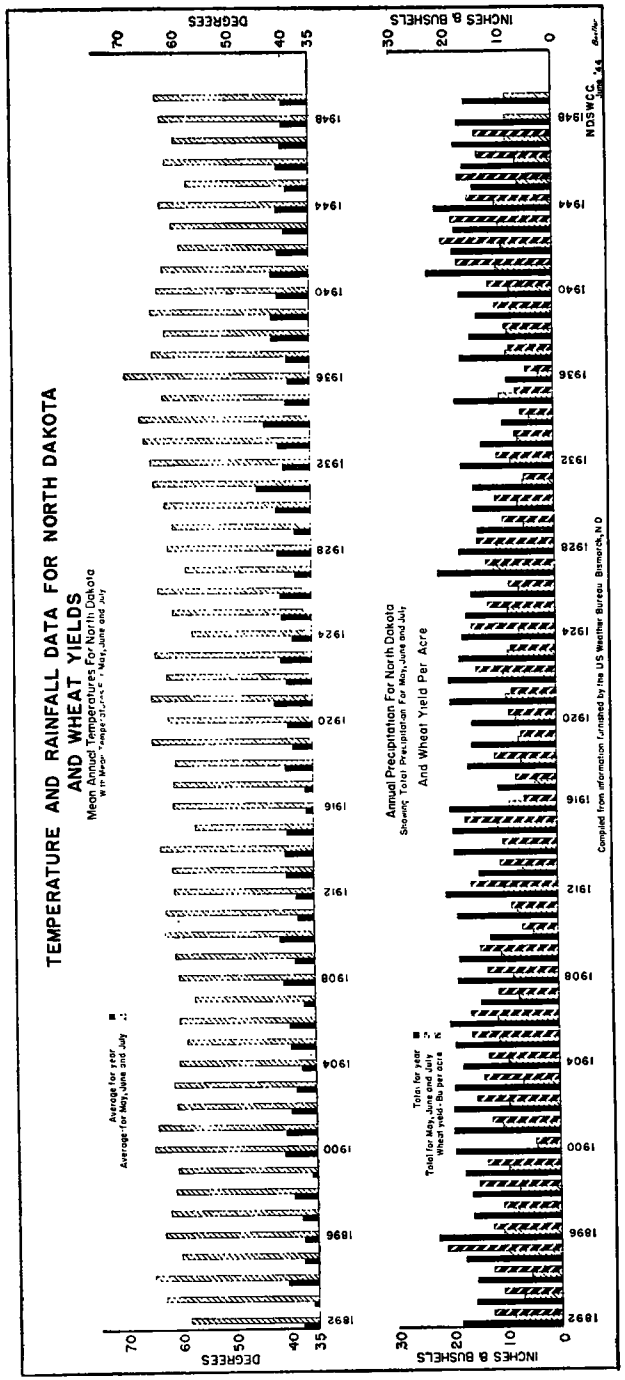
Stream	Near	Date	Second feet	Date	Second feet
Knife river at	Hazen	Mar. 26-27, 1943	11,400	April 17, 1950	23,800
Heart river	Richardton	July 25, 1939	14,000	April 16, 1950	22,000
Heart river	Lark	March 25, 1947	10,400	April 17, 1950	29,200
Heart river	Mandan	March 27, 1943	21,400	April 19, 1950	30,400
Greene river	Gladstone	March 24, 1947	2,200	April 16, 1950	5,500
Muddy Creek	Almont	March 24, 1948	2,250	April 17, 1950	20,200
Apple Creek	Menoken	April 7, 1948	2,346	April 18, 1950	6,000
Cannonball	New Leipzig	March 26, 1943	15,000	April 17, 1950	51,800
Cannonball	Breien	March 27, 1943	21,900	April 18, 1950	94,800
Grand River	Haley	March 31, 1913	5,810	April 15, 1950	11,300
James River	Jamestown	April 23, 1948	3,250	April 17, 1950	6,030

1950 FLOOD RELIEF IN NORTH DAKOTA

More than $150,000 was spent for relief of flood victims in North Dakota in 1950 by the American Red Cross, according to a report to Governor Aandahl.

Nineteen different counties out of the 53 in the state were damaged by the heavy spring run-off floodwaters, with 4,857 families suffering flood losses.

The largest losses were in Pembina county, where $42,645 was spent on relief work. Stutsman county was second on flood damage, where $18,766 was spent by the Red Cross on relief work. Grand Forks county had the third greatest flood loss with $16,461 spent on flood relief.



The report stated that the Red Cross helped repair 265 houses to make them livable, rebuilt 12 houses, repaired 34 barns, and rebuilt 32 other barns and outbuildings.

The report also stated that two deaths were attributed to the floods indirectly.

FLOOD CONTROL PROJECTS

Mandan has suffered severe losses from floods of the Heart river, and the records show has been inundated 24 times since 1881, causing extensive damage to domestic, business, industrial, railroad and civic properties. Severe losses have been experienced through traffic delays on U. S. Highway No. 10, and on the Northern Pacific Railroad, both of which are transcontinental routes.

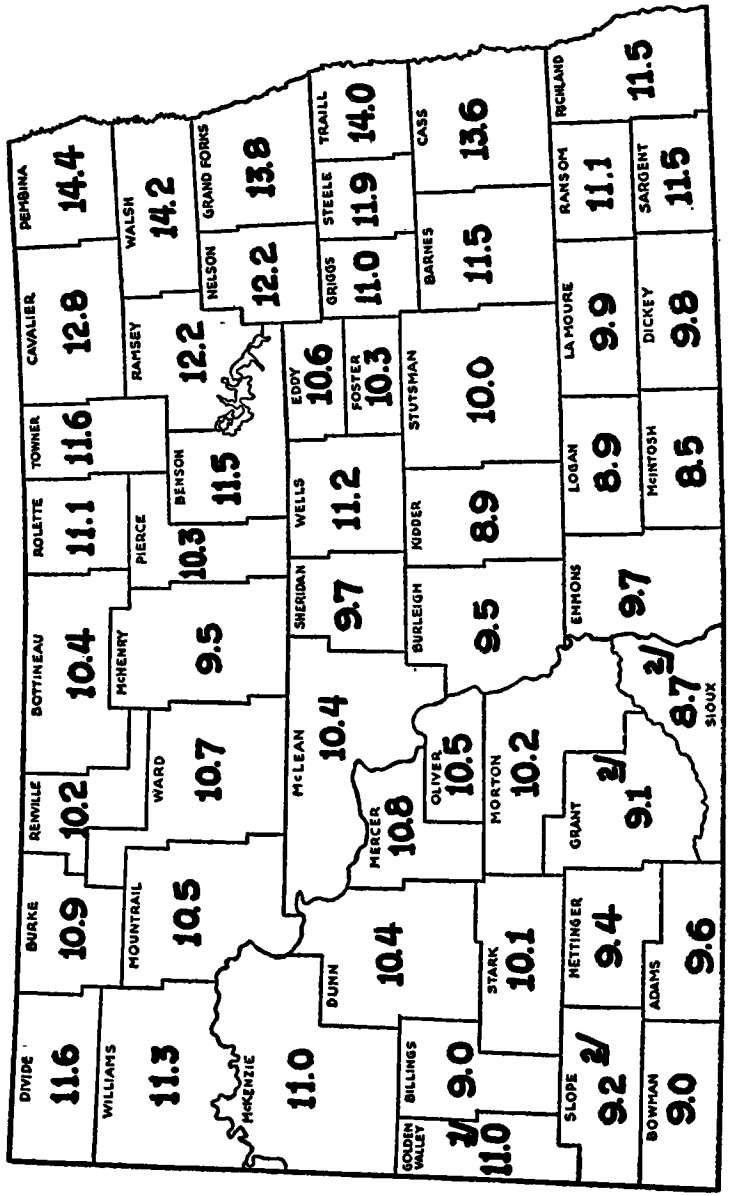
Damage to the city was prevented this year by the Heart Butte dam and levees constructed by the Corps of Engineers. The levees consisted of 287 lineal feet of concrete cantilever type flood wall; reinforcing approximately 5,500 lineal feet of railroad embankment used as a levee, placing rip-rap protection on 600 lineal feet of stream bank; raising two highway bridges and adding one 75-foot span, constructing one stop-log structure, and providing appurtenant drainage facilities to discharge sewage and storm flow during periods of floods. The cost was $551,700 federal and $93,100 local. Interior drainage works are to be completed by the Corps of Engineers in 1950.

RED RIVER OF THE NORTH FLOOD CONTROL

The congressional Flood Control Act of 1948 authorized the Corps of Engineers to proceed with its flood control program on the Red River of the North. The program comprises channel improvements, levees and flood walls including 38.2 miles of channel improvement on the Sheyenne river; 26.9 miles on the Rush River; 32.4 miles on the Maple river; 13.9 miles on the Bois de Sioux river and at Wahpeton and Breckenridge; 21.9 miles on the Red river at Grand Forks and East Grand Forks, including levees and flood wall; 29 miles on the Red river near Fargo and Moorhead, including levees and flood wall, at a total cost of $6,739,800. It is expected that these channel improvements will be completed in about five years, dependent on appropriation of sufficient funds. The estimated cost of the entire project in Minnesota and North Dakota is $11,766,100 and includes some dams and reservoirs on Minnesota tributary rivers, to hold back flood waters.

HOMME DAM AND RESERVOIR

The Homme dam is located near the northeast corner of North Dakota, on the south branch of Park River, about four miles upstream from the city of that name. Spring flooding has resulted in damage to agricultural lands as well as to the city of Grafton. During drought periods serious water shortages were experienced both for water supply



Average Wheat Yields by Counties for 35 Years as Compiled by Dean Walster

and sewage dilution. The dam is designed to protect from spring overflows and to assure a dependable stream flow during drought periods. The dam is an earth-fill structure 865 feet long with a controlled concrete conduit 5 feet in diameter under the dam, and a concrete overflow spillway about 150 feet in length adjacent to the dam. The reservoir has a storage capacity of 3650 acre-feet. Engineers state it will be finished by the fall of 1950, for which funds have been appropriated. It will give partial protection against the maximum flood of record and will increase low flows in Park River for water supply and pollution abatement, at the cities of Park River and Grafton.

BALDHILL RESERVOIR FULL

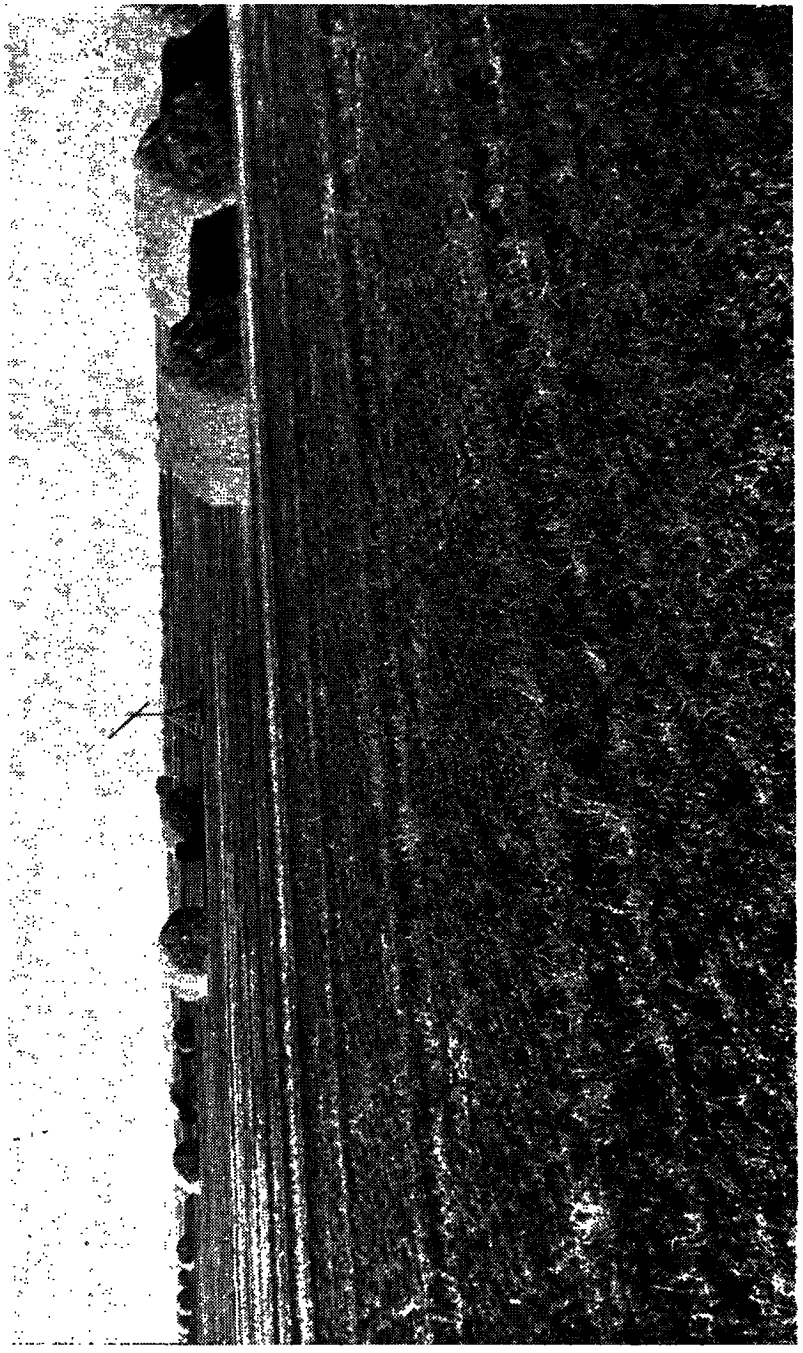
On September 25, 1949, engineers reported that earth rolling on the Baldhill dam would be finished in about a week, making the structure practically completed. No one dreamed that in the first spring run-off the capacity of this dam and reservoir would be taxed to the limit. In fact, stream run-off data indicated that it might take five years to fill the reservoir. On April 16, 1950, the engineers reported that the reservoir had been partially filled, and that because title to all the necessary land in the reservoir had not been taken, the pool was scheduled to be maintained at that level until 1951, but that because the rising waters threatened to flood sections of Valley City, the gates might be partially closed to hold down the flood level. But on May 30, 1950, it was reported that the unprecedented floodwaters were then pouring over the top of the 12 foot flood gates, and the dam was holding back a pool almost three feet above the expected normal operating level, making the depth of the water just back of the dam about 33 to 34 feet. This was two and a half times as much water as created serious flood damage in Valley City two years ago. Some estimate the flood loss saving to the city and other towns and cities down the Sheyenne Valley has fully warranted the expenditure which has created a reservoir about one-sixth of a mile wide and fills the river valley upstream for 42 miles. The runoff below the dam was held to the capacity of the river channel by control at the dam, thus preventing serious flood damage all down the valley.

Baldhill is an earth fill dam with concrete spillway and control works. It has a total length of 1650 feet with a concrete gravity ogee control works 140 feet in length, surmounted by three 40-feet Tainter gates, with two 3-foot diameter conduits in the piers for low water control.

This dam will provide substantial protection from the maximum flood stage so far recorded, in the area from the dam to the Red river flood plain, and to some extent reduce damage below this point.

1950 FLOOD IN RED RIVER VALLEY CAUSED $28,000,000 FARM DAMAGE

The Soil Conservation Survey have reported that the loss on crops, farm lands and buildings in the Red River Valley from the 1950 flood waters has been estimated by their engineers at twenty eight million dollars.



Irrigated alfalfa on the Clayton Worst farm in McKenzie County, North Dakota, yielded five tons to the acre.

FARGO PLANS SHEYENNE RIVER DIVERSION

Fargo started planning for diversion of waters of the Sheyenne river in December, 1949, by requesting its city engineer to survey the area of the proposed diversion canal and Sheyenne river dam and gates and submit a report. The question of easements or right-of-way for the canal and for the abutments of the diversion dam was also discussed.

This is a part of the original plan for controlling the flood waters of the Sheyenne river by the Baldhill Dam at Valley City and diverting a part of the floodwaters when needed by the city of Fargo through a canal into the Red River when at low stages of flow so as to utilize it through the city water treatment plant. There have been times during drouth years when the city of Fargo had insufficient water for all its needs.

MARMARTH FLOOD CONTROL

This project in southwestern North Dakota, on the Little Missouri river, was authorized by Congress. It consists of levees to protect the city of Marmarth from the Little Missouri and Little Beaver creek. Local cooperation was required, which has been approved by the Marmarth city authorities. In the mean time, costs have gone up and would now exceed the authorization given in 1936. A new report recommended an enlarged project. The original approval is therefore inactive pending action by Congress on the last report.

BEULAH FLOOD CONTROL

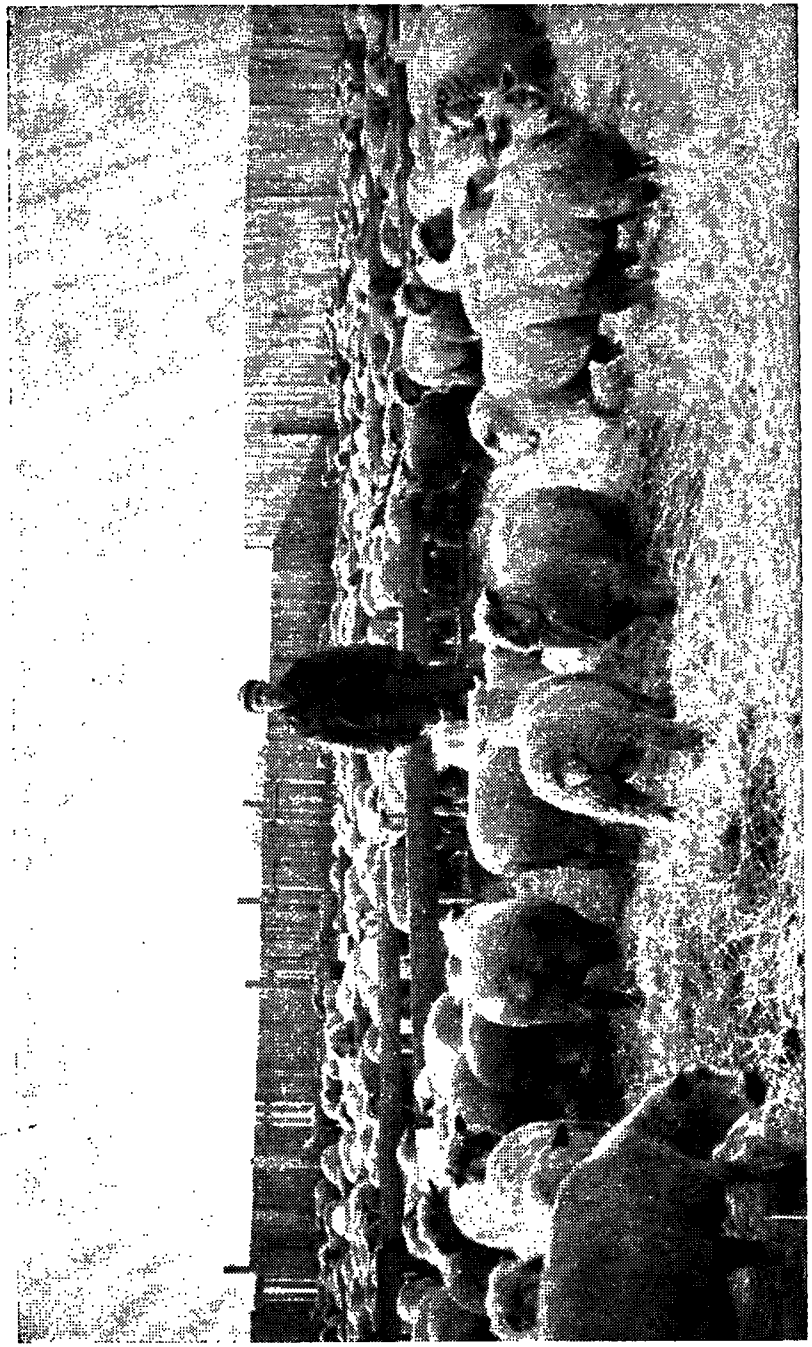
Past floods from two coulees which drain through the town of Beulah have inundated the major portion of it and caused damage to utilities, business and city property as well as the Northern Pacific Railroad. The plan would enlarge existing drainage channels to drain into the Knife river. The project requires local cooperation which has not as yet been assured. The present authorization will expire otherwise on Dec. 9, 1952.

HAZEN FLOOD CONTROL

A similar plan for flood relief for the city of Hazen is being held up awaiting the assurance of local cooperation as required by Congress. The present authorization will expire on March 30, 1953.

OTHER FLOOD DAMAGE INVESTIGATIONS

Committees of Congress have asked the Corps of Engineers to make investigations and reports on flood control on the Red River of the North; on the Pembina river; on the Souris (Mouse) River; on the James river; on the Missouri river; on the Little Missouri river; on the Lower Heart river and on the Cannonball river, on all of which much flood damage was reported in the spring of 1950 due to the unusual snow run-off.



Feeder lambs, on the George Haffner farm, on Lower Yellowstone Irrigation Project.

NORTH DAKOTA RECLAMATION ASSOCIATION

The North Dakota Reclamation Association of about 800 members scattered over North Dakota has had active representation in all the meetings of importance dealing with the water problems of North Dakota. It has directors in every county in the state. It has sent representatives to Washington, D.C., to appear before Congressional committees when Missouri river diversion and irrigation appropriations were under consideration.

It is active in conducting an educational campaign to bring to the citizens of the state a realization of the value and need in North Dakota and the Missouri Basin of irrigation, municipal water supplies, electric power, flood control, recreational facilities and preservation of fish, game and wild life. The association realizes the need of irrigation and raising of feeds within easy trucking distance of every farmer as a stabilizer in drouth seasons for agriculture and stockraising. It aids in the organization of irrigation districts.

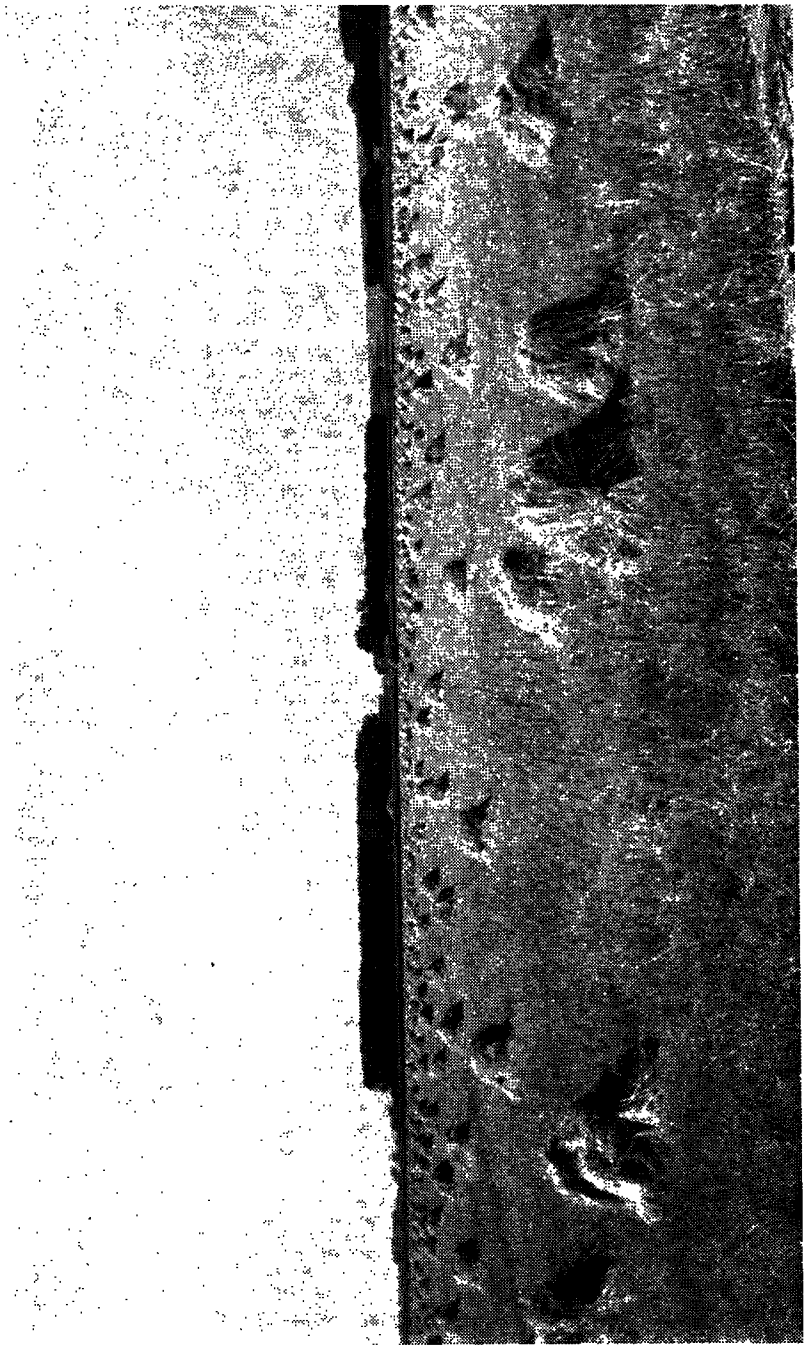
It is a member of the National Reclamation Association of which its State Director, Harry E. Polk of Williston, is national president. It favors an expanding program of irrigation, reclamation and water conservation for this and other states of the Missouri river basin. C. S. Summers of Bowbells, N. D., is president for 1949-50, and J. I. Rovig, Mandan, N. D., has been secretary since its organization.

The North Dakota Reclamation Association by resolution urged the Bureau of Reclamation to submit to congress a plan for the construction of small irrigation projects; urged continued investigations to assure the orderly development of the Missouri-Souris division; urged speedy construction of the Jamestown dam; commended NDAC for its cooperation with federal agencies on soil surveys in proposed irrigated areas; reaffirmed opposition to federal regional authorities and pledged support of the Pick-Sloan plan; and asked appointment of association committees on publicity, education, finance and membership.

LEGISLATURE AUTHORIZES CONSERVANCY DISTRICT

The 1949 North Dakota legislature, in order to facilitate the construction of the Missouri-Souris irrigation and water diversion project created a conservancy and reclamation district known as the "Missouri-Souris Conservancy and Reclamation District":

1. To provide for the future economic welfare and prosperity of the people of this state, and particularly of the people residing in the area embraced within the boundaries of such conservancy and reclamation district.
2. To provide for the irrigation of lands within the sections of such district periodically afflicted with drought, and to stabilize the production of crops on such lands.
3. To replenish and restore the depleted waters of lakes, rivers and streams in said district, and to stabilize the flow of said streams.



Irrigated oats and barley, John Hardy farm on Lower Yellowstone Irrigation District.

4. To replenish the waters of, and to restore the level of Devils lake.
5. To make available within the district, waters diverted from the Missouri river for irrigation, domestic, municipal and industrial needs, and for hydroelectrc power and other beneficial and public uses.

The district embraces the following fifteen counties: Divide, Burke, Williams, Renville, Ward, Bottineau, McHenry, Pierce, Benson, Ramsey, Eddy, Foster, Stutsman, LaMoure and Dickey. Other counties adjoining may become part of the district.

The district will have power to tax and enter into contracts with the government, and to take any steps found necessary in completing the construction and operation.

MISSOURI-SOURIS PROJECTS ASSOCIATION

The Missouri Souris Project Association, with headquarters at Minot, and with A. R. Weinhandl as president and Oscar N. Berg as executive secretary, and other officials and membership in Montana along the line of the proposed development, is assisting in every way possible to promote and speed up the development of this immense million-acre irrigation project.

They are urging a longer term repayment contract to cover the cost of the construction for those benefiting by the irrigation works, urging Congress to make needed appropriations to speed up the progress of construction, helping in educational work and in the organization of the district as needed, and other activities needed in the progress of this great development.

BURLINGTON IRRIGATION PROJECT

During the drouth years of the thirties, the United States acquired a tract of land near the town of Burlington, in Ward County, North Dakota, which was divided into small tracts on which small sets of buildings were constructed, and cultivated areas provided with irrigation water from reservoirs in the Des Lacs river. The tracts used were to rehabilitate small families made destitute by the drouth.

In 1947 these tracts were deeded to the State of North Dakota, including the reservoirs and lands adjacent, with the irrigation system. It was planned to use these tracts for the rehabilitation of returned soldiers of World War II who were released from the Veteran's Hospital at Minot.

Needed repairs on the dam and irrigation construction works was undertaken by engineers of the State Water Conservation Commission and placed in good operating condition in the spring of 1950. Some 30 to 35 families residing on these lands make use of these irrigated plots for gardens and feed lots.

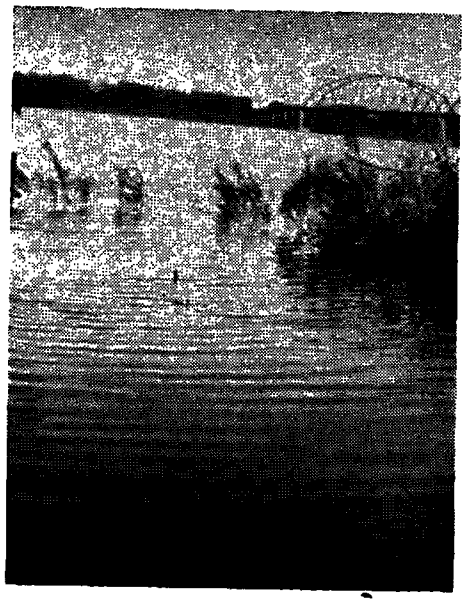
THEODORE ROOSEVELT NATIONAL MEMORIAL PARK

The Theodore Roosevelt National Memorial Park was established by act of congress, April 25, 1947. As extended by acts approved in June, 1948, it consists of 58,341 acres of federally owned land in three separate units—one near Medora, another near Watford City, and the Elkhorn ranch site about midway between the two along the Little Missouri river.

This park was dedicated to the citizens of these United States in memory of North Dakota's only citizen to become president, by the Honorable J. A. Krug, Secretary of the Interior.

BISMARCK IRRIGATED GARDENS

During the summer seasons of 1949 and 1950 the Bismarck irrigated gardens were operated under the direction of the North Dakota State Water Conservation Commission in cooperation with people of the Bismarck area. This project includes about 40 acres, located southwest of Bismarck along the Missouri river, and is divided into one-quarter acre plots, making about 150 individual gardens. Water for irrigating is pumped from the river. These gardens have proved to be successful and demonstrate the value and use of water for irrigation.



Missouri river at Bismarck, highway bridge in background.

ACTIVITIES OF THE DEPARTMENT OF THE INTERIOR

U. S. Geological Survey

During fiscal year 1950, the Geological Survey continued to make good progress. Work on water resources investigations, geologic mapping and mineral resources investigations, river surveys, and topographic mapping programs were carried on close to schedule throughout the year.

The following is a brief summary of the year's accomplishments under each of the above divisions.

Water Investigations
(Surface Water)

During the fiscal year, new stream-gaging stations were constructed and put into operation in the departmental program of the Geological Survey.

The regular operational program was carried on throughout the year. This included gaging stations in cooperation with the states and other federal agencies. At these stations, the daily stage and discharge of the streams were determined and the records supplied to interested agencies.

The highest, or near highest, floods ever known occurred during April on certain tributaries to the Missouri river in North Dakota, and in the basin of the Red river of the North. Field surveys were made to determine by indirect methods the magnitude of these floods.

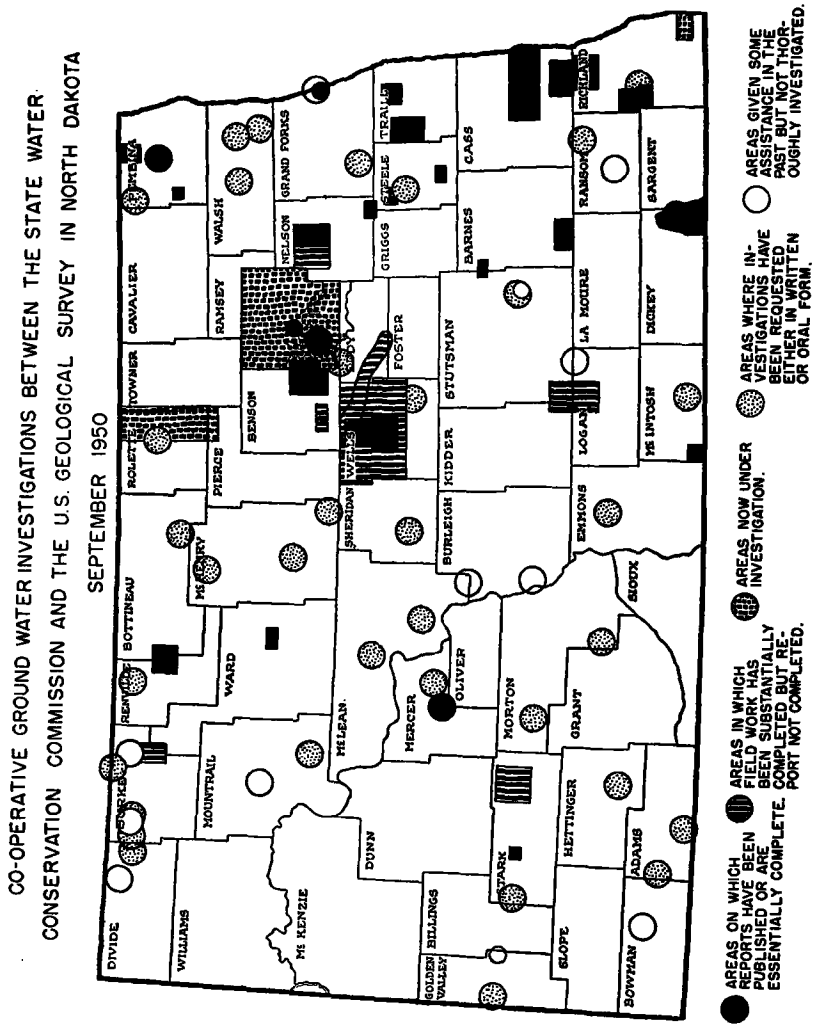
Ground Water—North Dakota

General ground-water studies of the Missouri-Souris project area, in progress since late 1945, were continued through the year. A detailed study of the Bowbells block area was made during the 1949 field season. A general study of the Fort Berthold Indian reservation was begun in the summer of 1949 and is being continued.

Periodic water-level measurements were continued also in the Heart river, Knife river, New Rockford, Jamestown, and Oakes units.

STREAM GAGING

During the spring run-off in 1950, the North Dakota State Water Conservation Commission cooperated with the U. S. Geological Survey, Surface Water Branch, in compiling data of stream flow throughout the state. This work was undertaken in addition to the regular cooperative work with this branch. Expenditures made in maintaining personnel and equipment for this work was matched in full by the U. S. Geological Survey under a supplemental agreement. Supplemental work performed included establishment of high water marks to determine flood flow measurements on the Cannonball, Grand, James and Red rivers. Information gathered will be incorporated with other recorded data to show the record-breaking flows and a more complete picture of the 1950



destructive floods that caused such great damage to farms, cities, villages, public roads and other structures in these flooded areas.

Cooperation With States

During the 1950 fiscal year, the following Missouri basin states maintained cooperatively financed ground-water studies with the Geological Survey: Kansas, Nebraska, Iowa, Colorado and North Dakota.

Studies continued during the fiscal year on the measurement, occurrence, and distribution of mineral constituents in surface waters. Chemical analyses were made of a large number of water samples.

Geologic Mapping and Mineral Resource Investigations

Missouri-Souris (North Dakota): Field work was completed and drafting of preliminary maps is nearing completion on 30 quadrangles (6,700 square miles) that cover all of the proposed Missouri-Souris irrigation plan. The maps also show the bedrock and glacial deposits, because these bear so directly on all plans and designs for irrigation structures.

Knife River Area: Field work was completed and geologic maps of six quadrangles (1,350 square miles) were compiled during the year. This area includes part of the Garrison dam and reservoir and also contains rich lignite reserves.

Reconnaissance of Williston Area: Field work was completed and a map compiled of a large area along the north side of the Missouri river. This project serves to tie together the detailed mapping that is being done on other projects.

River Surveys

During the year, 20 square miles of the Little Missouri river valley between Marmarth and Medora were mapped, completing the field work on this river. The maps show 393 miles of the river.

INDIANS

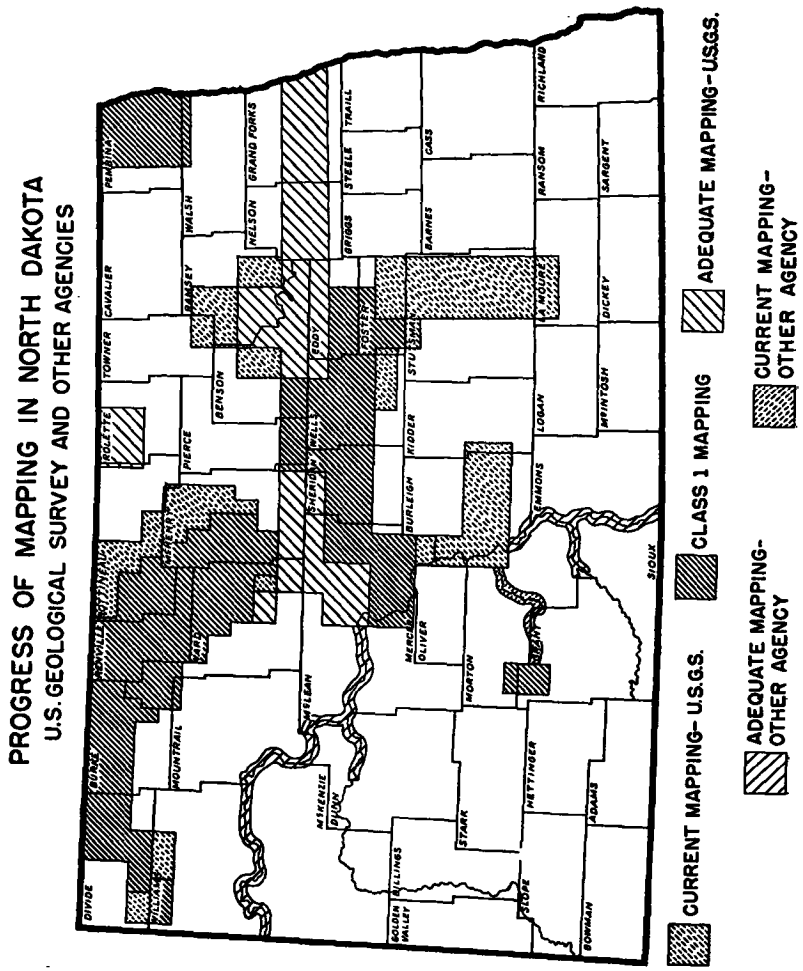
Fort Berthold Reservation: The construction of Garrison dam will necessitate the removal of about 280 Indian families from the reservoir area. Approximately 420,000 acres have been surveyed for dry farming as well as range lands.

Standing Rock Reservation (North Dakota): Investigations on the Oahe unit were made by the Land section. A tentative taking line was established at the 1,620-foot level, the acreage below this contour was compiled.

BUREAU OF LAND MANAGEMENT

Cadastral Surveys

All land disposition, public domain management, and operational programs involving the public domain require accurate legal cadastral



surveys. Cadastral resurveys function to restore lost and obliterated section corner markings of the original public land surveys.

During the year, field work was completed on the following units: Lower Yellowstone, Coleharbor, Oahe and Missouri-Souris units, and a great deal of additional cadastral work was accomplished in North Dakota.

BUREAU OF MINES

Mineral Investigations: Investigation of sodium sulfate-bearing lakes in northwestern North Dakota and eastern Montana was initiated in October, 1949. Fourteen lakes were sampled by auger drilling. Work is being done in cooperation with the North Dakota Geological Survey.

Solid Fuel Studies Adjacent to the Missouri River: During the year, the Bureau of Mines continued cooperative studies with the Corps of Engineers on the stockpiling of lignite taken from excavations at Garrison dam site.

Because of the increasing need for data on processing lignite that will be required in estimating the applicability of lignite to large scale industrial usage, Missouri basin projects were initiated at the Bureau of Mines laboratory at Grand Forks. The investigations pertain to phases of preparation and utilization of lignite and include drying, gasification, sulphur content studies, crushing and use in cyclone burners.

NATIONAL PARK SERVICE

Some progress has been made on the agreement between the Bureau of Reclamation, Dickinson park board, and the National Park Service in which the Dickinson park board will assume administrative and maintenance responsibility for proposed recreational area at Dickinson reservoir.

THE TOPOGRAPHIC BRANCH

Department of the Interior

United States Geological Survey

Topographic maps are the most accurate and give information in the most usable form to show each hill, valley and stream to scale and the heights and slope of the ground surface. This information is necessary before engineers can plan and design reservoirs, canals and irrigation projects.

The State Water Conservation Commission arranged for topographic mapping on a 50-50 cost basis with the U. S. Geological Survey to cover those portions of North Dakota where there was a prospect of constructing irrigation works. In addition, a large area of the state has been mapped for the Missouri river irrigation projects in cooperation with other government agencies.

Cooperative Program

To the 1697 square miles mapped up to the last biennium, there has been added 613 miles, to make a total of 2310 square miles mapped and published.

In addition to the above 868 miles of coop mapping are under way with the Bismarck 7.5′ and Wilton 15′ sheets ready for publication. The Bismarck 15′ N/2 and Mandan quadrangles have been field contoured and are being drafted.

The Bismarck 1 SW, Driscoll, McKenzie, and Menoken quadrangles have been stereo compiled and are ready for field contouring.

Following is a summary of accomplishments during the current biennium for the quadrangles in the cooperative mapping program:

Published
Stanton
Turtle Creek
Washburn

Office Processing Completed, Composite Proofs Available
Bismarck 7.5′
Wilton

Field Contouring Completed
Bismarck 7.5′
Bismarck 15′ N/2
Mandan
Wilton

Stereo Bases Completed
Bismarck 1 SW
Driscoll
McKenzie
Menoken ¾
Bismarck 15 N/2
Mandan

Missouri River Basin

To the 2174 square miles mapped under the Missouri Basin Development Program during the past biennium, there have been added an additional 2,226 square miles, making a total of 4,400 square miles of such mapping for which published maps are available.

In addition 2,200 square miles have been mapped and office processed and are now ready for final publication.

1,750 square miles of planimetric bases are ready for field contouring.

1,250 square miles have had primary control operations completed.

Following is a summary of accomplishments during the current biennium of the quadrangles of the Missouri Basin program:

Published

Alamo NE
Ambrose
Bowbells
Bowbells NE
Bowbells NW
Bowbells SE
Bremen
Bright Water Lake
Brush Lake
Burlington
Burlington NE
Burlington NW
Burlington SE
Carpio
Carpio NE
Cathay
Cathay SE
Columbus
Columbus SE
Columbus SW
Crosby
Crosby SE
Coulee
Des Lacs
Deering
Deering NW
Deering SW
Deering SE
Eckman
Eckman SE
Emrick
Fessenden East
Fessenden West
Fessenden SW
Glenburn
Grano
Grano NE
Grano SW
Granville
Granville NE
Granville NW
Granville SW
Greene
Grenora
Hanks
Hartland
Karlsruhe NW
Kenmare
Lansford NE
Lansford NW
Lansford SE
Lansford SW
Manfred
Manfred SW
Maxbass
Minot
Minot NW
Mohall NE
Mohall SW
Mosquito Butte
Mouse River Park NE
Mouse River Park NW
Mouse River Park SW
Munster
Newburg SW
Niobe
Noonan
Noonan SW
Norma
Northgate
Norwich
Paulson
Portal
Rennie Lake
Renville
Riga
Sawyer
Sherwood
Simcoe
Smoky Butte
Stampede
Surrey
Tolley SE
Vanville NE
Velva
Voltaire
Westhope SW
Zahl

Office Processing Completed, Composite Proofs Available

Antler
Antler NW.
Bantry
Brantford NE
Brantford NW
Brantford SW
Brantford SE
Bremen
Burlington
Burlington NW
Burlington SE
Carpio
Carpio NE
Carrington NE
Carrington NW
Carrington SE
Fessenden West
Fessenden SE
Fessenden SW
Glenburn
Grano
Grano NE
Grano SW.
Granville
Granville SW
Greene
Hartland
Karlsruhe NE
Karlsruhe NW
Lansford
Lansford NE
Lansford SE
New Rockford NE
New Rockford NW
New Rockford SE
New Rockford SW
Norwich
Noonan SE
Oberon SE
Oberon SW
Omemee SW
Renville
Rival 2 SW
Roth NW
Roth SW
Russell
Sawyer NE
Sawyer

Carrington SW
Cathay SE
Cathay
Columbus SE
Deep River
Deering SE
Deering SW
Denbigh
Denbigh NW
Des Lacs
Eckman
Eckman SE
Dokken SE
Fessenden East
Lansford SW
Manfred NE
Manfred NW
Manfred SE
Manfred SW
Maxbass
Minot
Minot NW
Mohall NE
Mohall SW
Mosquito Butte
Munster
Newburg SE
Newburg SW
Selz SE
Sherwood
Sheyenne Lake NE
Sheyenne Lake NW
Simcoe
Surrey
Tokio SW
Towner NW
Towner SW
Vanville NE
Velva
Voltaire
Westhope SW
Wolseth

Field Contouring Completed

Antler
Antler NW
Bantry
Brantford NE
Brantford NW
Brantford SE
Brantford SW
Bremen
Carpio
Carrington NE
Carrington NW
Carrington SE
Carrington SW
Cathay
Cathay SE
Deep River
Deep River SE
Denbigh
Denbigh NW
Des Lacs
Devils Lake SW
Eckman
Eckman SE
Fessenden East
Fessenden West
Fessenden SE
Fessenden SW
Flora SE
Glenburn
Grano
Jamestown 1 NW
Karlsruhe NE
Lansford SE
Manfred
Manfred NW
Manfred SE
Manfred SW
Mosquito Butte
Minot
Minot NW
Munster
New Rockford NE
New Rockford NW
New Rockford SE
New Rockford SW
Newburg SW
Noonan SE
Norwich
Oberon NW
Oberon SE
Oberon SW
Omemee SW
Renville
Roth NW
Roth SW
Rival 2 SW
Russell
Sawyer SW
Sawyer NE
Surrey
Selz SE
Selz SW
Sheyenne Lake NE
Sheyenne Lake NW
Simcoe
Tokio SW
Towner NW
Towner SW
Upham NW
Upham SE
Upham SW
Velva
Voltaire
Westhope NE
Westhope NW
Westhope SE
Westhope SW

Multiplex Completed

Antler
Antler NW
Aylmer SE
Aylmer SW
Flora NE
Flora NW
Flora SE
Flora SW
Pekin SW
Pingree 2 NE
Pingree 2 SE
Pingree 3 NE

Bantry
Bowdon NE
Bowdon NW
Brantford NE
Brantford NW
Brantford SE
Brantford SW
Brinsmade
Carpio
Carrington NE
Carrington NW
Carrington SE
Carrington SW
Crary SW
Deep River
Denbigh
Denbigh NW
Devils Lake NW
Devils Lake SE
Devils Lake SW
Grahams Island NE
Grahams Island NW
Grahams Island SE
Grahams Island SW
Hamar NE
Hamar NW
Karlsruhe NE
Maddock NE
Maddock NW
Maddock SE
Maddock SW
Maza
Newburg SE
Newburg SW
Oberon NE
Oberon NW
Omemee SW
Pekin NE
Pekin NW
Pekin SE
Pingree 3 SE
Pingree 4 NW
Pingree 4 SW
Renville
Sawyer SW
Selz NE
Selz NW
Sykeston NE
Sykeston NW
Roth NW
Roth SW
Russell
Upham NW
Upham SE
Upham SW
Devils Lake
Stump Lake Special
Towner NW
Towner SW
Westhope SW

Primary Control Completed

Antler
Antler NW
Bantry
Crary SW
Deep River
Denbigh NW
Devils Lake NE
Hamar NE
Hamar NW
Jamestown 1 NE
Jamestown 1 SE
Newburg SE
Omemee SW
Pekin NE
Pekin NW
Pekin SE
Pekin SW
Roth NW
Roth SW
Russell
Tokio NE
Tokio NW
Tokio SE
Towner NW
Towner SW
Westhope SW

Plans for the North Dakota State Water Conservation Commission cooperative program for the immediate future call for the publication of the Bismarck, Mandan, and Bismarck 1 SW 7½-minute quadrangles and the Wilton 15-minute quadrangle and the continuation of operations toward publication of the Bismarck, Menoken, Driscoll, and McKenzie 15-minute quadrangles. Control operations will be started on new quadrangles in order to keep the cooperative mapping hopper filled continuously.

Plans for the Missouri River Basin projects call for completion through publication of the quadrangles of the Missouri Souris Extension and the quadrangles of the Drake-Jamestown project. The area of the Drake-Jamestown project has been increased to take in the old beds of the Devils Lake and the Stump Lake.

The old lake beds are also being mapped for special large scale editions for the U. S. Fish and Wildlife Service.

UNITED STATES DEPARTMENT OF THE INTERIOR
Geological Survey
WATER RESOURCES BRANCH

Surface Water Division

Stream flow measurements are being conducted by the above U. S. department on a 50-50 cost distribution between the State of North Dakota and the government agency. This is done in order to obtain accurate records of the flow of streams in North Dakota. The work consists of obtaining daily and continuous river stages and actually measuring the amount of water that flows past a gaging station. From this data computations are made of the daily flow, peak stage, peak discharge, minimum stage and minimum discharge. Monthly and annual summaries are compiled for publication. During the past two years this agency has operated twenty-two such stream-gaging stations in this state. Forty-four additional stations are operated in cooperation with the U. S. Fish & Wildlife Service, Bureau of Reclamation, U. S. Departments of State, and Corps of Engineers. The complete records of stream flow thus obtained has been made available to the State Water Conservation Commission for its reports. Current records are available for immediate use by State Agencies.

These records are being used extensively by State and Federal agencies in the design, construction, operation and evaluation of projects and structures pertaining to flood control, wildlife propagation, control of stream pollution, highway and bridge design, recreation, and other water problems. The Missouri river development program and the Red river improvement program will divert, reroute, store and return water to many streams throughout the state. Accurate records of the flow are essential to the sound utilization of this water. The strength of stream flow data lies in long-time records which will show the extremes over a long period of time.

MISSOURI RIVER NEAR WILLISTON, N. DAK.

Location.—Water-stage recorder, lat. 48°07′, long. 103°44′, in sec. 31, T. 154 N., R. 101 W., at Lewis and Clark Highway bridge, 7 miles west of Williston and 25 miles downstream from Yellowstone River. Datum of gage is 1,830.20 feet above mean sea level, datum of 1929.

Drainage area.—164,500 square miles.

Records available.—September 1928 to September 1948.

Average discharge.—20 years, 19,180 second-feet.

Extremes.—Maximum discharge during year, 78,300 second-feet June 10; maximum gage-height, 12.00 feet Mar. 26 (affected by ice); minimum daily discharge, 7,800 second-feet Feb. 13.

1926-48: Maximum discharge, 231,000 second-feet Apr. 4, 1930, from rating curve extended above 80,000 second-feet; maximum gage height, 19.78 feet Mar. 28, 1943 (ice jam); minimum daily discharge, 1,320 second-feet Dec. 28, 1939.

Remarks.—Records good except those for period of ice effect, which are fair. Many diversions above station for irrigation. Flow partly regulated by Fort Peck Reservoir.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	682,300	30,200	17,500	22,010	1,353,000
November	297,800	15,800	4,000	9,927	590,700
December	259,000	10,100	6,100	8,355	513,700
January	272,800	12,600	6,900	8,800	541,100
February	286,500	17,000	7,200	10,230	568,300
March	769,700	180,000	6,800	24,830	1,527,000
April	934,700	38,600	23,500	31,160	1,854,000
May	1,350,600	64,600	31,100	43,570	2,679,000
June	1,619,100	74,200	37,900	53,970	3,211,000
July	1,371,400	62,800	33,700	44,240	2,720,000
August	1,057,100	44,000	25,000	34,100	2,097,000
September	950,600	34,500	26,600	31,690	1,885,000
Water Year 1946-47	9,851,600	180,000	4,000	26,990	19,540,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,047,600	35,000	32,600	33,790	2,078,000
November	638,200	33,600	16,200	21,270	1,266,000
December	436,000	18,400	11,000	14,060	864,800
January	320,600	12,000	8,500	10,340	635,900
February	304,400	17,000	7,800	10,500	603,800
March	537,100	28,000	9,900	17,330	1,065,000
April	697,100	35,000	17,000	23,240	1,383,000
May	984,400	57,600	22,900	31,750	1,953,000
June	1,979,200	77,200	55,300	65,970	3,926,000
July	1,524,000	60,400	35,600	49,160	3,023,000
August	1,039,200	40,000	28,500	33,520	2,061,000
September	933,100	37,200	27,700	31,100	1,851,000
Water Year 1947-48	10,440,900	77,200	7,800	28,530	20,710,000

MISSOURI RIVER MAIN STEM

Missouri River near Elbowoods, N. Dak.

Location.—Wire-weight gage, lat. 47°34′, long. 102°12′, in NE¼ NE¼ sec. 12, T. 147 N., R. 91 W., at bridge on State Highway 8, 2 miles downstream from Little Missouri River and 2½ miles west of Elbowoods. Datum of gage is 1,720.55 feet above mean sea level, datum of 1929.

Drainage area.—179,800 square miles.

Records available.—October 1939 to September 1948.

Extremes.—Maximum daily discharge during year, 76,500 second-feet June 10; maximum gage height observed, 15.14 feet Mar. 25 (affected by ice); minimum daily discharge, 7,800 second-feet Feb. 10; minimum gage height observed, 5.39 feet Nov. 14.

1938-48: Maximum discharge, about 260,000 second-feet Mar. 26, 1947, from rating curve extended above 110,000 second-feet by logarithmic plotting (gage-height, 23.2 feet); minimum discharge, about 1,500 second-feet Dec. 30, 1939; minimum gage height, 2.00 feet Sept. 18, 1940.

Remarks.—Records good except those for period of ice effect, which are fair. Flow partly regulated by Fort Peck Reservoir.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	735,000	30,800	19,300	23,710	1,458,000
November	314,000	20,200	3,400	10,470	622,800
December	252,700	10,800	5,300	8,152	501,200
January	275,450	10,600	7,250	8,885	546,300
February	320,300	17,800	7,100	11,440	635,300
March	890,600	210,000	7,800	28,730	1,766,000
April	1,089,600	49,500	24,900	36,320	2,161,000
May	1,320,500	59,600	32,300	42,600	2,619,000
June	1,714,600	90,400	37,500	57,150	3,401,000
July	1,481,100	69,900	36,500	47,780	2,938,000
August	1,099,800	44,000	26,600	35,480	2,181,000
September	965,300	35,600	22,800	32,180	1,915,000
Water Year 1946-47	10,458,950	210,000	3,400	28,660	20,740,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,052,800	35,300	32,300	33,960	2,088,000
November	634,400	33,700	13,000	21,150	1,258,000
December	407,300	16,500	9,500	13,140	807,900
January	322,400	14,000	8,700	10,400	639,500
February	277,000	14,200	7,800	9,552	549,400
March	632,300	34,500	10,400	20,400	1,254,000
April	855,100	62,800	18,000	28,500	1,696,000
May	983,800	57,100	23,100	31,740	1,951,000
June	1,990,100	76,500	54,100	66,340	3,947,000
July	1,578,400	63,000	35,700	50,920	3,131,000
August	1,064,200	40,100	29,100	34,330	2,111,000
September	926,300	37,400	27,900	30,880	1,837,000
Water Year 1947-48	10,724,100	76,500	7,800	29,300	21,270,000

MISSOURI RIVER BASIN

Missouri River Below Garrison Dam

Location.—Wire-weight gage, lat. 47°30′, long. 101°24′, in sec. 5, T. 146 N., R. 84 W., on construction bridge at Garrison dam site, 12 miles north of Stanton. Datum of gage is sea level (levels by Corps of Engineers).

Drainage area.—181,400 square miles.

Records available.—January to March 1948 (gage heights only), April to September 1948.

Extremes.—Maximum discharge during period, 75,700 second-feet June 11; maximum elevation 1890.70 Mar. 30 (affected by ice); minimum discharge, not determined.

Remarks.—Records good.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	------	------	------	------	------
November	------	------	------	------	------
December	------	------	------	------	------
January	------	------	------	------	------
February	------	------	------	------	------
March	------	------	------	------	------
April	------	------	------	------	------
May	978,500	55,500	23,500	31,560	1,941,000
June	1,980,700	75,000	53,100	66,020	3,929,000
July	1,585,500	64,000	35,800	51,150	3,145,000
August	1,068,400	40,400	28,400	34,460	2,119,000
September	928,600	38,900	28,100	30,950	1,842,000
Water Year 1947-48	------	------	------	------	12,980,000

MISSOURI RIVER MAIN STEM

Missouri River at Bismarck, N. Dak.

Location.—Water-stage recorder, lat. 46°48′50″, long. 100°49′10″, in sec. 31, T. 139 N., R. 80 W., at Bismarck city water plant, 2,100 feet downstream from Northern Pacific Railway bridge, 1 mile west of Bismarck, and about 4 miles upstream from Heart River. Datum of gage is 1,618.38 feet above mean sea level, datum of 1929.

Drainage area.—186,400 square miles.

Records available.—September 1904 to December 1905, October 1927 to September 1948.

Average discharge.—20 years (1928-48), 20,320 second-feet.

Extremes.—Maximum discharge during year, 76,400 second-feet June 12; maximum gage height, 15.84 feet Apr. 1 (affected by ice); minimum daily discharge, 7,900 second-feet Feb. 13; minimum gage height, 5.64 feet Nov. 14.

1904-05, 1927-48: Maximum discharge, 282,000 second-feet Apr. 3, 1943; maximum gage height, 22.2 feet Apr. 1, 1943, from floodmarks; minimum discharge, about 1,800 second-feet Jan. 3, 1940; minimum gage height, 1.35 feet, present site and datum, Sept. 4, 1934.

Maximum stage known, 31.6 feet, present site and datum, Mar. 31, 1881 (ice jam).

Remarks.—Records good except those for period of ice effect, which are fair Flow partly regulated by Fort Peck Reservoir.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	752,700	38,900	19,900	24,280	1,493,000
November	335,100	20,400	2,800	11,170	664,700
December	246,900	11,400	4,600	7,965	489,700
January	282,600	10,700	7,400	9,116	560,500
February	316,300	18,000	7,800	11,300	627,400
March	891,400	241,000	8,800	28,750	1,768,000
April	1,180,500	52,300	29,500	39,350	2,341,000
May	1,300,800	61,000	31,200	41,960	2,580,000
June	1,738,700	104,000	35,100	57,960	3,449,000
July	1,467,300	66,800	36,300	47,330	2,910,000
August	1,125,400	44,000	30,600	36,300	2,232,000
September	953,200	34,500	26,900	31,770	1,891,000
Water Year 1946-47	10,590,900	241,000	2,800	29,020	21,010,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,052,000	33,300	32,400	33,940	2,087,000
November	630,300	34,900	11,000	21,010	1,250,000
December	398,900	17,000	9,000	12,870	791,200
January	329,200	13,400	8,800	10,620	653,000
February	266,400	12,500	7,900	9,186	528,400
March	641,400	40,000	13,100	20,690	1,272,000
April	1,029,500	60,500	26,600	34,320	2,042,000
May	976,400	56,800	23,200	31,500	1,937,000
June	1,983,300	75,600	51,700	66,110	3,934,000
July	1,602,800	67,400	36,500	51,700	3,179,000
August	1,071,000	40,000	28,600	34,550	2,124,000
September	916,900	37,700	28,400	30,560	1,819,000
Water Year 1947-48	10,898,100	75,600	7,900	29,780	21,620,000

LITTLE MUDDY CREEK BASIN

Little Muddy Creek near Williston, N. Dak.

Location.—Staff gage, lat. 48°11′40″, long. 103°35′50″, on line between sec. 31, T. 155 N., R. 100 W. and sec. 6, T. 154 N., R. 100 W., at highway bridge, 4 miles northeast of Williston and 6 miles upstream from mouth.

Drainage Area.—1,010 square miles.

Records available.—June 1932 to July 1933, April 1946 to September 1949. February 1904 to April 1909 (no winter records) at site just above Camp Creek, 2½ miles upstream.

Extremes.—Maximum discharge during year, 1,300 second-feet Mar. 28, Apr. 3; maximum gage height, 12.0 feet Mar. 28 (floodmark), affected by ice; minimum, 0.5 second-foot Jan. 26 to Feb. 21.

1904-09, 1932-33, 1946-49: Maximum discharge, 4,340 second-feet (estimated) Apr. 11, 1904 (gage height, 10.3 feet, site and datum then in use); minimum, 0.1 second-foot Feb. 1-20, 1933.

Remarks.—Records fair except those for period of ice effect, which are poor. Gage read once daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	400	21	9	12.9	793
November	240	10	4	8.0	476
December	179	9	3	5.8	355
January	156	7	4	5.0	309
February	274	50	2	9.8	543
March	8,754	2,200	1	282	17,360
April	4,848	953	31	162	9,620
May	711	30	18	22.9	1,410
June	1,122	82	17	37.4	2,230
July	361	30	7	11.6	716
August	320	41	7	10.3	635
September	233	8	7	7.8	462
Water Year 1946-47	17,598	2,200	1	48.2	34,910

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	251	9	8	8.1	498
November	282	11	8	9.4	559
December	286	11	8	9.2	567
January	192	8	4	6.2	381
February	55	3	1	1.9	109
March	7,092	1,700	3	229	14,070
April	4,812	318	60	160	9,540
May	1,079	81	16	34.8	2,140
June	606	37	10	20.2	1,200
July	541	106	9	17.5	1,070
August	271	12	7	8.7	538
September	204	8	6	6.8	405
Water Year 1947-48	15,671	1,700	1	42.8	31,077

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	290.8	10	8.8	9.38	577
November	283.1	11	9.1	9.44	562
December	185.9	9.1	4.6	6.00	369
January	73.0	4	.5	2.35	145
February	15.3	.7	.5	.55	30
March	4,131.7	1,100	.8	133	8,200
April	6,707	1,200	24	224	13,300
May	580	32	15	18.7	1,150
June	464	26	10	15.5	920
July	286.7	15	5.5	9.25	569
August	154.0	7.3	3.9	4.97	305
September	161.5	6.1	4.3	5.38	320
Water Year 1948-49	13,333.0	1,200	.5	36.5	26,450

LITTLE MISSOURI RIVER BASIN

Little Missouri River near Watford City, N. Dak.

Location.—Water-stage recorder and wire-weight gage, lat. 47°36′, long. 103°16′, in NW¼ sec. 35, T. 148 N., R. 99 W., at highway bridge, 17½ miles south of Watford City and 18 miles upstream from Cherry Creek. Datum of gage is 1,929.03 feet above mean sea level, datum of 1929.

Drainage area.—8,490 square miles.

Records available.—October 1934 to September 1949.

Average discharge.—15 years, 642 second-feet.

Extremes.—Maximum discharge during year, 26,000 second-feet Mar. 28; (gage height, 13.7 feet, backwater from ice); minimum, 1 second-foot Jan. 26 to Mar. 3.

1934-49: Maximum discharge, 110,000 second-feet Mar. 25, 1947 (gage height 24.0 feet, floodmark); no flow at times.

Remarks.—Records fair except those for periods of ice effect, which are poor. Some diversions above station for irrigation. Wire-weight gage read once daily or oftener.

Revisions (water years).—W 926:1935.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	25,428	2,410	79	820	50,440
November	12,284	1,500	40	409	24,360
December	4,270	350	30	138	8,470
January	2,105	400	20	68	4,180
February	39,151	6,000	6	1,398	77,650
March	186,500	55,000	150	6,016	369,900
April	117,473	9,670	490	3,916	233,000
May	9,229	452	210	298	18,300
June	80,134	9,300	201	2,671	158,900
July	38,622	6,100	330	1,246	76,610
August	19,615	2,900	89	633	38,910
September	1,626	82	39	54	3,230
Water Year 1946-47	536,437	55,000	6	1,470	1,064,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,277	63	31	41.2	2,530
November	764	44	18	25.5	1,520
December	438	30	7	14.1	869
January	67	6	1	2.2	133
February	7,465	2,500	0	257	14,810
March	96,310	10,300	50	3,107	191,000
April	34,378	2,590	373	1,146	68,190
May	13,955	1,130	158	450	27,680
June	30,705	2,960	199	1,024	60,900
July	33,565	2,550	309	1,083	66,580
August	12,001	2,010	82	387	23,800
September	1,096	74	18	36.5	2,170
Water Year 1947-48	232,021	10,300	0	634	460,200

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	616	24	16	19.9	1,220
November	1,933	116	27	64.4	3,830
December	366	60	3	11.8	726
January	63	3	1	2.0	125
February	28	1	1	1.0	56
March	177,715	24,000	1	5,733	352,500
April	112,485	14,700	488	3,750	223,100
May	9,257	465	181	299	18,360
June	3,815	248	65	127	7,570
July	2,572	154	49	83.0	5,100
August	1,439	112	18	46.4	2,850
September	527	39	10	17.6	1,050
Water Year 1948-49	310,816	24,000	1	852	616,500

KNIFE RIVER BASIN

Knife River at Hazen, N. Dak.

Location.—Water-stage recorder and wire weight gage, lat. 47°17′, long. 101°37′, in NE¼ Sec. 19, T. 144 N., R. 86 W., at county highway bridge, 0.5 mile south of Hazen and 2 miles upstream from Antelope Creek.

Drainage area.—2,352 square miles.

Records available.—October 1928 to August 1933 (fragmentary), August 1937 to September 1949.

Average discharge.—12 years (1937-49), 195 second-feet.

Extremes.—Maximum discharge during year, 7,760 second-feet Apr. 6 (gage height, 23.3 feet); maximum gage height, 24.1 feet (backwater from ice) Apr. 3; minimum daily discharge, 7 second-feet Feb. 21 to Mar. 4; minimum gage height 3.19 feet Oct. 1-3.

1928-33, 1937-49: Maximum discharge, 11,400 second-feet Mar. 26 or 27, 1943 (gage height, 26.3 feet, from floodmarks); no flow (estimated) Jan. 21 to Feb. 5 1933.

Remarks.—Records good except those for periods of ice effect, which are poor. Gage read once daily to Mar. 22 and twice daily or oftener. thereafter. Some diversions above station. Flow regulated by Ilo Lake (capacity, 7,130 acre-feet).

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,039	41	30	33.5	2,060
November	957	37	28	31.9	1,900
December	801	35	20	25.8	1,590
January	571	23	14	18.4	1,130
February	561	100	11	19.3	1,110
March	43,840	6,700	25	1,414	86,960
April	23,994	3,590	156	800	47,590
May	6,029	847	53	194	11,960
June	8,980	1,990	60	299	17,810
July	2,310	177	43	74.5	4,580
August	1,139	53	22	36.7	2,260
September	617	21	19	20.6	1,220
Water Year 1947-48	90,838	6,700	11	248	180,200

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	748	31	19	24.1	1,480
November	989	40	28	33.0	1,960
December	595	28	14	19.2	1,180
January	347	14	10	11.2	688
February	226	9	7	8.1	448
March	4,604	3,000	7	149	9,130
April	64,342	7,640	155	2,145	127,600
May	3,425	194	83	110	6,790
June	2,761	323	48	92.0	5,480
July	1,682	111	40	54.3	3,340
August	1,489	149	27	48.0	2,950
September	823	47	24	27.4	1,630
Water Year 1948-49	82,031	7,640	7	225	162,700

HEART RIVER BASIN

Heart River near Lark, N. Dak.

Location.—Water-stage recorder, lat. 46°36′00″, long. 101°22′30″, in S½ sec. 9, T. 136 N., R. 85 W., at bridge on State Highway 31, 1 mile downstream from Muddy Creek and 10 miles north of Lark. Prior to Nov. 16, wire-weight gage at same site and datum.

Records available.—June 1946 to September 1949.

Extremes.—Maximum discharge during year, 9,810 second-feet Mar. 29 (gage-height, 14.72 feet); minimum daily, 0.3 second-foot Feb. 15 to Mar. 4.

1946-49: Maximum discharge, 10,400 second-feet Mar. 25, 1947 (gage height, 15.85 feet); minimum, that of Feb. 15 to Mar. 4, 1949.

Remarks.—Records good except those for periods of ice effect or no gage-height record, which are fair. Gage read intermittently.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	858.5	36	7.5	27.7	1,700
November	687	36	11	22.9	1,360
December	262	16	3	8.5	520
January	293	100	2	9.5	581
February	11,498	1,800	25	411	22,810
March	34,254	7,800	45	1,105	67,940
April	32,967	3,500	170	1,099	65,390
May	2,787	150	55	89.9	5,530
June	26,140	5,400	48	871	51,850
July	6,815	1,060	51	220	13,520
August	2,369	327	25	76.4	4,700
September	558	30	15	18.6	1,110
Water Year 1946-47	119,488.5	7,800	2	327	237,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	723	35	15	23.3	1,430
November	648	28	19	21.6	1,290
December	484	18	13	15.6	960
January	304	13	7	9.8	603
February	693	100	6	23.9	1,370
March	58,721	7,500	15	1,894	116,500
April	15,981	1,750	130	533	31,700
May	4,460	399	55	144	8,850
June	6,717	1,700	55	224	13,320
July	6,701	2,000	36	216	13,290
August	2,579	500	13	83.2	5,120
September	263.4	12	7.1	8.78	522
Water Year 1947-48	98,274.4	7,500	6	269	195,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	462.2	31	7	14.9	917
November	900	55	20	30.0	1,790
December	346	24	6	11.2	686
January	48.8	6	.6	1.57	97
February	10.5	.6	.3	.38	21
March	32,718.2	9,000	.3	1,055	64,900
April	72,587	8,380	148	2,420	144,000
May	3,310	243	66	107	6,570
June	1,822	192	21	60.7	3,610
July	786	53	15	25.4	1,560
August	1,054.4	119	9.7	34.0	2,090
September	312.6	24	5.5	10.4	620
Water Year 1948-49	114,357.7	9,000	.3	313	226,900

HEART RIVER BASIN

Heart River near Mandan, N. Dak.

Location.—Water-stage recorder and wire-weight gage, lat. 46°50′, long. 100°59′, in NE¼NW¼ sec. 25, T. 139 N., R. 82 W., at bridge on U. S. Highway 10, 3 miles west of Mandan and 4 miles downstream from Sweetbriar Creek. Datum of gage is 1,638.70 feet above mean sea level, datum of 1929, and 1,632.03 feet above Northern Pacific Railway datum.

Drainage area.—3,360 square miles.

Records available.—April to September 1924, March 1928 to June 1933, August 1937 to September 1949.

Average discharge.—14 years (1929, 1931, 1937-49), 266 second-feet.

Extremes.—Maximum discharge during year, about 16,000 second-feet Mar. 29; maximum gage height, 21.95 feet Mar. 29, affected by ice; no flow Jan. 20 to Mar. 7.

1924, 1928-33, 1937-49: Maximum discharge, 21,400 second-feet Mar. 27, 1943 (gage height, 24.7 feet); no flow on many days.

Remarks.—Records good except those for periods of ice effect or no gage-height record, which are poor. Some diversions above station.

Revision (water years).—W 926: 1938.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,047	45	11	33.8	2,080
November	839	53	13	28.0	1,660
December	359	21	4	11.6	712
January	168	100	1	5.4	333
February	12,549	2,200	30	448	24,890
March	43,397	9,500	68	1,400	86,080
April	39,369	3,950	259	1,312	78,090
May	3,805	238	68	123	7,550
June	26,596	4,900	62	887	52,750
July	8,912	1,040	77	287	17,680
August	2,673	255	42	86.2	5,300
September	953	105	17	31.8	1,890
Water Year 1946-47	140,667	9,500	1	385	279,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	951	105	17	30.7	1,890
November	878	47	21	29.3	1,740
December	594	21	17	19.2	1,180
January	321	16	6	10.4	637
February	51.3	5	.2	1.77	102
March	90,012.8	11,600	.4	2,900	171,500
April	26,171	3,300	242	872	51,910
May	5,716	380	80	184	11,340
June	7,220	1,610	75	241	14,320
July	7,162	1,780	52	231	14,210
August	2,810	350	15	90.6	5,570
September	400.8	27	6.9	14.4	795
Water Year 1947-48	142,287.9	11,600	.2	389	282,200

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	621	34	13	20.0	1,230
November	919	45	20	30.6	1,820
December	396	32	2	12.8	785
January	39.0	5	0	1.26	77
February	0	0	0	0	0
March	32,612.9	9,940	0	1,052	64,690
April	87,436	9,470	198	2,915	173,400
May	4,656	296	91	150	9,240
June	2,485	180	22	82.8	4,930
July	1,199	90	26	38.7	2,380
August	1,375	188	17	44.4	2,730
September	489	24	12	16.3	970
Water Year 1948-49	132,227.9	9,940	0	362	262,300

HEART RIVER BASIN

Muddy Creek near Almont, N. Dak.

Location.—Wire-weight gage, lat. 46°41′40″, long. 101°27′50″, in SW¼, sec. 7, T. 137 N., R. 85 W., at bridge on county road, 2 miles downstream from Hailstone Creek, 3 miles southeast of Almont, and 12 miles (revised) upstream from mouth.

Records available.—October 1945 to September 1949.

Extremes.—Maximum discharge during year, 1,400 second-feet Apr. 1 (gage height, 15.41 feet); no flow Jan. 21 to Feb. 16, Feb. 18-22.

1945-49: Maximum discharge, 2,250 second-feet Mar. 24, 1948 (gage height, 19.20 feet, affected by ice); no flow at times.

Remarks.—Records fair.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	63.0	3.5	1.0	2.03	125
November	58.8	3.4	1.4	1.96	117
December	32.5	1.7	.5	1.05	64
January	142.2	40	.2	4.59	282
February	968.9	350	.3	34.6	1,920
March	4,658	1,300	2	150	9,240
April	3,287	400	13	110	6,520
May	124.3	10	1.8	4.01	247
June	3,118.7	932	1.8	104	6,190
July	345.4	46	1.7	11.1	685
August	31.6	1.8	.4	1.02	63
September	15.7	.8	.4	.52	31
Water Year 1946-47	12,846.1	1,300	.2	35.2	25,480

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	27.9	2.0	0.5	0.90	55
November	37.5	1.5	1.0	1.25	74
December	38.4	1.4	.9	1.24	76
January	46.5	6	.3	1.50	92
February	168.1	30	.2	5.80	333
March	13,011.4	2,150	1.0	420	25,810
April	4,916	973	11	164	9,750
May	240.0	21	1.9	7.74	476
June	110.8	11	1.4	3.69	220
July	388.3	150	.6	12.5	770
August	25.3	2.6	.4	.82	50
September	13.1	.6	.4	.44	26
Water Year 1947-48	19,023.3	2,150	.2	52.0	37,730

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	21.4	1.1	0.5	0.69	42
November	33.0	1.3	.9	1.10	65
December	10.9	1.1	.1	.35	22
January	2.0	.1	0	.06	4.0
February	.7	.1	0	.02	1.4
March	3,852.3	1,270	.1	124	7,640
April	10,112.8	1,360	8.4	337	20,060
May	494.5	160	2.3	16.0	981
June	208.4	54	.7	6.95	413
July	41.7	4.6	.6	1.35	83
August	86.5	23	.4	2.79	172
September	17.4	.8	.4	.58	35
Water Year 1948-49	14,881.6	1,360	0	40.8	29,520

APPLE CREEK BASIN

Apple Creek near Menoken, N. Dak.

Location.—Staff gage, lat. 46°47′35″, long. 100°39′15″, on line between secs. 4 and 9, T. 138 N., R. 79 W., at bridge on former U. S. Highway 10, 4 miles upstream from Hay Creek, 6.3 miles west of Menoken, and 6.4 miles east of Bismarck.

Drainage area.—1,520 square miles.

Records available.—October 1945 to September 1949.

Extremes.—Maximum discharge during year, 750 second-feet Apr. 5 (gage height, 12.40 feet, affected by ice); minimum, 0.1 second-feet Feb. 1 to Mar. 3, Sept. 22, 23.

1945-49: Maximum discharge, 2,340 sec.-ft. Apr. 7, 1948 (gage height, 15.80 feet); no flow Aug. 25 to Sept. 17, 1946.

Remarks.—Records good except those for period Dec. 10 to Mar. 23, which are poor.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	21.7	2.0	------	0.70	43
November	15.0	------	0.2	.50	30
December	24.0	------	------	.77	48
January	26.1	5.0	------	.84	52
February	25.6	8.0	------	.91	51
March	4,482.5	780	------	145	8,890
April	3,829	360	26	128	7,590
May	347	22	------	11.2	688
June	511.7	40	4.7	17.1	1,010
July	428	34	2	13.8	849
August	15.5	1.0	------	.50	31
September	14.9	------	------	.50	30
Water Year 1946-47	9,741.0	780	.2	26.7	19,310

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	13.3	1.0	.2	.43	26
November	15.2	4.1	.1	.51	30
December	7.2	.4	.1	.23	14
January	4.6	.2	.1	.15	9.1
February	15.1	1.0	.1	.52	30
March	57.4	15	.4	1.85	114
April	20,061	2,000	50	669	39,790
May	2,516.9	200	.3	81.2	4,990
June	413.1	30	4.4	13.8	819
July	305.2	28	3.6	9.85	605
August	90.6	5.6	1.1	2.92	180
September	19.2	1.0	.3	.64	38
Water Year 1947-48	23,518.8	2,000	.1	64.3	46,650

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	9.7	0.5	0.2	0.31	19
November	20.9	1.1	.4	.70	41
December	18.7	1.0	------	.60	37
January	14.0	1.0	.2	.45	28
February	2.8	.1	.1	.1	5.6
March	873.3	240	.2	28.2	1,730
April	6,556	700	31	219	13,000
May	391.4	31	4.7	12.6	776
June	510.8	49	2.7	17.0	1,010
July	88.8	13	1.0	2.86	176
August	192.8	48	.4	6.22	382
September	14.3	.9	.1	.48	28
Water Year 1948-49	8,693.5	700	.1	23.8	17,230

CANNONBALL RIVER BASIN

Cannonball River at Breien, N. Dak.

Location.—Water-stage recorder, staff, and wire-weight gage, lat. 46°23′, long. 100°56′, in sec. 36, T. 134 N., R. 82 W., at bridge on State Highway 6, 950 feet downstream from Louise Creek and 0.5 mile south of Breien. Datum of gage is 1,676.54 feet above mean sea level, datum of 1929.

Drainage area.—4,066 square miles.

Records available.—August 1934 to September 1949.

Average discharge.—15 years, 229 second-feet.

Extremes.—Maximum discharge during year, 8,320 second-feet Apr. 1; maximum gage height, 11.9 feet Mar. 30 (from floodmark), affected by ice; no flow Feb. 20 to Mar. 1.

1934-49: Maximum discharge, 21,900 second-feet Mar. 27, 1943 (gage height, 17.4 feet, from floodmark); no flow at times in some years.

Remarks.—Records good except those for period of ice effect, which are fair. Some diversions above station. Some storage in several small lakes above station.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,796.2	222	6.6	57.9	3,560
November	676	48	13	22.5	1,340
December	250.0	16	2.5	8.06	496
January	321.5	75	2.5	10.4	638
February	12,605	2,000	25	450	25,000
March	27,745	7,000	80	895	55,030
April	29,629	2,980	199	988	58,770
May	3,029	182	57	97.7	6,010
June	28,922	4,640	53	964	57,370
July	7,930	926	53	256	15,730
August	812	50	12	26.2	1,610
September	266.5	15	6.6	8.88	529
Water Year 1946-47	113,982.2	7,000	2.5	312	226,100

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,181.6	158	7.3	38.1	2,340
November	960	128	18	32.0	1,900
December	587	40	14	18.9	1,160
January	573	30	7	18.5	1,140
February	1,187	320	1	40.9	2,350
March	72,760	11,100	50	2,347	144,300
April	8,897	658	124	297	17,650
May	4,089	536	42	132	8,110
June	2,311	244	26	77.0	4,580
July	4,283	412	51	138	8,500
August	2,391	162	25	77.1	4,740
September	236.2	25	2.5	7.87	468
Water Year 1947-48	99,455.8	11,100	1	272	197,200

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	195.4	21	2.5	6.30	388
November	761	40	16	25.4	1,510
December	319	20	6	10.3	633
January	79.5	8	.2	2.56	158
February	2.0	.2	0	.07	4.0
March	55,052.3	8,000	0	1,776	109,200
April	65,935	8,200	169	2,198	130,800
May	9,889	3,160	82	319	19,610
June	4,606	1,660	29	154	9,140
July	971	74	10	31.3	1,930
August	1,882.4	330	8.0	60.7	3,730
September	396.9	27	4.8	13.2	787
Water Year 1948-49	140,089.5	8,200	0	384	277,900

JAMES RIVER BASIN

James River at Jamestown, N. Dak.

Location.—Wire-weight gage, lat. 46°54′, long. 98°41′, in SE¼ sec. 36, T. 140 N., R. 64 W., at Asylum bridge at southeast corner of Jamestown, 2.5 miles downstream from Pipestem Creek.

Drainage area.—2,740 square miles.

Records available.—June 1928 to August 1933, August 1937 to September 1938, March 1943 to September 1949.

Average discharge.—12 years (1928-33, 1937-38, 1943-49) 41.3 second-feet.

Extremes.—Maximum discharge during year, 1,350 second-feet Apr. 23 (gage height, 10.06 feet); minimum observed discharge, 1.1 second-feet Oct. 9; minimum gage-height record observed, 2.55 feet, Sept. 30.

1928-33, 1937-38, 1943-49: Maximum discharge, 3,250 second-feet Apr. 23, 1948; maximum gage-height, 14.31 feet Apr. 24, 1948; no flow June 28, 29, July 4, 5, 1933.

Remarks.—Records good from March to August, otherwise fair. Gage read once daily. Flow regulated by Arrowood and Jim Lakes (capacity, 16,000 acre-feet).

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	139.0	17	1.6	4.48	276
November	42.3	2.5	1.1	1.41	84
December	57.3	2.5	1.2	1.85	114
January	75.9	15	1.2	2.45	151
February	55.5	6.4	1.2	1.98	110
March	3,201.5	550	1.2	103	6,350
April	8,226	680	41	274	16,320
May	1,553	128	16	50.1	3,080
June	1,318	86	13	43.9	2,610
July	1,756	148	22	56.6	3,480
August	357.5	27	1.7	11.5	709
September	43.0	1.6	1.2	1.43	85
Water Year 1946-47	16,825.0	680	1.1	46.1	33,370

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	61.4	3.4	1.5	1.98	122
November	66.2	2.6	1.9	2.21	131
December	76.4	2.6	2.2	2.46	152
January	76.7	2.9	1.8	2.47	152
February	60.5	2.4	1.8	2.09	120
March	3,453.5	750	2.4	111	6,850
April	43,737	3,140	397	1,458	86,750
May	16,860	1,740	103	544	33,440
June	2,027	98	50	67.6	4,020
July	1,151	55	26	37.1	2,280
August	895.1	42	9.1	28.9	1,780
September	78.9	11	1.2	2.63	156
Water Year 1947-48	68,543.7	3,140	1.2	187	136,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	88.1	5.0	1.1	2.84	175
November	62.6	3.8	1.2	2.09	124
December	56.0	2.0	1.6	1.81	111
January	66.3	2.7	1.7	2.14	132
February	56.9	2.3	1.8	2.03	113
March	2,841.8	689	2.0	91.7	5,640
April	20,651	1,230	245	688	40;960
May	3,537	236	28	114	7,020
June	3,035	295	22	101	6,020
July	735.5	96	6.0	23.7	1,460
August	111.6	8.6	1.7	3.60	221
September	66.9	3.2	1.6	2.23	133
Water Year 1948-49	31,308.7	1,230	1.1	85.8	62,110

LITTLE MISSOURI RIVER BASIN

Little Missouri River at Marmarth, N. Dak.

Location.—Wire-weight gage, lat. 46°14′, long. 103°54′, in SE¼ sec. 30, T. 133 N., R. 105 W., at highway bridge in Marmarth, 1½ miles downstream from Little Beaver Creek.

Drainage area.—4,570 square miles.

Records available.—March 1938 to September 1949.

Average discharge.—11 years, 402 second-feet.

Extremes.—Maximum discharge during year, 11,700 second-feet Mar. 24 (gage height, 11.2 feet, from graph based on gage readings; no flow at times.

1938-49: Maximum discharge. 45,000 second-feet Mar. 23, 1947 (gage height, 21.7 feet); no flow for part of most winters.

Remarks.—Records fair except those for periods of ice effect or doubtful or no gage-height record, which are poor. Gage read once or twice daily, oftener during high stages. Some small diversions above station for irrigation.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	21,948	2,230	41	708	43,530
November	7,224	1,490	25	241	14,330
December	3,096	500	5	100	6,140
January	469	90	3	15.1	930
February	27,319	4,500	5	97.6	54,190
March	85,735	28,300	50	2,766	170,100
April	41,050	6,710	190	1,368	81,420
May	3,264	200	55	105	6,470
June	45,262	6,980	58	1,509	89,780
July	9,769	1,300	44	315	19,380
August	3,290	773	15	106	6,530
September	442	22	10	14.7	877
Water Year 1946-47	248,868	28,300	3	682	493,700

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	658	60	12	21.2	1,310
November	449	40	10	15.0	891
December	423	30	6	13.6	839
January	1,448	350	4	46.7	2,870
February	3,022	1,000	2	104	5,990
March	46,430	6,000	10	1,498	92,090
April	13,655	2,050	155	455	27,080
May	5,683	460	32	183	11,270
June	22,274	3,950	45	742	44,180
July	13,800	1,860	58	445	27,370
August	5,579	2,340	11	180	11,070
September	191.3	10	3.0	6.38	379
Water Year 1947-48	113,612.3	6,000	2	310	225,300

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	300.5	15	4	9.69	596
November	1,328	101	16	44.3	2,630
December	193	30	0	6.2	383
January	0	0	0	0	0
February	0	0	0	0	0
March	109,510	11,000	0	3,533	217,200
April	40,054	3,550	188	1,335	79,450
May	4,409	248	94	142	8,750
June	1,269	83	13	42.3	2,520
July	874.2	203	6.2	28.2	1,730
August	239.8	64	.7	7.74	476
September	174.0	25	1.7	5.80	345
Water Year 1948-49	158,351.5	11,000	0	434	314,100

LITTLE MISSOURI RIVER BASIN

Little Missouri River at Medora, N. Dak.

Location.—Wire-weight gage, lat. 46°55′10″, long. 103°31′40″, in NE¼ sec. 27, T. 140 N., R. 102 W., at bridge on U. S. Highway No. 10, 1 mile upstream from Andrews Creek.

Drainage area.—6,190 square miles.

Records available.—May 1903 to October 1908, October 1921 to September 1924, August 1928 to September 1934, October 1945 to September 1949.

Extremes.—Maximum discharge during year, 14,600 second-feet Mar. 27; maximum gage height, 13.0 feet (flood mark, backwater from ice); minimum daily discharge, 0.2 second-foot Feb. 15 to Mar. 3.

1903-08; 1921-24; 1928-34; 1945-49: Maximum discharge, 65,000 second-feet Mar. 23, 1947 (gage height, 20.5 feet); no flow at times during 1933, 1934 and 1946.

Remarks.—Records good except those for periods of ice effect or no gage height record, which are poor. Gage usually read once daily; two or three times daily at higher stages. Some small diversions above station for irrigation.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	22,227	2,340	66	717	44,090
November	11,074	1,540	35	369	21,960
December	3,922	450	12	127	7,780
January	1,392	400	7	44.9	2,760
February	30,104	5,000	4	1,075	59,710
March	110,410	38,000	100	3,562	219,000
April	77,109	8,360	343	2,570	152,900
May	5,692	320	117	184	11,290
June	59,648	7,830	100	1,988	118,300
July	19,561	3,900	110	631	38,800
August	6,451	1,340	30	208	12,800
September	734	31	17	24.5	1,460
Water Year 1946-47	348,324	38,000	4	953	690,800

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	977	54	21	31.5	1,940
November	530	36	10	17.7	1,050
December	353	20	8	11.4	700
January	179	10	2	5.8	355
February	7,399	3,500	1	255	14,680
March	70,020	6,940	35	2,259	138,900
April	19,802	1,590	234	660	39,280
May	8,372	542	79	270	16,610
June	30,607	3,350	136	1,020	60,710
July	20,269	2,240	120	654	40,200
August	8,465	2,050	35	273	16,790
September	505.8	28	5.5	16.9	1,000
Water Year 1947-48	167,478.8	6,940	1	458	332,200

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	392.6	26	8.0	12.7	779
November	1,288	95	17	42.9	2,550
December	249	40	2	8.0	494
January	27.4	2	.6	.88	54
February	8.8	.6	.2	.31	17
March	145,502.6	14,000	.2	4,694	288,600
April	59,475	6,400	311	1,982	118,000
May	6,446	311	113	208	12,790
June	2,047	151	17	68.2	4,060
July	1,154.8	174	9.8	37.3	2,290
August	768.7	113	6.1	24.8	1,520
September	337.0	31	6.1	11.2	668
Water Year 1948-49	217,696.9	14,000	.2	596	431,800

LITTLE MISSOURI RIVER BASIN

Little Beaver Creek near Marmarth, N. Dak.

Location.—Staff and wire-weight gages, lat. 46°16′, long. 103°58′, at center of sec. 7, T. 132 N., R. 106 W., a quarter of a mile downstream from Corral Creek, 3¼ miles southwest of Marmarth, and 5½ miles upstream from mouth.

Records available.—April 1936 to September 1949.

Average discharge.—Eleven years, 51.9 second-feet.

Extremes.—Maximum discharge during year, 3,300 second-feet Mar. 23 (gage-height, 10.5 feet, from graph based on gage readings); no flow at times.

1938-1949: Maximum discharge, 6,820 second-feet during night of June 22, 1944 (gage height, 12.5 feet, observer's estimate at site then in use) but may have been higher during flood of March 23, 1947; no flow at times.

Remarks.—Records fair except those for periods of ice effect which are poor. Gage read once daily, oftener during high stages.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	2,258.4	530	0.5	72.9	4,480
November	226.1	19	4.4	7.54	448
December	775.1	222	1.5	25.0	1,540
January	153.9	50	.4	4.96	305
February	3,173.5	900	2	113	6,290
March	10,451	5,000	3	337	20,730
April	7,878	1,940	29	263	15,630
May	561	26	11	18.1	1,110
June	6,101.8	1,280	6.4	203	12,100
July	787.1	136	4.5	25.4	1,560
August	1,365.0	371	2.1	44.0	2,710
September	72.3	4.6	1.2	2.41	143
Water Year 1946-47	33,803.2	5,000	0.4	92.6	67,050

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	133.6	28	2.2	4.31	265
November	98.5	5.6	2.2	3.28	195
December	85.8	5.6	2.0	2.77	170
January	1,541.5	400	1.4	49.7	3,060
February	1,790	800	1	61.7	3,550
March	7,189	1,800	1	232	14,260
April	762	70	14	25.4	1,510
May	1,283.1	539	5.2	41.4	2,540
June	6,598.0	1,240	6.4	220	13,090
July	984.4	219	1.0	31.8	1,950
August	2,250.0	1,870	.3	72.6	4,460
September	6.9	.5	.1	.23	14
Water Year 1947-48	22,722.8	1,870	.1	62.1	45,060

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	57.6	4.1	0.5	1.86	114
November	148.3	21	1.4	4.94	294
December	30.6	3.1	.1	.99	61
January	0	0	0	0	0
February	0	0	0	0	0
March	15,805	3,000	0	510	31,350
April	3,211	305	18	107	6,370
May	448.2	40	8.5	14.4	889
June	147.2	8.5	1.4	4.91	292
July	85.0	25	.1	2.74	169
August	18.1	4.5	0	.58	36
September	7.6	1.0	0	.25	15

KNIFE RIVER BASIN

Knife River near Golden Valley, N. Dak.

Location.—Water-stage recorder, lat. 47°09′, long. 102°05′, in SW¼ sec. 3, T. 142 N., R. 90 W., at highway bridge, 2½ miles downstream from Elm Creek and 10 miles south of Golden Valley.

Drainage area.—1,230 square miles.

Records available.—(In reports of Geological Survey) April 1943 to September 1949. April to November 1904 at site 3 miles downstream, published as Knife River at Broncho. March 1905 to October 1919, October 1921 to September 1924 at site 1 mile upstream, published as Knife River near Broncho.

Records as above, also June to September 1903, October 1924 to September 1925 and March to September 1927 in reports of the North Dakota Water Conservation Board.

Average discharge.—12 years (1909-11, 1921-25, 1943-49), 101 second-feet.

Extremes.—Maximum daily discharge during year, 5,300 second-feet Apr. 4; maximum gage height, 22.9 feet, backwater from ice, Apr. 4; minimum daily, 2 second-feet Feb. 1 to Mar. 2.

1903-19, 1921-24, 1943-49: Maximum discharge, 7,700 second-feet June 26, 1914 (gage height, 24.0 feet, from floodmark, site and datum then in use), from rating curve extended above 2,000 second-feet; no flow Sept. 6-8, 1905, Sept. 18, 19, 1908.

Maximum stage since 1903 (according to local residents), 26.7 feet, from floodmark, March 26, 27, 1943 (discharge, 11,500 second-feet, from rating table extended above 6,500 second-feet).

Remarks.—Records good except those for period of ice effect, which are poor.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	327.4	12	9.8	10.6	649
November	341	13	10	11.4	676
December	310	13	9	10.0	615
January	216	9	5	7.0	428
February	479	70	4	16.5	950
March	27,263	4,100	10	879	54,080
April	7,999	890	54	267	15,870
May	3,492	645	20	113	6,930
June	5,626	2,080	20	188	11,160
July	1,050	77	17	33.9	2,080
August	403.2	24	5.1	13.0	800
September	134.4	5.1	3.9	4.48	267
Water Year 1947-48	47,641.0	4,100	3.9	130	94,500

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	196.5	8.8	4.2	6.34	390
November	282.9	11	7	9.43	561
December	175	8	4	5.6	347
January	100	4	3	3.2	198
February	56	2	2	2.0	111
March	6,814	3,000	2	220	13,520
April	36,646	5,300	58	1,222	72,690
May	1,137	63	25	36.7	2,260
June	774	50	15	25.8	1,540
July	621	36	13	20.0	1,230
August	704.3	128	6.9	22.7	1,400
September	189.5	11	4.5	6.32	376
Water Year 1948-49	47,696.2	5,300	2	131	94,620

KNIFE RIVER BASIN

Spring Creek at Zap, N. Dak.

Location.—Water-stage recorder, lat. 47°16′50″, long. 101°55′10″, in SW¼ sec. 14 T. 144 N., R. 89 W., 250 feet downstream from Northern Pacific Railroad trestle in Zap, and 9 miles upstream from Knife River.

Drainage area.—545 square miles.

Records available.—March to September, 1924; October 1945 to September 1949.

Extremes.—Maximum discharge during year, 2,890 second-feet Apr. 7 (gage height, 16.0 feet); no flow Feb. 1 to Mar. 6, Mar. 15-20.

1924, 1945-49: Maximum discharge, that of Apr. 7, 1949; no flow at times.

Remarks.—Records good except those for period of ice effect, which are poor. Flow regulated by Ilo Lake (capacity, 7,130 acre-feet).

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	255.0	14	7.0	8.23	506
November	219.7	9.0	6	7.32	436
December	177	8	5	5.7	351
January	143	6	3	4.6	284
February	74	5	1	2.6	147
March	9,301	1,330	2	300	18,450
April	6,281	1,040	44	209	12,460
May	1,565	173	11	50.5	3,100
June	1,382.1	326	8.7	46.1	2,740
July	404.4	26	8.4	13.0	802
August	296.1	15	4.6	9.55	587
September	125.0	5.0	3.4	4.17	248
Water Year 1947-48	20,223.3	1,300	1	55.3	40,110

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	193.1	8.7	5.0	6.23	383
November	209.3	8.4	6	6.98	415
December	135	6	3	4.4	268
January	69	3	1	2.2	137
February	0	0	0	0	0
March	105	40	0	3.4	208
April	12,470	2,540	32	416	24,730
May	678	38	14	21.9	1,340
June	523.1	59	6.4	17.4	1,040
July	263.2	12	7.2	8.49	522
August	232.1	17	4.6	7.49	460
September	164.7	6.7	4.8	5.49	327
Water Year 1948-49	15,042.5	2,540	0	41.2	29,830

HEART RIVER BASIN

Heart River near South Heart, N. Dak.

Location.—Water-stage recorder, lat. 46°51′40″, long. 102°56′50″, in SW¼ sec. 8, T. 139 N., R. 97 W., half a mile downstream from North Creek and 2 miles east of South Heart.

Drainage area.—315 square miles.

Records available.—May 1947 to September 1949.

Extremes.—Maximum discharge during year, 2,400 second-feet Mar. 31 (gage height, 17.75 feet); minimum daily 0.3 second-foot Dec. 26 to Feb. 23.

1947-49: Maximum discharge, that of Mar. 31, 1949; minimum daily, 0.3 second-foot Feb. 6-14, 1948, Dec. 26 to Feb. 23, 1949.

Remarks.—Records fair except those for periods of ice effect, which are poor.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	------	------	------	------	------
November	------	------	------	------	------
December	------	------	------	------	------
January	------	------	------	------	------
February	------	------	------	------	------
March	------	------	------	------	------
April	------	------	------	------	------
May 17-31	26.4	2.2	1.2	1.76	52
June	5,289.2	1,630	1.3	176	10,490
July	1,560.9	803	1.7	50.4	3,100
August	55.8	15	.6	1.80	111
September	26.7	1.2	.6	.89	53
The period 1946-47	------	------	------	------	13,810

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	32.0	1.2	0.8	1.03	63
November	27.4	1.1	.8	.91	54
December	23.5	1.2	.6	.76	47
January	18.6	.9	.4	.60	37
February	89.0	15	.3	3.07	177
March	8,502	1,530	1	274	16,860
April	522.5	77	2.8	17.4	1,040
May	311.9	47	1.8	10.1	619
June	1,486.6	635	1.9	49.6	2,950
July	416.7	86	1.3	13.4	827
August	37.1	4.5	.5	1.20	74
September	17.0	.7	.5	.57	34
Water Year 1947-48	11,484.3	1,530	.3	31.4	22,780

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	26.5	1.2	0.7	0.85	53
November	39.4	4.3	.7	1.31	78
December	13.6	.8	.3	.44	27
January	9.3	.3	.3	.30	18
February	8.9	.4	.3	.32	18
March	4,694.9	1,860	.4	151	9,310
April	12,964.1	2,260	6.4	432	25,710
May	95.7	7.5	1.8	3.09	190
June	46.9	3.8	1.1	1.56	93
July	65.9	11	.8	2.13	131
August	41.6	13	.4	1.34	83
September	14.6	.7	.4	.49	29
Water Year 1948-49	18,021.4	2,260	.3	49.4	35,740

HEART RIVER BASIN

Heart River near Dickinson, N. Dak.

Location.—Wire-weight gage, lat. 46°51′10″, long. 102°53′30″, in NW¼ sec. 14, T. 139 N., R. 97 W., 3 miles upstream from Duck Creek and 5 miles west of Dickinson.

Drainage area.—330 square miles.

Records available.—June 1946 to May 1947.

Extremes.—Maximum discharge during period, 2,200 second-feet Mar. 24 (gage height, 17.0 feet, from graph based on gage readings, backwater from ice); minimum daily discharge, 0.5 second-foot Nov. 21-30, Jan. 5-24.

1946-47: Maximum discharge, that of Mar. 24, 1947; minimum observed, 0.4 second-foot, Aug. 9, 10, 1946.

Remarks.—Records fair except those for periods of ice effect or no gage-height record, which are poor.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	191.9	24	.8	6.19	381
November	54.8	6.2	.5	1.83	109
December	78.0	12	1	2.5	155
January	26.0	2	.5	.84	52
February	2,517	800	1	89.9	4,990
March	6,341	2,000	2	205	12,580
April	6,171.0	1,440	9.0	206	12,240
May	106.6	8.0	2.0	3.44	211
June					
July					
August					
September					
The period 1946-47					30,720

HEART RIVER BASIN

Heart River at Lehigh, N. Dak.

Location.—Wire-weight gage, lat. 46°52′, long. 102°43′, in NE¼ sec. 7, T. 139 N., R. 95 W., at county highway bridge in Lehigh, 150 feet downstream from Northern Pacific Railway bridge and about 10 miles upstream from Green River.

Drainage area.—453 square miles.

Records available.—March 1943 to September 1949.

Extremes.—Maximum discharge during year, 3,800 second-feet Apr. 2; (gage height, 14.9 feet, from highwater mark, backwater from ice); minimum discharge, 0.5 second-foot Sept. 23-25 (gage height, 3.27 feet).

1943-49: Maximum discharge, 5,420 second-feet Mar. 25, 1943; maximum gage height, 17.7 feet, from floodmark, Mar. 25, 1943 and Mar. 13, 1945; no flow Mar. 14-18, 1944.

Maximum stage known, that of Mar. 25, 1943, Mar. 13, 1945.

Remarks.—Records good above 10 second-feet and fair below, except those for periods of ice effect, which are poor. Gage read twice daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	354.9	36	1.4	11.4	704
November	162.4	14	2	5.41	322
December	167	15	3	5.4	331
January	127	17	2	4.1	252
February	3,216	900	3	115	6,380
March	9,053	3,200	6	292	17,960
April	7,856	1,520	20	262	15,580
May	288.2	16	2.9	9.30	572
June	6,129.0	1,640	3.2	204	12,160
July	2,260.6	715	6.6	72.9	4,480
August	135.7	14	.8	4.38	269
September	82.6	5.4	1.2	2.75	164
Water Year 1946-47	29,832.4	3,200	.8	81.7	59,170

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	82.1	5.0	1.1	2.65	163
November	133.7	7	2.6	4.46	265
December	123	6	2	4.0	244
January	102	5	2	3.3	202
February	258	25	2	8.9	512
March	11,604	1,500	4	374	23,020
April	1,285.4	200	9.4	42.8	2,550
May	612.2	69	3.2	19.7	1,210
June	1,846.8	695	5.8	61.6	3,660
July	647.9	94	3.5	20.9	1,290
August	98.0	10	.4	3.16	194
September	20.7	1.2	.4	.69	41
Water Year 1947-48	16,813.8	1,500	.4	45.9	33,350

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	108.3	42	0.8	3.49	215
November	102.4	7	1	3.41	203
December	71	5	1	2.3	141
January	58	3	1	1.9	115
February	56	2	2	2.0	111
March	5,774	2,000	2	186	11,450
April	17,199	3,000	14	573	34,110
May	359.8	48	5.2	11.6	714
June	123.8	7.7	1.9	4.13	246
July	133.2	12	1.6	4.30	264
August	100.6	35	.6	3.25	200
September	39.3	14	.5	1.31	78
Water Year 1948-49	24,125.4	3,000	.5	66.1	47,847

HEART RIVER BASIN
Heart River near Richardton, N. Dak.

Location.—Water-stage recorder and wire-weight gage, lat. 46°45′, long. 102°18′, in NE¼ sec. 29, T. 138 N., R. 92 W., at bridge on State Highway 8, half a mile downstream from Blacktail Creek and 9½ miles south of Richardton.

Drainage area.—1,310 square miles.

Records available.—May 1903 to September 1922. April 1943 to September 1949.

Extremes.—Maximum discharge during year, 6,540 second-feet Apr. 6 (gage height, 18.8 feet, from graph based on gage readings); minimum daily discharge, 1 second-feet Jan. 24 to Mar. 2.

1903-1922, 1943-49: Maximum discharge, 9,920 second-feet Mar. 14, 1945 (gage height, 22.57 feet); no flow during some periods in 1903, 1905, 1914, 1919, 1945, and 1946.

Maximum stage known, about 26.0 feet July 5, 1938, from information by local resident (discharge, 14,000 second-feet).

Flood of Mar. 25, 1943, reached a stage of 24.2 feet, from floodmarks (discharge 11,700 second-feet).

Remarks.—Records good except those for periods of ice effect or indefinite stage-discharge relation, which are poor. Wire-weight gage read once daily, with additional readings on days of changing stage.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	567.7	36	2.3	18.3	1,130
November	347	25	6	11.6	688
December	407	23	7	13.1	807
January	1,416	300	4	45.7	2,810
February	7,737	1,100	11	276	15,350
March	20,818	4,500	16	672	41,290
April	20,249	3,260	67	675	40,160
May	1,071	62	18	34.5	2,120
June	16,898	3,870	15	563	33,520
July	4,591	1,020	20	148	9,110
August	1,858.5	376	9.0	60.0	3,690
September	302.5	12	7.5	10.1	600
Water Year 1946-47	76,262.7	4,500	2.3	209	151,300

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	367.5	16	8.5	11.9	729
November	422	19	11	14.1	837
December	321	17	8	10.4	637
January	235	13	4	7.6	466
February	888	100	2	30.6	1,760
March	29,393	3,500	8	948	58,300
April	6,531	950	60	218	12,950
May	2,846	312	20	91.8	5,640
June	5,422	1,580	20	181	10,750
July	4,232	1,720	12	137	8,390
August	794.5	279	5.5	25.6	1,580
September	118.0	6.0	2.8	3.93	234
Water Year 1947-48	51,570.0	3,500	2	141	102,300

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	256.1	16	4	8.26	508
November	416	21	10	13.9	825
December	180	14	3	5.8	357
January	56	3	1	1.8	111
February	28	1	1	1.0	56
March	15,395	3,600	1	497	30,550
April	43,161	6,050	68	1,440	85,610
May	1,648	93	31	53.2	3,270
June	676	74	11	22.5	1,340
July	496.3	70	9.3	16.0	984
August	567.6	153	4.4	18.3	1,130
September	144.9	8.4	2.5	4.83	287
Water Year 1948-49	63,024.9	6,050	1	173	125,000

HEART RIVER BASIN
Heart River near Glen Ullin, N. Dak.

Location.—Water-stage recorder, lat. 46°35′50″, long. 101°48′05″, in NE¼ Sec. 13, T. 136 N., R. 89 W., 10 miles upstream from Heart Butte Creek, 14 miles south of Glen Ullin, and 14 miles north of Elgin.

Drainage area.—1,760 square miles.

Records available.—April 1943 to September 1949.

Extremes.—Maximum discharge during year, 7,300 second-feet Mar. 28 (gage height, 10.78, backwater from ice); minimum discharge, 0.3 second-feet Sept. 30 (gage height, 1.37 feet).

1943-49: Maximum discharge, 25,000 second-feet Mar. 24, 1947 (gage height 21.5 feet, former site and datum, from floodmark, backwater from ice); no flow Dec. 21-28, 1945, Feb. 13-18, 1946.

Flood of Mar. 25, 1943 reached a stage of 18.77 feet, former site and datum (discharge 20,000 second-feet, by slope-area method).

Remarks.—Records good except those for periods of ice effect, which are poor. Flow regulated by Heart Butte Reservoir after September 29, 1949.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	676.6	34	3.6	21.8	1,340
November	535	29	8	17.8	1,060
December	447	25	8	14.4	887
January	1,786	350	4	57.6	3,540
February	8,751	1,400	15	313	17,360
March	29,168	12,000	24	941	57,850
April	24,788	3,370	115	826	49,170
May	1,594	101	21	51.4	3,160
June	20,373	4,110	17	679	40,410
July	6,204	1,100	38	200	12,310
August	2,098	322	13	67.7	4,160
September	391	15	11	13.0	776
Water Year 1946-47	96,811.6	12,000	3.6	265	192,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	565	24	13	18.2	1,120
November	507	24	11	16.9	1,010
December	376	20	9	12.1	746
January	207	15	2	6.7	411
February	1,032	150	2	35.6	2,050
March	38,215	4,300	20	1,230	75,800
April	8,691	1,000	86	290	17,240
May	3,534	335	36	114	7,010
June	6,396	1,780	41	213	12,690
July	6,375	2,150	26	206	12,640
August	2,551	707	10	82.3	5,060
September	240.3	9.3	6.9	8.01	477
Water Year 1947-48	68,689.3	4,300	2	188	136,300

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	396.2	29	6.9	12.8	786
November	657	29	15	21.9	1,300
December	279	24	3	9.0	553
January	45	3	1	1.5	89
February	28	1	1	1.0	56
March	28,217	6,500	1	910	55,970
April	53,029	6,730	100	1,770	105,200
May	2,087	114	46	67.3	4,140
June	1,107	100	18	36.9	2,200
July	656	43	12	21.2	1,300
August	876.7	222	7.4	28.3	1,740
September	274.8	22	.3	9.16	545
Water Year 1948-49	87,652.7	6,730	.3	240	173,900

HEART RIVER BASIN

Green River near Gladstone, N. Dak.

Location.—Wire-weight gage, lat. 46°53′20″, long. 102°38′20″, in SW¼ sec. 36, T. 140 N., R. 95 W., at bridge on U. S. Highway 10, 3 miles northwest of Gladstone and 3 miles upstream from the mouth.

Drainage area.—356 square miles.

Records available.—October 1945 to September 1949.

Extremes.—Maximum discharge during year, 3,780 second-feet Apr. 5 (gage height 16.9 feet); minimum, 0.8 second-foot Aug. 10.

1945-49: Maximum daily discharge, that of Apr. 5, 1949; no flow at times in 1946.

Maximum stage known, about 20 feet March 1943.

Remarks.—Records fair except those for period of ice effect, which are poor. Gage read once daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	155.5	8.0	1.9	5.02	308
November	109.2	5.0	2	3.64	217
December	140.5	12	2	4.53	279
January	118	15	2	3.8	234
February	2,682	800	2	95.8	5,320
March	8,237	2,200	4	266	16,340
April	7,982	1,310	18	266	15,830
May	302.3	17	6.1	9.75	600
June	5,527.1	1,280	5.4	184	10,960
July	894.7	232	5.4	28.9	1,780
August	1,598.3	440	4.8	51.6	3,170
September	112.7	5.2	2.6	3.76	224
Water Year 1946-47	27,859.3	2,200	1.9	76.3	55,260

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	137.4	6.3	3.2	4.43	273
November	183.9	7	5	6.13	365
December	134	7	2	4.3	266
January	95	5	2	3.1	188
February	389	60	2	13.4	772
March	10,446	1,700	2	337	20,720
April	3,258	450	18	109	6,460
May	1,327.8	168	9.8	42.8	2,630
June	2,962.5	1,080	9.5	98.8	5,880
July	508.8	47	5.9	16.4	1,010
August	183.6	10	2.0	5.92	364
September	57.3	3.0	1.4	1.91	114
Water Year 1947-48	19,683.3	1,700	1.4	53.8	39,040

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	112.0	6	2.2	3.61	222
November	164.8	7	4	5.49	327
December	144	6	3	4.6	286
January	70	3	2	2.3	139
February	56	2	2	2.0	111
March	1,274	350	2	41.1	2,530
April	16,633	3,420	20	554	32,990
May	578	56	10	18.6	1,150
June	210.9	10	5.7	7.03	418
July	111.1	5	2.2	3.58	220
August	70.7	8.4	.8	2.28	140
September	43.3	2.0	.9	1.44	86
Water Year 1948-49	19,467.8	3,420	0.8	53.3	38,620

HEART RIVER BASIN

Antelope Creek near Carson, N. Dak.

Location.—Wire-weight gage, lat. 46°32′, long. 101°39′, in NW¼ NE¼ sec. 8, T. 135 N., R. 87 W., at county road bridge, 4 miles upstream from mouth and 8 miles northwest of Carson.

Drainage area.—221 square miles.

Records available.—June 1948 to September 1949.

Extremes.—Maximum discharge observed during year, 1300 second-feet Mar. 28 (gage height, 13.84 feet, affected by ice); no flow at times.

1948-49: Maximum discharge, that of Mar. 28, 1949; no flow at times in each year.

Maximum stage known, 17.1 feet Mar. 25, 1943.

Remarks.—Records fair. Gage read once daily Oct. 1 to Nov. 13 and intermittently from Mar. 26 to Sept. 30.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	------	------	------	------	------
November	------	------	------	------	------
December	------	------	------	------	------
January	------	------	------	------	------
February	------	------	------	------	------
March	------	------	------	------	------
April	------	------	------	------	------
May	------	------	------	------	------
June 23-30	28.9	5.6	2.2	3.61	57
July	291.1	75	.2	9.39	577
August	18.5	2.2	0	.60	37
September	0	0	0	0	0
The period 1948	------	------	------	------	671

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	2.7	0.6	0	0.09	5.4
November	31.9	1.6	.7	1.06	63
December	7.7	1.0	------	.25	15
January	1.0	------	------	.03	2.0
February	0	0	0	0	0
March	4,607	1,200	0	149	9,140
April	1,961.9	428	7.0	65.4	3,890
May	248.7	48	2.9	8.02	493
June	56.2	20	.3	1.87	111
July	61.1	25	.1	1.97	121
August	1.5	.1	0	.05	3.0
September	0	0	0	0	0
Water Year 1948-49	6,979.7	1,200	0	19.1	13,840

CANNONBALL RIVER BASIN

Cannonball River near New Leipzig, N. Dak.

Location.—Water-stage recorder, lat. 46°20′, long. 101°57′, in SW¼ sec. 11, T. 133 N., R. 90 W., at bridge on State Highway No. 49, 2½ miles south of New Leipzig and 8 miles downstream from Thirtymile Creek.

Drainage area.—1,180 square miles (revised).

Records available.—April 1943 to September 1949.

Extremes.—Maximum discharge during year, 5,350 second-feet Mar. 30; maximum gage height, 18.3 feet, backwater from ice, Mar. 28; no flow at times in February and March.

1943-49: Maximum discharge, 8,000 second-feet Mar. 24, 1947 (gage height, 20.5 feet); no flow at times in 1946 and 1949; minimum gage height, 4.54 feet Aug. 12, 1946.

Maximum discharge known, 15,000 second-feet Mar. 25, 26, 1943 (gage height, 26.9 feet, from floodmarks), by slope-area method.

Remarks.—Records good except those for period of ice effect, which are poor. Some diversions and some storage in small lakes above station.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	250.2	12	6.1	8.07	496
November	280.3	13	7.7	9.34	556
December	198	10	4	6.4	393
January	147	9	3	4.7	292
February	299	80	2	10.3	593
March	16,995	2,000	20	548	33,710
April	1,955	150	32	65.2	3,880
May	907	71	11	29.3	1,800
June	655.2	53	7.3	21.8	1,300
July	2,019	213	15	65.1	4,000
August	1,535	258	8.2	49.5	3,040
September	147.3	7.3	2.9	4.91	292
Water Year 1947-48	25,388.0	2,000	2	69.4	50,350

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	157.9	18	2.5	5.09	313
November	274.5	12	7	9.15	544
December	100	7	1	3.2	198
January	15.5	------	------	.5	31
February	2.8	------	------	.1	5.6
March	19,726	4,910	0	636	39,130
April	26,769	4,770	41	892	53,100
May	1,096	68	22	35.4	2,170
June	676.1	63	3.6	22.5	1,340
July	313.3	47	3.4	10.1	621
August	1,154	602	3.6	37.2	2,290
September	139.7	8.9	2.9	4.66	277
Water Year 1948-49	50,424.8	4,910	0	138	100,000

CANNONBALL RIVER BASIN

Cedar Creek near Pretty Rock, N. Dak.

Location.—Water-stage recorder lat. 46°02′, long. 101°49′, in S½ sec. 33, T. 130 N., R. 89 W., at county highway bridge, 7 miles north of Keldron, S. Dak., 10½ miles south of Pretty Rock, and 15 miles downstream from Timber Creek.

Drainage area.—1,260 square miles.

Records available.—April 1943 to September 1949.

Extremes.—Maximum daily discharge during year, 3,500 second-feet, Apr. 2; maximum gage height, 18.0 feet, backwater from ice, Apr. 2; no flow at times.

1943-49: Maximum discharge, 4,450 second-feet (revised) Apr. 20, 1944 (gage height, 14.9 feet); no flow at times; minimum gage height, 2.51 feet Sept. 6, 1946.

Maximum stage known, 21.8 feet, from floodmarks, March 24, 1943 (discharge, 15,000 second-feet).

Remarks.—Records good except those below five second-feet, which are fair, and those for periods of ice effect, which are poor.

Revisions.—Revised figures of discharge for high water periods in the water years 1944 and 1947 are given herein. They supersede those previously published.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
April 1944	33,563	4,410	54	1,119	66,570
June 1944	11,208	1,150	13	374	22,230
Water Year 1943-44	49,724.9	4,410	------	136	98,630

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
April 1947	9,134	1,620	38	305	18,120
June 1947	10,209.4	2,720	6.1	340	20,250
Water Year 1946-47	40,533.2	3,000	.2	111	80,400

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	66.3	4.2	.2	2.14	132
November	109.6	6	3	3.65	217
December	132	5	3	4.3	262
January	87	6	2	2.8	173
February	866	150	1	29.9	1,720
March	15,983	1,900	20	516	31,700
April	1,439	149	22	48.0	2,850
May	573.4	42	5.4	18.5	1,140
June	853.1	80	3.8	28.4	1,690
July	1,109	80	15	35.8	2,200
August	786.8	106	6.1	25.4	1,560
September	36.7	4.7	.2	1.22	73
Water Year 1947-48	22,041.9	1,900	.2	60.2	43,720

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	3.0	0.6	0	0.10	6.0
November	116.6	5.7	.3	3.89	231
December	78.0	4.3	1.3	2.52	155
January	12.4	------	------	.4	25
February	2.8	------	------	.1	5.6
March	17,212	3,000	0	555	34,140
April	18,602	3,500	42	620	36,900
May	857	57	14	27.6	1,700
June	253.8	20	2.4	8.46	503
July	48.6	4.3	.5	1.57	96
August	265.9	156	0	8.58	527
September	9.0	1.1	0	.30	18
Water Year 1948-49	37,461.1	3,500	0	103	74,310

GRAND RIVER BASIN

North Fork Grand River at Haley, N. Dak.

Location.—Wire-weight gage, lat. 45°57′, long. 103°07′, in NE¼ sec. 36, T. 129 N., R. 100 W., at bridge on county road about 300 feet south of post office at Haley and half a mile north of the South Dakota State line.

Records available.—May 1908 to September 1917 (no winter records), October 1945 to September 1949.

Extremes.—Maximum discharge during year, 1,770 second-feet Mar. 28; maximum gage height, 14.0 feet from graph based on gage readings, backwater from ice; no flow at times.

1908-17, 1945-49: Maximum discharge observed, 5,810 second-feet March 31, 1913, discharge measurement (gage height, 9.85 feet, datum then in use); no flow at times.

Remarks.—Records good except those for period of ice effect, which are poor. Gage read once daily or oftener.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	46.5	2.0	1.2	1.50	92
November	70.7	3.1	2.0	2.36	140
December	72.8	3.1	2.0	2.35	144
January	48.4	2.2	.8	1.56	96
February	1,096.2	250	.7	37.8	2,170
March	4,220	1,100	1.0	136	8,370
April	357.7	19	4.9	11.9	709
May	176.2	19	1.9	5.68	349
June	293.7	50	1.3	9.79	583
July	923.7	214	2.2	29.8	1,830
August	44.9	2.7	.4	1.45	89
September	15.1	.8	.3	.50	30
Water Year 1947-48	7,365.9	1,100	.3	20.1	14,600

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	23.4	1.0	0.6	0.75	46
November	38.2	2.2	.8	1.27	76
December	28.2	1.2	.5	.91	56
January	4.5	.5	0	.15	9
February	0	0	0	0	0
March	10,698	1,600	0	345	21,220
April	4,318	580	17	144	8,560
May	369.3	21	6.9	11.9	732
June	157.4	16	1.5	5.25	312
July	213.1	96	.7	6.87	423
August	52.1	12	.2	1.68	103
September	27.3	1.8	.3	.91	54
Water Year 1948-49	15,929.5	1,600	0	43.6	31,590

RED RIVER OF THE NORTH BASIN

Red River of the North at Wahpeton, N. Dak.

Location.—Chain gage, lat. 46°15′55″, long. 96°35′40″, in NE¼ sec. 8, T. 132 N., R. 47 W., in Wahpeton, 800 feet downstream from confluence of Bois de Sioux and Otter Tail Rivers. Datum of gage is 942.97 feet above mean sea level, datum of 1929.

Drainage area.—4,010 square miles.

Records available.—April 1942 to September 1949

Extremes.—Maximum discharge during year, 2,290 second-feet July 10 (gage height, 9.24 feet); minimum daily, 40 second-feet Dec. 31, Jan. 1.

1942-49: Maximum daily discharge, 5,000 second-feet Apr. 2-6, 1943; maximum gage height, 14.75 feet Apr. 2, 1943, from floodmark (affected by ice); minimum daily discharge, that of Dec. 31, 1948, Jan. 1, 1949.

Remarks.—Records good except those for periods of ice effect or doubtful gage height record, which are fair. Gage read twice daily. Flow regulated by Lake Traverse Reservoir and by several power plants on Otter Tail River.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	6,085	258	169	196	12,070
November	6,153	250	149	205	12,200
December	5,780	210	160	186	11,460
January	4,610	180	120	149	9,140
February	3,340	140	80	115	6,620
March	7,940	800	80	256	15,750
April	38,374	2,200	616	1,279	76,110
May	43,492	1,640	859	1,403	86,270
June	16,360	1,120	330	545	32,450
July	7,920	359	183	255	15,710
August	6,731	265	183	217	13,350
September	5,377	241	139	179	10,670
Water Year 1947-48	152,162	2,200	80	416	301,800

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	4,055	222	58	131	8,040
November	3,532	152	75	118	7,010
December	1,698	80	40	54.8	3,370
January	2,163	90	40	69.8	4,290
February	2,400	110	70	85.7	4,760
March	7,510	900	100	242	14,900
April	12,191	1,130	125	406	24,180
May	6,755	313	149	218	13,400
June	6,740	284	202	225	13,370
July	22,559	2,240	180	728	44,750
August	6,143	395	120	198	12,180
September	2,764	125	66	92.1	5,480
Water Year 1948-49	78,510	2,240	40	215	155,700

RED RIVER OF THE NORTH BASIN

Red River of the North at Fargo, N. Dak.

Location.—Staff gage, lat. 46°52′10″, long. 96°47′00″, in NE¼, sec. 7, T. 139 N., R. 48 W., just upstream from Island Park Dam in Fargo and 10 miles upstream from Sheyenne River. Datum of gage is 870.00 feet above mean sea level, adjustment of 1912.

Drainage area.—6,800 square miles.

Records available.—May 1901 to September 1949.

Average discharge.—47 years (1902-1949), 458 second-feet (unadjusted).

Extremes.—Maximum discharge during year, 2,660 second-feet July 12 (gage-height, 11.27 feet); minimum observed, 38 second-feet Nov. 1, 2 (gage-height, 7.48 feet).

1901-49: Maximum discharge, 17,000 second-feet Apr. 7, 1943 (gage height, 28.40 feet); no flow for many days in each year for period 1932-41.

Maximum stage known, 40.1 feet Apr. 7, 1897, Weather Bureau gage, datum of which is 863.5 feet above mean sea level, adjustment of 1912.

Remarks.—Records good except those for days of no gage-height record, which are fair. Flow partly regulated by several lakes in Otter Tail River Basin and municipal pools created by dams in channel of Red River. Figures of daily discharge do not include diversion by city of Fargo.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	6,730	262	188	224	13,750
November	6,139	255	114	211	12,550
December	5,672	202	159	189	11,630
January	4,346	184	114	146	9,000
February	2,996	131	83	109	6,300
March	6,688	877	75	222	13,650
April	54,174	3,340	819	1,812	107,800
May	50,190	1,990	1,190	1,627	100,000
June	18,763	1,270	396	633	37,650
July	8,484	414	173	281	17,300
August	6,752	255	195	226	13,880
September	5,164	228	139	181	10,770
Water year 1947-48	176,098	3,340	75	488	354,300

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	4,384	188	56	149	9,130
November	3,112	137	40	110	6,540
December	1,962	90	47	69.3	4,260
January	2,024	88	42	71.1	4,370
February	2,416	106	70	92.3	5,130
March	5,609	619	101	187	11,500
April	21,533	1,780	175	724	43,100
May	7,788	336	178	258	15,870
June	6,736	264	194	232	13,790
July	27,029	2,600	204	879	54,040
August	7,125	546	117	239	14,680
September	2,652	139	47	95.9	5,700
Water Year 1948-49	92,370	2,600	40	260	188,100

RED RIVER OF THE NORTH BASIN

Red River of the North at Halstad, Minn.

Location.—Wire-weight gage, lat. 47°21′, long. 96°51′, on line between sec. 24 and 25, T. 145 N., R. 49 W., at highway bridge half a mile west of Halstad and 2½ miles downstream from Wild Rice River. Datum of gage is 826.65 feet above mean sea level, datum of 1929.

Drainage area.—21,800 square miles (includes 3,940 square miles in closed Devils Lake Basin).

Records available.—March 1936 to June 1937 (no winter records); April 1942 to August 1949 (fragmentary).

Extremes.—Maximum discharge observed during season, 7,710 second-feet Apr. 7 (gage height, 16.53 feet); minimum not determined.

1936-37, 1942-49: Maximum discharge, 24,500 second-feet Apr. 10, 1947; maximum gage height, 34.00 feet Apr. 17, 1947; minimum observed, 5.4 second-feet Oct. 8, 9, 12-14, 1936.

Remarks.—Records good. Gage read once daily during high stages.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	------	------	------	------	------
November	------	------	------	------	------
December	------	------	------	------	------
January	------	------	------	------	------
February	------	------	------	------	------
March	------	------	------	------	------
April 7-30	217,990	16,000	3,740	9,083	432,400
May	107,850	4,420	1,930	3,479	213,900
June	35,708	1,890	881	1,190	70,830
July	17,298	846	385	558	34,310
August	------	------	------	------	------
September	------	------	------	------	------
Water Year 1948	------	------	------	------	751,400

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	------	------	------	------	------
November	------	------	------	------	------
December	------	------	------	------	------
January	------	------	------	------	------
February	------	------	------	------	------
March	------	------	------	------	------
April 8-30	62,000	6,890	1,640	2,696	123,000
May	35,980	2,190	600	1,161	71,370
June	22,139	1,260	540	738	43,910
July	48,252	3,390	425	1,557	95,710
August	22,081	1,470	304	712	43,800
September	------	------	------	------	------
Water Year 1949	------	------	------	------	377,800

RED RIVER OF THE NORTH BASIN

Red River of the North at Grand Forks, N. Dak.

Location.—Water-stage recorder, lat. 47°56′26″, long. 97°02′47″, in SE¼NE¼ sec. 33, T. 152 N., R. 50 W., in Grand Forks, 2 miles downstream from Red Lake River. Datum of gage is 778.42 feet above mean sea level, datum of 1929.

Drainage area.—30,100 square miles (includes 3,940 square miles in closed Devils Lake Basin).

Records available.—May 1901 to September 1949 in reports of the Geological Survey. April 1882 to November 1912 in report of Minnesota State Drainage Commission.

Average discharge.—67 years, 2,215 second-feet.

Extremes.—Maximum discharge during year, 15,200 second-feet Apr. 10; maximum gage height, 29.11 feet Apr. 10; minimum discharge, 365 second-feet Nov. 20 (gage height, 3.02 feet).

1882-1949: Maximum discharge observed, 43,000 second-feet Apr. 10, 1897 (gage height, 50.2 feet), from rating curve extended above 32,000 second-feet; minimum discharge, 2.4 second-feet Feb. 3-5, 12, 14, 16-19, 1937 (caused by unusual regulation during repair of dam at Grand Forks).

Remarks.—Records good except those for period of ice effect, which are fair, and those for period of no gage-height record, which are poor.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	18,598	656	553	600	36,890
November	17,808	687	382	594	35,320
December	14,360	720	380	463	28,480
January	12,930	480	380	417	25,650
February	12,430	560	400	444	24,650
March	21,060	1,000	520	679	41,770
April	203,390	15,100	1,050	6,780	403,400
May	82,360	3,440	1,630	2,657	163,400
June	145,280	13,400	1,560	4,843	288,200
July	102,490	5,530	1,370	3,306	203,300
August	95,030	3,840	2,270	3,065	188,500
September	48,371	2,360	926	1,612	95,940
Water Year 1948-49	774,107	15,100	380	2,121	1,536,000

RED RIVER OF THE NORTH BASIN

Red River of the North at Oslo, Minn.

Location.—Wire-weight gage, lat. 48°11′, long. 97°09′, in sec. 31, T. 155 N., R. 50 W., on highway bridge in Oslo. Auxiliary staff gage, lat. 48°13′30″, long. 97°07′10″ in SE¼SW¼ sec. 20, T. 155 N., R. 50 W., 7½ miles downstream from Oslo.

Drainage area.—30,500 square miles (includes 3,940 square miles in closed Devils Lake Basin).

Records available.—April 1936 to June 1937, April 1941 to September 1949 (fragmentary). Records prior to 1945 do not include flow in bypass channel.

Extremes.—Maximum discharge during season, 18,700 second-feet Apr. 10; maximum gage height, 24.08 feet Apr. 10; minimum discharge not determined.

1936-37, 1941-49: Maximum daily discharge, 41,400 second-feet Apr. 17, 1948; maximum gage height, 31.17 feet Apr. 15, 1948; minimum not determined.

Remarks.—Records good. Gage read once or twice daily during high stages only. For stages above 13 feet, discharge includes flow in bypass channel 1½ miles west of Oslo.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	-------	-------	-------	-------	-------
November	-------	-------	-------	-------	-------
December	-------	-------	-------	-------	-------
January	-------	-------	-------	-------	-------
February	-------	-------	-------	-------	-------
March	-------	-------	-------	-------	-------
April 16-30	458,400	41,400	16,200	30,560	909,200
May	256,630	14,400	4,170	8,278	509,000
June	75,250	3,970	1,790	2,508	149,300
August	-------	-------	-------	-------	-------
September	-------	-------	-------	-------	-------
Water Year 1948	-------	-------	-------	-------	1,568,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	-------	-------	-------	-------	-------
November	-------	-------	-------	-------	-------
December	-------	-------	-------	-------	-------
January	-------	-------	-------	-------	-------
February	-------	-------	-------	-------	-------
March	-------	-------	-------	-------	-------
April 9-30	193,410	18,600	3,690	9,019	393,500
May	86,520	3,570	1,800	2,791	171,600
June	155,780	14,200	1,780	5,193	309,000
July	105,390	5,720	1,480	3,400	209,000
August	98,460	3,680	2,440	3,176	195,300
September	-------	-------	-------	-------	-------
Water Year 1949	-------	-------	-------	-------	1,278,000

RED RIVER OF THE NORTH BASIN

Red River at Drayton, North Dakota

Location.—Wire-weight gage, lat. 48°33'40", long. 97°10'30" in NW¼SE¼ sec. 26, T. 159 N., R. 51 W. on highway bridge in Drayton. Datum of gage is 756.59 feet above mean sea level, datum of 1929.

Drainage area.—34,800 square miles (includes 3,940 square miles in closed Devils Lake Basin).

Records available.—April 1936 to June 1937, April 1941 to September 1949 (fragmentary).

Extremes.—Maximum discharge during season, 27,900 second-feet Apr. 12; maximum gage height, 31.65 feet Apr. 15; minimum discharge not determined.

1936-37, 1941-49: Maximum daily discharge, 57,000 second-feet Apr. 21, 1948; maximum gage height, 40.05 feet Apr. 22, 1948; minimum discharge not determined. Maximum stage known, about 41 feet in 1897 from marks furnished by local residents.

Remarks.—Records good except those for period of no gage-height record, which are fair, and those for period of ice effect, which are poor. Gage read twice daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	------	------	------	------	------
November	------	------	------	------	------
December	------	------	------	------	------
January	------	------	------	------	------
February	------	------	------	------	------
March	------	------	------	------	------
April 18-30	602,600	57,000	31,200	46,350	1,195,000
May	393,650	28,500	4,580	12,700	780,800
June	92,870	4,440	2,200	3,096	184,200
July	64,090	2,870	1,560	2,067	127,100
August	------	------	------	------	------
September	------	------	------	------	------
Apr. 18 to July 31, 1948	------	------	------	------	2,287,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	------	------	------	------	------
November	------	------	------	------	------
December	------	------	------	------	------
January	------	------	------	------	------
February	------	------	------	------	------
March	------	------	------	------	------
April	343,130	27,800	1,000	11,440	680,600
May	92,290	4,200	1,920	2,977	183,100
June	166,430	13,500	1,970	5,548	330,100
July	110,090	5,540	1,670	3,551	218,400
August	106,880	4,010	2,700	3,448	212,000
September	54,600	2,600	1,100	1,820	108,300
Water Year 1949	------	------	------	------	1,732,000

RED RIVER OF THE NORTH BASIN

Red River of the North at Emerson, Manitoba

(International gaging station)

Location.—Chain gage, lat. 49°00'30", long. 97°13'00", on Canadian National Railway bridge in Emerson. Datum of gage is at mean sea level, datum of 1929, by Geodetic Survey of Canada. Prior to Oct. 1, 1948, at datum 0.57 foot higher.

Drainage area.—40,200 square miles (includes 3,940 square miles of closed Devils Basin).

Records available.—March to November 1902 and October 1929 to September 1949 in reports of Geological Survey; May 1912 to September 1949 in reports of the Dominion Water and Power Bureau, Department of Mines and Resources, Canada.

Average discharge.—36 years (1913-49) 2,392 second-feet.

Extremes.—Maximum daily discharge during year, 29,200 second-feet Apr. 15; maximum elevation observed 777.49 feet Apr. 16; minimum daily discharge, 409 second-feet Jan. 20; minimum elevation observed, 746.58 feet Oct. 28.

1912-49: Maximum daily discharge, 51,800 second-feet Apr. 27, 1948 (elevation, 787.98 feet, present datum); minimum observed, 0.9 second-feet Feb. 6-8, 1937.

Remarks.—Records good except those for periods of ice effect, which are fair. Gage read once daily.

Cooperation.—This station is one of the international gaging stations maintained by Canada under agreement with the United States.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	57,810	2,160	1,700	1,860	114,700
November	49,600	1,930	1,150	1,650	98,380
December	41,720	1,540	1,150	1,350	82,750
January	33,616	1,250	921	1,080	66,680
February	24,492	921	801	845	48,580
March	26,380	1,270	781	851	52,320
April	746,610	51,800	1,410	24,900	1,481,000
May	621,610	45,100	6,320	20,100	1,233,000
June	115,730	6,030	2,300	3,860	229,500
July	97,320	4,500	2,070	3,140	193,000
August	51,500	2,630	1,300	1,660	102,100
September	30,262	1,260	734	1,010	60,000
Water Year 1947-48	1,896,650	51,800	734	5,180	3,762,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	20,886	728	633	674	41,430
November	21,356	768	648	712	42,360
December	17,251	644	486	556	34,220
January	13,919	486	409	449	27,610
February	12,709	497	417	454	25,210
March	18,491	876	497	596	36,680
April	441,714	29,200	910	14,700	876,100
May	157,850	8,700	2,820	5,090	313,100
June	164,770	13,100	2,190	5,490	326,800
July	105,840	5,450	1,840	3,410	209,900
August	101,970	3,910	2,450	3,290	202,300
September	54,180	2,610	1,060	1,810	107,500
Water Year 1948-49	1,130,936	29,200	409	3,100	2,243,000

RED RIVER OF THE NORTH BASIN

Bois de Sioux River near White Rock, S. Dak.

Location.—Water-stage recorder, lat. 45°51′45″, long. 96°34′25″, in SW¼SW¼ sec. 27, T. 128 N., R. 47 W., just downstream from Sig Slough outlet, 300 feet downstream from White Rock dam, 4 miles south of White Rock, and 5 miles northwest of Wheaton, Minn. Datum of gage is 959.89 feet above mean sea level, adjustment of 1912 (levels by Corps of Engineers).

Drainage area.—1,160 square miles.

Records available.—October 1941 to September 1949.

Extremes.—Maximum daily discharge during year, 210 second-feet July 15; minimum gage height, 8.84 feet Mar. 29 (backwater from ice); no flow on many days.

1941-49: Maximum discharge observed, 1,120 second-feet May 24, 1943; maximum gage height, 9.28 feet June 23, 1944; no flow at times in most years.

Remarks.—Records good except for those periods of flow during ice effect. Flow partly regulated by Lake Traverse-Bois de Sioux Flood Control and Water Conservation Project. Available capacity for flood control, 137,000 acre-feet.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	96.7	5.7	1.5	3.12	192
November	313.9	25	3.8	10.5	623
December	137.6	7.0	2.0	4.44	273
January	52.7	.....	1.1	1.70	105
February	22.7	1.2	.7	.81	45
March	191.1	24	.2	6.16	379
April	8,144.1	875	4.9	271	16,150
May	18,354	900	334	592	36,400
June	13,001	580	.....	433	25,790
July	14,057	775	13	453	27,880
August	280.2	16	5.7	9.04	556
September	179.5	9.0	4.5	5.98	356
Water Year 1946-47	54,830.5	900	.2	150	108,700

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	209.5	10	4.1	6.76	416
November	250.8	22	5.0	8.36	497
December	57.1	4.8	.2	1.84	113
January	.2	.1	0	.01	.4
February	0	0	0	0	0
March	1,144.0	320	0	36.9	2,270
April	10,762.5	1,000	6.5	359	21,350
May	23,255	1,000	90	750	46,130
June	2,535.0	380	7.0	84.5	5,030
July	477.5	27	7.0	15.4	947
August	563	30	14	18.2	1,120
September	449.9	38	.7	15.0	892
Water Year 1947-48	39,704.5	1,000	0	108	78,770

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	19.3	1.1	0.2	0.62	38
November	21.0	1.1	.5	.70	42
December	6.8	.5	0	.22	13
January	.....	.....	.....	.....	.....
February	.....	.....	.....	.....	.....
March	612	65	0	19.7	1,210
April	247.9	55	1.5	8.26	492
May	62.5	7.5	.9	2.02	124
June	85.1	10	.5	2.84	169
July	2,010.8	210	.2	64.9	3,990
August	140.4	6.6	2.1	4.53	278
September	45.3	4.9	.2	1.51	90
Water year 1948-49	3,251.1	210	0	8.91	6,450

RED RIVER OF THE NORTH BASIN

Wild Rice River near Mantador, N. Dak.

Location.—Staff gage, lat. 46°10′20″, long. 97°00′35″, in SE¼ sec. 12, T. 131 N., R. 51 W., 1½ miles west of Mantador. Datum of gage is 997.78 feet above mean sea level, datum of 1929 (Corps of Engineers, bench mark).

Records available.—March 1944 to September 1949.

Extremes.—Maximum discharge during year, 105 second-feet Mar. 28 (gage height, 4.9 feet, affected by ice); no flow during several months.

1944-49: Maximum discharge, 938 second-feet Mar. 20, 1945, (gage height, 9.57 feet); no flow at times in each year.

Remarks.—Records fair except those for periods of ice effect or no gage height record, which are poor. Gage read once daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	137.7	8.1	0	4.44	273
November	116.7	8.6	.7	3.89	231
December	42.9	1.9	0	1.38	85
January	0	0	0	0	0
February	0	0	0	0	0
March	395	70	0	12.7	783
April	8,826	551	50	294	17,500
May	3,473	313	26	112	6,890
June	1,506	119	20	50.2	2,990
July	417.9	28	2.4	13.5	829
August	6.1	1.6	0	.20	12
September	0	0	0	0	0
Water year 1946-47	14,921.3	551	0	40.9	29,590

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	.5	.1	0	.02	1.0
December	0	0	0	0	0
January	0	0	0	0	0
February	0	0	0	0	0
March	155	50	0	5.0	307
April	1,588	140	21	52.9	3,150
May	324.1	20	1.1	10.5	643
June	133.3	15	.1	4.44	264
July	88.1	14	0	2.84	175
August	243.5	63	0	7.85	483
September	.7	.4	0	.02	1.4
Water Year 1947-48	2,533.2	140	0	6.92	5,020

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	5.1	2.7	0	0.16	10
November	44.5	3.9	.2	1.48	88
December	2.5	.5	0	.08	5.0
January	0	0	0	0	0
February	0	0	0	0	0
March	668	100	0	21.5	1,320
April	1,234	80	20	41.1	2,450
May	480.5	31	4.4	15.5	953
June	163.0	9.8	1.8	5.43	323
July	743.8	71	1.8	24.0	1,480
August	184.8	39	0	5.96	367
September	0	0	0	0	0
Water Year 1948-49	3,526.2	100	0	9.66	7,000

RED RIVER OF THE NORTH BASIN

Wild Rice River near Abercrombie, N. Dak.

Location.—Staff gage, lat. 46°28′35″, long. 96°47′15″, in NE¼SW¼ sec. 25, T. 135 N., R. 49 W., 160 feet upstream from rubble masonry dam which serves as control, 3½ miles northwest of Abercrombie, and 8 miles downstream from Antelope Creek. Datum of gage is 907.94 feet above mean sea level, datum of 1929.

Drainage area.—2,170 square miles.

Records available.—April 1932 to September 1949.

Average discharge.—13 years (1932-33, 1936-37, 1938-49), 69.4 second-feet.

Extremes.—Maximum discharge during year, about 650 second-feet Apr. 3 (gage height 5.60 feet, affected by ice); no flow Oct. 1 to Mar. 24, Aug. 27 to Sept. 30.

1932-49: Maximum discharge, 5,500 second-feet Apr. 2, 1943 (gage height, 21.02 feet, from flood mark) from rating table extended above 2,100 second-feet; no flow for some periods each year.

Remarks.—Records good. Gage read once or twice daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	163.4	8.3	.2	5.27	324
November	206.8	11	2.5	6.89	410
December	64.8	2.7	1.2	2.09	129
January	29.8	3.9	.3	.96	59
February	6.8	.8	0	.24	13
March	1,636	200	0	52.8	3,240
April	21,507	2,450	140	717	42,660
May	4,911	388	47	158	9,740
June	2,236	154	32	74.5	4,440
July	683.7	53	5.2	22.1	1,360
August	18.8	4.4	0	.61	37
September	0	0	0	0	0
Water Year 1946-47	31,464.1	2,450	0	86.2	62,410

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	0	0	0	0	0
December	0	0	0	0	0
January	0	0	0	0	0
February	0	0	0	0	0
March	117.1	64	0	3.78	232
April	6,515	680	47	217	12,920
May	608.8	44	3.9	19.6	1,210
June	188.8	28	1.1	6.29	374
July	172.9	20	0	5.58	343
August	222.1	44	.3	7.16	441
September	1.8	.8	0	.06	3.6
Water Year 1947-48	7,826.5	680	0	21.4	15,520

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	0	0	0	0	0
December	0	0	0	0	0
January	0	0	0	0	0
February	0	0	0	0	0
March	1,011	350	0	32.6	2,010
April	4,509	600	38	150	8,940
May	774.5	50	7.4	25.0	1,540
June	214.0	20	4.6	7.13	424
July	2,945.9	491	3.6	95.0	5,840
August	411.9	44	0	13.3	817
September	0	0	0	0	0
Water Year 1948-49	9,866.3	600	0	27.0	19,570

RED RIVER OF THE NORTH BASIN

Antelope Creek at Dwight, N. Dak.

Location.—Chain gage, lat. 46°18′50″, long. 96°44′05″, in SE¼SE¼ sec. 20, T. 133 N., R. 48 W., at bridge on U. S. Highway 81, half a mile north of Dwight and 7 miles upstream from mouth.

Drainage area.—About 250 square miles.

Records available.—March 1944 to September 1949 (discontinued).

Extremes.—Maximum discharge during year, 270 second-feet Mar. 31; maximum gage height, 6.3 feet July 8 (backwater from weeds); no flow in several months.

1944-49: Maximum discharge, 1,360 second-feet Mar. 21, 1946 (gage height, 12.33 feet); no flow for several months in each year.

Remarks.—Records fair. Gage read once daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	0	0	0	0	0
December	0	0	0	0	0
January	0	0	0	0	0
February	0	0	0	0	0
March	1,268	200	0	40.9	2,520
April	6,055.3	1,100	3.8	202	12,010
May	37.4	4.4	.2	1.21	74
June	126.8	24	.2	4.23	252
July	11.2	1.3	0	.36	22
August	0	0	0	0	0
September	0	0	0	0	0
Water Year 1946-47	7,498.7	1,100	0	20.5	14,880

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	0	0	0	0	0
December	0	0	0	0	0
January	0	0	0	0	0
February	0	0	0	0	0
March	3	2	0	.10	6.0
April	960.6	100	3	32.0	1,910
May	14.6	2.2	0	.47	29
June	0	0	0	0	0
July	0	0	0	0	0
August	0	0	0	0	0
September	0	0	0	0	0
Water Year 1947-48	978.2	100	0	2.67	1,940

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	0	0	0	0	0
December	0	0	0	0	0
January	0	0	0	0	0
February	0	0	0	0	0
March	524	250	0	16.9	1,040
April	704.1	200	.2	23.5	1,400
May	3.2	.2	0	.10	6.3
June	0.4	.1	0	.01	.8
July	776.0	211	0	25.0	1,540
August	41.3	11	0	1.33	82
September	0	0	0	0	0
Water year 1948-49	2,049.0	250	0	5.61	4,070

RED RIVER OF THE NORTH BASIN

Sheyenne River near Harvey, N. Dak.

Location.—Staff gage and loose rock dam, lat. 47°47′25″, long. 99°53′25″, in SE¼SW¼ sec. 21, T. 150 N., R. 72 W., 300 feet north of Harvey Water Works and 2¼ miles northeast of Harvey.

Records available.—October 1945 to September 1949.

Extremes.—Maximum discharge during year, 846 second-feet Apr. 7 (gage height, 6.20 feet); no flow during several months.

1945-49: Maximum discharge observed, 1,220 second-feet Apr. 18, 1948 (gage height, 6.45 feet); no flow during several months in each year.

Remarks.—Records fair except those for the period of ice effect, which are poor. Gage read once daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	1.4	.1	0	.05	2.8
December	1.0	.1	0	.03	2.0
January	0	0	0	0	0
February	0	0	0	0	0
March	740	150	0	23.9	1,470
April	467.7	40	3.9	15.6	928
May	119.7	8.4	.7	3.86	237
June	213.5	22	.4	7.12	423
July	211.1	40	.5	6.81	419
August	11.2	1.0	0	.36	22
September	5.0	.8	0	.17	9.9
Water Year 1946-47	1,770.6	150	0	4.85	3,510

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	17.9	1.6	.1	.58	36
November	20.3	1.4	.2	.68	40
December	19.2	1.0	.4	.62	38
January	3.5	.4	0	.11	6.9
February	0	0	0	0	0
March	5	2	0	.2	9.9
April	6,304	952	3	210	12,500
May	907.2	89	2.1	29.3	1,800
June	97.2	15	.6	3.24	193
July	36.9	4.0	.3	1.19	73
August	7.4	.7	0	.24	15
September	0	0	0	0	0
Water Year 1947-48	7,418.6	952	0	20.3	14,710

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	0	0	0	0	0
December	0	0	0	0	0
January	0	0	0	0	0
February	0	0	0	0	0
March	9	5	0	.29	18
April	4,941	547	13	165	9,800
May	238.7	24	1.4	7.70	473
June	205.0	31	.5	6.83	407
July	35.7	5.2	0	1.15	71
August	0	0	0	0	0
September	0	0	0	0	0
Water Year 1948-49	5,429.4	547	0	14.9	10,770

RED RIVER OF THE NORTH BASIN

Sheyenne River at Sheyenne, N. Dak.

Location.—Staff gage, lat. 47°50′20″, long. 99°07′30″, in NE¼ sec. 5, T. 150 N., R. 66 W., at recreation-pond dam, 1 mile north of Sheyenne. Datum of gage is 1,408.65 feet above mean sea level, adjustment of 1912.

Drainage area.—1,980 square miles.

Records available.—April 1929 to June 1933, October 1939 to September 1949.

Average discharge.—11 years (1929-30, 1939-49), 36.5 second-feet.

Extremes.—Maximum discharge during year, 2,080 second-feet Apr. 9 (gage height, 7.15 feet); no flow at times.

1929-33, 1939-49: Maximum discharge, 3,840 second-feet Apr. 18, 19, 1948 (gage-height, 8.51 feet); no flow during parts of most years.

Remarks.—Records fair above 50 second-feet and poor below. Gage read once daily. Stage-discharge relation substantially affected by wind at times.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	34.9	6.6	0	1.13	69
November	60.4	2.4	1.7	2.01	120
December	28.2	1.7	.1	.91	56
January	1.0	.1	0	.03	2.0
February	0	0	0	0	0
March	3,881	600	0	125	7,700
April	2,934	215	27	97.8	5,820
May	462.0	36	1.4	14.9	916
June	277.1	48	1.2	9.24	550
July	617.6	36	6.6	19.9	1,220
August	163.5	18	0	5.27	324
September	4.5	1.2	0	.15	8.9
Water Year 1946-47	8,464.2	600	0	23.2	16,790

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	9.1	1.7	0	.29	18
November	12.5	1.7	0	.42	25
December	6.2	.2	.2	.20	12
January	3.7	.2	.1	.12	7.3
February	2.9	.1	.1	.10	5.8
March	6.6	2	.1	.21	13
April	32,038	3,840	2	1,068	63,550
May	3,809	448	25	123	7,560
June	412.3	39	5.1	13.7	818
July	276.9	18	1.7	8.93	549
August	20.3	1.7	0	.65	40
September	0	0	0	0	0
Water Year 1947-48	36,597.5	3,840	0	100	72,600

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	4.7	.7	0	.16	9.3
December	5.6	.5	.1	.18	11
January	1.5	.1	0	.05	3.0
February	0	0	0	0	0
March	26	20	0	.84	52
April	20,334	2,030	30	678	40,330
May	1,139	72	12	36.7	2,260
June	604.5	34	1.7	20.2	1,200
July	250.4	24	0	8.08	497
August	0	0	0	0	0
September	0	0	0	0	0
Water Year 1948-49	22,365.7	2,030	0	61.3	44,360

RED RIVER OF THE NORTH BASIN

Sheyenne River near Cooperstown, N. Dak.

Location.—Wire-weight gage, lat. 47°26′, long. 98°02′, in NE¼SE¼ sec. 27, T. 146 N., R. 58 W., at county bridge 5 miles east of Cooperstown. Datum of gage is 1,274.57 feet above mean sea level, datum of 1929 (Corps of Engineers, bench mark).

Records available.—March 1945 to September 1949.

Extremes.—Maximum discharge during year, 2,290 second-feet Apr. 17 (gage height, 15.95 feet); minimum discharge observed, 1.6 second-feet Oct. 3 (gage height, 3.53 feet).

1945-49: Maximum discharge, 5,600 second-feet Apr. 23, 1948; minimum daily discharge, 1 second-foot Mar. 1-9, 1947; minimum gage height observed, 3.52 feet Sept. 6, 1945 and Sept. 27, 1948.

Remarks.—Records good except those for period of ice effect, which are fair.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	578.8	37	2.2	18.7	1,150
November	467	27	11	15.6	926
December	375	14	10	12.1	744
January	330	15	5	10.6	655
February	157	8	4	5.4	311
March	210	12	6	6.8	417
April	53,408	5,130	8	1,780	105,900
May	19,178	2,170	114	619	38,040
June	2,080	124	44	69.3	4,130
July	1,451	86	27	46.8	2,880
August	824.4	66	7.3	26.6	1,640
September	82.7	7.0	1.3	2.76	164
Water Year 1947-48	79,141.9	5,130	1.3	216	157,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	194.0	13	1.6	6.26	385
November	469	19	12	15.6	930
December	354	14	9	11.4	702
January	174	8	4	5.6	345
February	130	6	4	4.6	258
March	688	250	7	22.2	1,360
April	34,271	2,280	300	1,142	67,980
May	4,351	282	74	140	8,630
June	2,222	306	36	74.1	4,410
July	1,728	96	29	55.7	3,430
August	761.7	87	3.6	24.6	1,510
September	85.5	5.0	2.0	2.85	170
Water Year 1948-49	45,428.2	2,280	1.6	124	90,110

RED RIVER OF THE NORTH BASIN

Sheyenne River at Valley City, N. Dak.

Location.—Water-stage recorder and concrete control, lat. 46°54′50″, long. 98° 00′30″, SE¼NW¼ sec. 28, T. 140 N., R. 58 W., 100 feet downstream from College Dam in Valley City and 15 miles downstream from Baldhill Creek.

Drainage area.—8,360 square miles (includes 3,940 square miles in closed Devils Lake Basin).

Records available.—March to August 1919, March 1938 to September 1949.

Average discharge.—11 years (1938-49), 110 second-feet.

Extremes.—Maximum discharge during year, 2,120 second-feet Apr. 21 (gage height, 10.90 feet); minimum, 0.2 second-foot on many days; minimum gage height, 2.38 feet Sept. 29.

1919, 1938-49: Maximum discharge, 4,580 second-feet Apr. 28, 1948 (gage height, 17.51 feet); no flow during several periods in 1938-41.

Remarks.—Records good except those for period of no gage-height record, which are poor. Regulation by Baldhill Reservoir and other smaller reservoirs. Storage in Baldhill Reservoir began in August 1949.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	741.5	62	2.0	23.9	1,470
November	462.4	49	.8	15.4	917
December	460.6	33	.6	14.9	914
January	253.9	12	4.9	8.19	504
February	144.4	7.5	3.7	4.98	286
March	990.5	176	5.7	32.0	1,960
April	62,306	4,490	129	2,077	123,600
May	29,753	3,270	155	960	59,010
June	2,946	146	68	98.2	5,840
July	1,690	88	38	54.5	3,350
August	1,256	72	19	40.5	2,490
September	313.9	18	1.3	10.5	623
Water Year 1947-48	101,318.2	4,490	.6	277	201,000

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	24.5	1.4	0.4	0.79	49
November	783.9	66	.8	26.1	1,550
December	335.5	49	.2	10.8	665
January	193.6	12	.2	6.25	384
February	201.5	8.0	6	7.20	400
March	2,500.9	488	4.6	80.7	4,960
April	37,606	2,110	467	1,254	74,590
May	5,838	433	88	188	11,580
June	3,102	302	40	103	6,150
July	3,114	449	22	100	6,180
August	94.0	22	.3	3.03	186
September	36.9	7.0	.2	1.25	73
Water Year 1948-49	53,830.8	2,110	.2	147	106,800

RED RIVER OF THE NORTH BASIN
Sheyenne River at West Fargo, N. Dak.

Location.—Water-stage recorder, lat. 46°53′20″, long. 96°54′55″, in sec. 31., T. 140 N., R. 49 W., one mile north of West Fargo and 3 miles upstream from Maple River. Datum of gage is 877.19 feet above mean sea level, datum of 1929.

Drainage area.—9,460 square miles (includes 3,940 square miles in closed Devils Lake Basin).

Records available.—September 1929 to September 1949. March 1902 to June 1907 and March to August 1919 at site a quarter of a mile upstream.

Average discharge.—20 years, 128 second-feet.

Extremes.—Maximum discharge during year, 1,980 second-feet Apr. 29 (gage height, 16.19 feet); minimum, 5.7 second-feet Aug. 20 (gage height 2.48 feet).

1902-07, 1919, 1929-49: Maximum discharge, 2,300 second-feet Apr. 18, 1947 (gage height, 20.53 feet); minimum, 2.0 second-feet Dec. 14, 1936 (gage height, 1.90 feet).

Remarks.—Records good except those for period of ice effect, which are fair. Flow regulated by Baldhill Reservoir after August 1949.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	2,371	107	54	76.5	4,700
November	1,746	73	44	58.2	3,460
December	1,293	48	37	41.7	2,560
January	1,179	40	35	38.0	2,340
February	1,130	50	32	40.4	2,240
March	2,218	280	34	71.5	4,400
April	38,294	2,800	422	1,276	75,960
May	7,394	405	157	239	14,670
June	6,936	400	139	231	13,760
July	3,538	159	72	114	7,020
August	1,793	70	50	57.8	3,560
September	966	49	24	32.2	1,920
Water year 1946-47	68,858	2,800	24	189	136,600

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,058	82	22	34.1	2,100
November	1,944	89	32	64.8	3,860
December	1,473	64	33	47.5	2,920
January	1,000	42	30	32.3	1,980
February	870	30	30	30.0	1,730
March	1,228	110	30	39.6	2,440
April	43,500	2,320	150	1,450	86,280
May	50,475	2,620	437	1,628	100,100
June	8,166	409	190	272	16,200
July	4,646	188	123	150	9,220
August	3,206	127	76	103	6,360
September	1,634	86	40	54.5	3,240
Water Year 1947-48	119,201	2,620	22	326	236,400

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,068	39	32	34.5	2,120
November	1,574	79	37	52.5	3,120
December	1,207	60	30	38.9	2,390
January	866	40	25	27.9	1,720
February	625	25	20	22.3	1,240
March	3,680	350	30	119	7,300
April	34,720	1,970	180	1,157	68,870
May	16,091	1,740	204	519	31,920
June	5,819	293	125	194	11,540
July	4,295	251	89	139	8,520
August	2,653	336	22	85.6	5,260
September	818	61	19	27.3	1,620
Water Year 1948-49	73,416	1,970	19	201	145,600

RED RIVER OF THE NORTH BASIN
Maple River at Mapleton, N. Dak.

Location.—Wire-weight gage and loose rock dam, lat. 46°53′20″, long. 97°03′20″, in NE¼ NE¼ sec. 1, T. 139 N., R. 51 W., in Mapleton, 10.5 miles upstream from mouth. Datum of gage is 886.67 feet above mean sea level, datum of 1929 (Corps of Engineers bench mark).

Drainage area.—1,480 square miles.

Records available.—April 1944 to September 1949.

Extremes.—Maximum discharge during year, 850 second-feet Apr. 3 (gage height, 14.75 feet, affected by ice); no flow at times.

1944-49: Maximum discharge, 3,880 second-feet Apr. 14, 1947 (gage height, 18.11 feet); no flow at times in most years.

Remarks.—Records good above 10 second-feet and fair below except those for periods of ice effect or doubtful or no gage-height record, which are poor. Gage read twice daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	184.8	8.4	1.9	5.96	367
November	164.4	6.9	2.7	5.48	326
December	39.7	3.1	.4	1.28	79
January	4.0	.3	0	.13	7.9
February	0	0	0	0	0
March	3,121	470	0	101	6,190
April	28,368	3,820	80	946	56,270
May	1,837	136	25	59.3	3,640
June	10,596	2,290	19	353	21,020
July	556.0	58	3.8	17.9	1,100
August	31.6	3.4	.2	1.02	63
September	121.2	16	.1	4.04	240
Water Year 1946-47	45,023.7	3,820	0	123	89,300

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	73.8	6.9	.5	2.38	146
November	194.3	6.9	6.0	6.48	385
December	173.8	6.9	5	5.61	345
January	80	4	1	2.6	159
February	9.4	.8	.2	.32	19
March	196.2	60	.2	6.33	389
April	15,526	1,460	60	518	30,800
May	1,591	104	15	51.3	3,160
June	584	28	13	19.5	1,160
July	428	18	12	13.8	849
August	283.4	13	4.4	9.14	562
September	46.6	4	.2	1.55	92
Water Year 1947-48	19,186.5	1,460	.2	52.4	38,070

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	21.5	2.6	0.1	0.69	43
November	185.9	9.4	3.2	6.20	369
December	54.4	4	.1	1.75	108
January	1.3	.1	0	.04	2.6
February	0	0	0	0	0
March	277.8	80	0	8.96	551
April	6,272	800	21	209	12,440
May	477.6	30	4.8	15.4	947
June	242.1	14	4	8.07	480
July	225	12	2	7.26	446
August	7.1	1	0	.23	14
September	0	0	0	0	0
Water year 1949	7,764.7	800	0	21.3	15,400

RED RIVER OF THE NORTH BASIN

Rush River at Amenia, N. Dak.

Location.—Wire-weight gage, lat. 47°00′40″, long. 97°13′10″, on line between sec. 23 and 24, T. 141 N., R. 52 W., on bridge on State Highway 18, 0.4 mile north of Amenia. Prior to Sept. 7, 1947, staff gage 150 feet downstream, at same datum.

Records available.—July 1946 to September 1949.

Extremes.—Maximum discharge during year, 400 second-feet Mar. 31; maximum gage height observed, 9.63 feet Mar. 29 (affected by ice): no flow during several months.

1946-49: Maximum discharge, 1,230 second-feet Apr. 14, 1947; maximum gage height, 10.20 feet, Apr. 8, 1948 (affected by ice); no flow for some periods in each year.

Remarks.—Records good except those for period of ice effect, which are fair.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	9.4	0.9	0	0.30	19
November	25.4	1.9	.3	.85	50
December	5.2	.3	0	.17	10
January	0	0	0	0	0
February	0	0	0	0	0
March	952	167	0	30.7	1,890
April	5,233	1,180	14	174	10,380
May	242.8	13	4.8	7.83	482
June	1,162.5	291	6	38.8	2,310
July	47.5	5.5	.1	1.53	94
August	0	0	0	0	0
September	0	0	0	0	0
Water Year 1946-47	7,677.8	1,180	0	21.0	15,240

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1.1	0.1	0	0.04	2.2
November	3.0	.1	.1	.10	6.0
December	4.0	1	.1	.13	7.9
January	3.1	.1	.1	.10	6.1
February	0	0	0	0	0
March	0	0	0	0	0
April	4,136	520	1	138	8,200
May	170.6	13	1.2	5.50	338
June	45.1	4.0	.5	1.50	89
July	15.7	1.6	.1	.51	31
August	3.5	.2	0	.11	6.9
September	0	0	0	0	0
Water Year 1947-48	4,382.1	520	0	12.0	8,690

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	5.5	.4	0	.18	11
December	1.0	.2	0	.03	2.0
January	0	0	0	0	0
February	0	0	0	0	0
March	472	320	0	15.2	936
April	1,218.3	250	1.8	40.6	2,420
May	80.0	7.2	.9	2.58	159
June	32.6	5.1	.2	1.09	65
July	61.5	13	.2	1.98	122
August	3.1	.5	0	.10	6.1
September	0	0	0	0	0
Water Year 1948-49	1,874.0	320	0	5.13	3,720

RED RIVER OF THE NORTH BASIN

Goose River near Portland, N. Dak.

Location.—Chain gage, lat. 47°33′, long. 97°28′, on line between secs. 12 and 13, T. 147 N., R. 54 W., at highway bridge 6½ miles northwest of Portland. Datum of gage is 978.76 feet above mean sea level, datum of 1929.

Drainage area.—544 square miles.

Records available.—October 1939 to September 1949.

Average discharge.—10 years, 19.9 second-feet.

Extremes.—Maximum discharge during year, 1,200 second-feet Apr. 7 (gage height, 13.60 feet, affected by ice); no flow for several months.

1939-49: Maximum discharge, 4,700 second-feet Apr. 21, 1948 (gage height, 21.30 feet); no flow for several months in each year.

Remarks.—Records good except those for periods of indefinite stage-discharge relation, which are poor. Gage read once daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	0	0	0	0	0
December	0	0	0	0	0
January	0	0	0	0	0
February	0	0	0	0	0
March	0	0	0	0	0
April	24,584	4,110	0	819	48,760
May	2,052	200	17	66.2	4,070
June	218.1	16	4.2	7.27	433
July	193.2	31	3.4	6.23	383
August	93.8	8.0	.2	3.03	186
September	0	0	0	0	0
Water Year 1947-48	27,141.1	4,110	0	74.2	53,830

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	3.0	.1	.1	.10	6.0
December	4.0	.2	.1	.13	7.9
January	3.1	.1	.1	.10	6.1
February	0	0	0	0	0
March	5.1	3	0	.16	10
April	7,709	1,100	5	257	15,290
May	341.1	23	3.2	11.0	677
June	1,730.2	535	2.1	57.7	3,430
July	150.4	40	.1	4.85	298
August	27.1	4.0	0	.87	54
September	0	0	0	0	0
Water Year 1948-49	9,973.0	1,100	0	27.3	19,780

RED RIVER OF THE NORTH BASIN

Goose River at Hillsboro, N. Dak.

Location.—Water-stage recorder, lat. 47°24′, long. 97°03′, in NW¼ sec. 5, T. 145 N., R. 50 W., 50 feet upstream from city water-supply dam.

Drainage area.—1,200 square miles.

Records available.—March 1931 to September 1949 (no winter records prior to 1938).

Average discharge.—11 years (1938-49), 44.6 second feet.

Extremes.—Maximum discharge during year, 1,640 second-feet Apr. 8 (gage height, 3.38 feet); minimum, 0.1 second-foot Oct. 1-11; minimum gage height, -1.03 feet Sept. 30.

1931-49: Maximum discharge, 4,180 second feet Apr. 16, 1948 (gage height, 10.65 feet); no flow at times in 1936, 1938-47.

Maximum stage since 1897, 11.55 feet March 25, 26, 1920 (present datum); discharge 4,800 second feet. Stage in 1897 was about 3 feet higher.

Remarks.—Records good except those for periods of ice effect or indefinite stage-discharge relation, which are fair.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	23.8	1.2	0.6	0.77	47
November	65.6	2.8	1.3	2.19	130
December	45.2	2.3	.9	1.46	90
January	14.0	.8	.2	.45	28
February	2.9	.1	.1	.10	5.8
March	16.5	1.6	.1	.53	33
April	55,198.8	4,150	1.5	1,840	109,500
May	4,588	474	46	148	9,100
June	696	44	14	23.2	1,380
July	485	46	10	15.6	961
August	307.0	18	2.0	9.90	609
September	28.5	2.0	.2	.95	57
Water Year 1947-48	61,471.3	4,150	.1	168	121,900

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	13.8	2.3	0.1	.45	27
November	113.3	5.8	2.5	3.78	225
December	50.0	2	.5	1.61	99
January	14.2	.5	.4	.46	28
February	7.2	.3	.2	.26	14
March	35.2	6	.3	1.14	70
April	15,486	1,550	8	516	30,720
May	1,174	62	14	37.9	2,330
June	4,766	838	14	159	9,450
July	577.6	65	9.4	18.6	1,150
August	388.6	73	1.5	12.5	771
September	33.3	1.4	.8	1.11	66
Water Year 1948-49	22,659.2	1,550	.1	62.1	44,950

RED RIVER OF THE NORTH BASIN

Turtle River at Manvel, N. Dak.

Location.—Chain gage, lat. 48°05′, long. 97°11′, in SE¼ sec. 10, T. 153 N., R. 51 W., at bridge on State Highway 33, 0.3 mile west of Manvel and 10 miles upstream from mouth.

Records available.—October 1945 to September 1949.

Extremes.—Maximum daily discharge during year, 1,600 second-feet Apr. 10; maximum gage height, 16.35 feet Apr. 9 (affected by ice); minimum discharge, 0.1 second-foot Jan. 10 to Apr. 6, Sept. 24, 25.

1945-49: Maximum discharge, 3,450 second-feet Apr. 19, 1948 (gage-height, 17.88 feet); minimum, 0.1 second-foot at times each year.

Remarks.—Records good except those for period of ice effect which are fair. Gage read once daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	353.5	57	1.6	11.4	701
November	131.3	6.9	1.9	4.38	260
December	58.8	2.5	.8	1.90	117
January	5.8	.8	.1	.19	12
February	2.8	.1	.1	.10	5.6
March	2,273.1	350	.1	73.3	4,510
April	5,793	418	27	193	11,490
May	639	31	14	20.6	1,270
June	1,763	259	11	58.8	3,500
July	257.1	16	2.8	8.29	510
August	266.3	35	1.4	8.59	528
September	45.7	5.6	.5	1.52	91
Water Year 1946-47	11,589.4	418	.1	31.8	22,990

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	198.4	12	1.7	6.40	394
November	211.6	9.9	5.0	7.05	420
December	77.4	5.0	.3	2.50	154
January	3.6	.2	.1	.12	7.1
February	2.9	.1	.1	.10	5.8
March	3.1	.1	.1	.10	6.1
April	27,063.7	3,360	.1	902	53,680
May	2,121	212	20	68.4	4,210
June	2,646	447	19	88.2	5,250
July	654.3	62	7.9	21.1	1,300
August	310.0	28	3.4	10.0	615
September	65.7	19	.4	2.19	130
Water Year 1947-48	33,357.7	3,360	.1	91.1	66,170

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	40.2	4.8	0.2	1.30	80
November	138.6	8.6	1	4.62	275
December	14.5	1	.2	.47	29
January	4.0	.2	.1	.13	7.9
February	2.8	.1	.1	.10	5.6
March	3.1	.1	.1	.10	6.1
April	11,536.6	1,600	.1	385	22,880
May	889	51	14	28.7	1,760
June	1,021.2	162	8.2	34.0	2,030
July	260.3	13	4.4	8.40	516
August	94.5	9.7	.5	3.05	187
September	12.4	.8	.1	.41	25
Water Year 1948-49	14,017.2	1,600	.1	38.4	27,800

RED RIVER OF THE NORTH BASIN

Forest River near Fordville, N. Dak.

Location.—Chain gage, lat. 48°12′, long. 97°44′, on line between sec. 32 and 33, T. 155 N., R. 55 W., at highway bridge, a quarter of a mile downstream from South Branch and 3 miles southeast of Fordville.

Drainage area.—491 square miles.

Records available.—April 1940 to September 1949.

Extremes.—Maximum discharge observed during year, 1,470 second-feet Apr. 7 (gage height 5.64 feet); minimum daily discharge, 2.1 second-feet Oct. 5; minimum gage height observed, 1.23 feet Aug. 22.

1940-49: Maximum discharge, 19,000 second-feet, Apr. 18, 1948, (gage height, 14.25 feet), by slope area method; no flow Apr. 1-13, Sept. 3, 1940.

Remarks.—Records fair after Apr. 6 and poor before. Gage read once daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	142.2	6.0	3.6	4.59	282
November	127.5	4.5	4.0	4.25	253
December	131.5	4.5	2.0	4.24	261
January	99.6	3.8	2.0	3.21	198
February	60.8	2.6	1.7	2.17	121
March	2,030.0	600	2.6	65.5	4,030
April	1,249	150	12	41.6	2,480
May	279.1	12	7.3	9.00	554
June	223.6	8.4	5.9	7.45	444
July	182.7	48	3.4	5.89	362
August	105.8	5.0	3.0	3.41	210
September	105.5	10	2.8	3.52	209
Water Year 1946-47	4,737.3	600	1.7	13.0	9,400

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	150.9	7.6	4.0	4.87	299
November	139.5	6.0	3.8	4.65	277
December	174.1	6.0	5.0	5.62	345
January	155	5	5	5.0	307
February	145	5	5	5.0	288
March	161.5	5.5	5	5.21	320
April	26,770	7,480	5	892	53,100
May	1,416	126	19	45.7	2,810
June	638	72	12	21.3	1,270
July	276.1	15	5.9	8.91	548
August	261.9	20	4.5	8.45	519
September	118.3	4.5	3.5	3.94	235
Water Year 1947-48	30,406.3	7,480	3.5	83.1	60,320

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	133.3	5.5	2.1	4.30	264
November	155.2	6.3	4.5	5.17	308
December	117.4	4.6	3.5	3.79	233
January	93	------	------	3	184
February	84	------	------	3	167
March	149.2	10	3	4.81	296
April	10,019	1,180	13	334	19,870
May	553	38	11	17.8	1,100
June	228.3	15	5.1	7.61	453
July	340.3	23	5.0	11.0	675
August	159.1	6.9	3.4	5.13	316
September	107.3	4.0	3.2	3.58	213
Water Year 1948-49	12,139.1	1,180	2.1	33.3	24,080

RED RIVER OF THE NORTH BASIN

Forest River at Minto, N. Dak.

Location.—Wire-weight gage, lat. 48°16′10″, long. 97°22′10″, in SE¼ sec. 31, T. 156 N., R. 52 W., in Minto.

Records available.—April 1944 to September 1949.

Extremes.—Maximum discharge during year, 2,140 second-feet Apr. 7 (gage height, 8.19 feet); minimum, 0.4 second-foot Mar. 13-19; minimum gage height, 1.14 feet Oct. 7-10.

1944-49: Maximum discharge, 12,000 second-feet April 19, 1948 (gage height, 11.80 feet); by contracted opening measurement; no flow at times each year 1945-47.

Remarks.—Records fair. Gage read once daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	157.1	7.2	2.3	5.07	312
November	174.8	7.2	3.8	5.83	347
December	84.9	4.6	.8	2.74	168
January	15.4	1.2	.3	.50	31
February	.6	.1	0	.02	1.2
March	2,790	700	0	90.0	5,530
April	2,901	270	24	96.7	5,750
May	532	26	13	17.2	1,060
June	466.3	30	9.3	15.5	925
July	607.9	129	5.4	19.6	1,210
August	166.6	8.2	3.8	5.37	330
September	109.4	6.2	1.2	3.65	217
Water Year 1946-47	8,006.0	700	0	21.9	15,880

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	121.3	6.2	1.7	3.91	241
November	182.9	7.2	5.4	6.10	363
December	162.2	5.4	4.6	5.23	322
January	107.0	4.6	2.3	3.45	212
February	21.9	2.3	.3	.76	43
March	5.5	.3	.1	.18	11
April	37,519.3	9,900	.5	1,251	74,420
May	3,294	270	39	106	6,530
June	1,215	80	23	40.5	2,410
July	581	35	12	18.7	1,150
August	294.8	16	5.4	9.51	585
September	142.2	7.2	3.8	4.74	282
Water Year 1947-48	43,647.1	9,900	.1	119	86,570

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	125.4	7.2	0.5	4.05	249
November	210.4	9.3	6.2	7.01	417
December	114.1	6.2	2	3.68	226
January	35.2	2	.6	1.14	70
February	14.0	------	------	.5	28
March	18.4	1	.4	.59	36
April	15,514	2,000	2	517	30,770
May	1,162	71	22	37.5	2,300
June	523	24	12	17.4	1,040
July	347.0	30	4.8	11.2	688
August	102.3	8.9	1.0	3.30	203
September	19.6	1.0	.5	.65	39
Water Year 1948-49	18,185.4	2,000	.4	49.8	36,070

RED RIVER OF THE NORTH BASIN

South Branch Park River near Park River, N. Dak.

Location.—Chain gage, lat. 48°24′, long. 97°50′, on line between sec. 15 and 16, T. 157 N., R. 56 W., at highway bridge, half a mile upstream from small stream and 4½ miles northwest of town of Park River.

Drainage area.—255 square miles.

Records available.—March 1940 to September 1949.

Extremes.—Maximum discharge observed during year, 1,200 second-feet Apr. 9 (gage height, 5.93 feet); no flow Aug. 5-10, 15-21, 25-31, Sept. 1-5.

1940-49: Maximum discharge, 11,000 second-feet Apr. 18, 1948 (gage height, 11.80 feet); no flow during part of most years.

Remarks.—Records good except those for periods of ice effect or doubtful gage-height record, which are poor. Gage read once daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	11.6	1.0	0.1	0.37	23
November	5.1	.2	.1	.17	10
December	3.1	.1	.1	.10	6.1
January	1.0	.1	0	.03	2.0
February	0	0	0	0	0
March	912.3	160	0	29.4	1,810
April	2,399.9	210	8.4	80.0	4,760
May	122.2	8.9	2.3	3.94	242
June	473.9	94	2.0	15.8	940
July	739.4	258	.4	23.9	1,470
August	77.5	9.4	.3	2.50	154
September	94.7	38	.1	3.16	188
Water Year 1946-47	4,840.7	258	0	13.3	9,610

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	48.0	5.6	0.8	1.55	95
November	28.4	1.4	.6	.95	56
December	14.3	.6	.3	.46	28
January	4.6	.2	.1	.15	9.1
February	2.9	.1	.1	.10	5.8
March	9.4	.8	.1	.30	19
April	17,354.7	4,900	.8	578	34,420
May	1,420	113	12	45.8	2,820
June	349	18	6.8	11.6	692
July	625.4	59	9.4	20.2	1,240
August	673.3	144	2.2	21.7	1,340
September	7.8	.9	.2	.26	15
Water Year 1947-48	20,537.8	4,900	.1	56.1	40,740

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	11.8	0.8	0.2	0.38	23
November	6.2	.3	.2	.21	12
December	4.3	.2	.1	.14	8.5
January	3.1	.1	.1	.10	6.1
February	2.8	.1	.1	.10	5.6
March	3.5	.4	.1	.11	6.9
April	7,532.7	1,110	.7	251	14,940
May	401.5	35	4.6	13.0	796
June	67.8	6.1	.7	2.26	134
July	11.4	1.0	.1	.37	23
August	1.3	.2	0	.04	2.6
September	4.4	.2	0	.15	8.7
Water Year 1948-49	8,050.8	1,110	0	22.1	15,970

RED RIVER OF THE NORTH BASIN

Park River at Grafton, N. Dak.

Location.—Wire-weight gage, lat. 48°25′, long. 97°24′, in NE¼ sec. 13, T. 157 N., R. 53 W., in Grafton. Rubble masonry control dam 2 miles downstream. Datum of gage is 807.39 feet above mean sea level, adjustment of 1929.

Drainage area.—753 square miles.

Records available.—April 1931 to September 1949 (incomplete prior to 1937).

Average discharge.—13 years (1936-49), 46.2 second-feet.

Extremes.—Maximum discharge during year, 2,530 second-feet Apr. 11; maximum gage height, 17.25 feet Apr. 9 (affected by ice); no flow Sept. 18-30.

1931-49: Maximum discharge, 11,700 second-feet Apr. 19, 1948 (gage height, 20.06 feet); no flow at times in most years.

Remarks.—Records good except those for period of ice effect, which are fair. Gage read once or twice daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	11.8	1.9	0	0.38	23
November	5.7	.5	.1	.19	11
December	1.2	.1	0	.04	2.4
January	0	0	0	0	0
February	0	0	0	0	0
March	147	60	0	4.7	292
April	5,095	500	26	170	10,110
May	302.3	26	2.2	9.75	600
June	625.1	40	1.5	20.8	1,240
July	1,921.5	375	1.0	62.0	3,810
August	394.3	55	.8	12.7	782
September	112.3	30	.1	3.74	223
Water Year 1946-47	8,616.2	500	0	23.6	17,090

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	39.8	3.3	0.3	1.28	79
November	75.3	5.3	1.0	2.51	149
December	74.6	3.3	1.0	2.41	148
January	15.0	1.0	.3	.48	30
February	3.4	.2	.1	.12	6.7
March	14.4	1.5	.1	.46	29
April	54,257.4	10,500	1.5	1,809	107,600
May	6,744	868	47	218	13,380
June	1,134	88	14	37.8	2,250
July	1,400	80	23	45.2	2,780
August	945.1	261	7.5	30.5	1,870
September	70.0	7.5	.9	2.33	139
Water Year 1947-48	64,773.0	10,500	.1	177	128,500

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	15.0	2.2	.1	.48	30
November	31.0	2.2	.5	1.03	61
December	11.9	.5	.3	.38	24
January	7.0	.3	.2	.23	14
February	5.6	.2	.2	.20	11
March	9.6	1	.2	.31	19
April	23,065	2,500	2	769	45,750
May	1,592	122	17	51.4	3,160
June	344.8	21	4.6	11.5	684
July	70.6	3.9	1.0	2.28	140
August	35.8	4.6	.2	1.15	71
September	1.8	.2	0	.06	3.6
Water Year 1948-49	25,190.1	2,500	0	69.0	49,970

RED RIVER OF THE NORTH BASIN

Pembina River near Manitou, Manitoba

Location.—Chain gage, lat. 49°08′50″, long. 98°23′30″, on bridge near Lea's farm, 9 miles south of Manitou.

Drainage area.—2,060 square miles.

Records available.—October 1929 to September 1949 (incomplete) in reports of Geological Survey. April 1921 to September 1949 in reports of Dominion Water and Power Bureau, Department of Mines and Resources, Canada.

Extremes.—Maximum discharge observed during year, 5,030 second-feet Apr. 17 (gage height, 101.68 feet); minimum discharge not determined.

1921-49: Maximum daily discharge observed, that of Apr. 17, 1949; no flow on many days in 1934, 1937, 1939-41.

Remarks.—Records good except those for period of ice effect, which are poor. Gage read once daily.

Cooperation.—Records furnished by Dominion Water and Power Bureau, Department of Mines and Resources, Canada.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,032.5	40.8	28.0	33.3	2,050
November 1-7	210.5	31.5	29.0	20.1	418
December	------	------	------	------	------
January	------	------	------	------	------
February	------	------	------	------	------
March	------	------	------	------	------
April 12-30	9,839	1,190	10.0	518	19,520
May	18,194	684	413	587	36,090
June	7,884	399	172	263	15,640
July	4,928	258	131	159	9,780
August	4,287	199	106	138	8,500
September	2,576	113	58	86	5,110
Water Year 1947-48	------	------	------	------	------

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,269.3	55	29.5	40.9	2,520
November 1-13	392.5	31.5	29.0	30.2	779
December	------	------	------	------	------
January	------	------	------	------	------
February	------	------	------	------	------
March	------	------	------	------	------
April 5-30	60,790	5,030	20	2,340	120,600
May	33,667	1,950	641	1,090	66,780
June	14,122	795	272	471	28,010
July	6,009	262	144	194	11,920
August	2,892	138	65	93	5,740
September	1,592.4	74	32	53	3,160
Water Year 1948-49	------	------	------	------	------

RED RIVER OF THE NORTH BASIN

Pembina River near Walhalla, N. Dak.

Location.—Water-stage recorder, lat. 48°53′32″, long. 97°59′09″, in SE¼SW¼ sec. 35, T. 163 N., R. 57 W., 1½ miles downstream from Little Pembina River and 3½ miles southwest of Walhalla.

Drainage area.—3,020 square miles.

Records available.—October, 1939 to September 1949.

Average discharge.—10 years, 210 second-feet.

Extremes.—Maximum discharge during year, 5,840 second-feet Apr. 19 (gage height, 13.18 feet); minimum discharge, 4 second-feet Mar. 5-22; minimum gage height, 1.97 feet Nov. 9.

1939-49: Maximum discharge, 7,280 second-feet Apr. 19, 1948 (gage height, 14.94 feet); no flow during parts of 1940, 1941, 1947.

Remarks.—Records good except those for period of ice effect, which are fair.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,416	64	38	45.7	2,810
November	780	37	16	26.0	1,550
December	445	18	11	14.4	883
January	375	14	8	12.1	744
February	150	7	5	5.2	298
March	213	10	5	6.9	422
April	29,315	4,340	11	977	58,150
May	25,826	1,050	603	833	51,230
June	10,833	580	230	361	21,490
July	8,493	504	171	274	16,850
August	5,896	260	154	190	11,690
September	3,324	154	76	111	6,590
Water year 1947-48	87,066	4,340	5	238	172,700

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,887	74	47	60.9	3,740
November	1,119	56	26	37.3	2,220
December	597	30	14	19.3	1,180
January	510	18	14	16.5	1,010
February	258	14	6	9.2	512
March	174	14	4	5.6	345
April	81,079	5,740	16	2,703	160,800
May	43,667	2,550	830	1,409	86,610
June	18,068	969	342	602	35,840
July	7,156	330	177	231	14,190
August	3,713	175	76	120	7,360
September	1,748	74	41	58.3	3,470
Water Year 1948-49	159,976	5,740	4	438	317,300

RED RIVER OF THE NORTH BASIN

Pembina River at Neche, N. Dak.

Location.—Water-stage recorder 60 feet upstream from concrete dam, lat. 48°59′20″, long. 97°33′05″, in SE¼NW¼ sec. 31, T. 164 N., R. 53 W., in Neche.

Drainage area.—3,080 square miles.

Records available.—May 1903 to September 1915, April 1919 to September 1949.

Average discharge.—30 years (1919-49), 142 second-feet.

Extremes.—Maximum discharge during year, 5,010 second-feet Apr. 22 (gage height, 20.83 feet); minimum discharge, 10 second-feet Mar. 28 to Apr. 2; minimum gage height, 5.88 feet Dec. 17-24, Jan. 16.

1903-15, 1919-49: Maximum discharge, that of Apr. 22, 1949; no flow at times during each year, 1932-41.

Remarks.—Records excellent except those for periods of ice effect, which are fair.

Cooperation.—This station is one of the international gaging stations maintained by the United States under agreement with Canada.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	2,064	82	51	66.6	4,090
November	1,371	64	33	45.7	2,720
December	640	33	12	20.6	1,270
January	397	14	12	12.8	787
February	336	12	12	12.0	666
March	355	12	10	11.5	704
April	72,838	4,910	10	2,428	144,500
May	48,650	3,070	857	1,569	96,500
June	19,708	970	401	657	39,090
July	8,448	388	215	273	16,760
August	4,413	208	88	142	8,750
September	2,073	88	56	69.1	4,110
Water Year 1948-49	161,293	4,910	10	442	319,900

RED RIVER OF THE NORTH BASIN

Tongue River at Cavalier, N. Dak.

Location.—Staff gage and concrete control, lat. 48°47′55″, long. 97°37′35″, in SE¼NE¼ sec. 4, T. 161 N., R. 54 W., half a mile upstream from State Highway 5 in Cavalier.

Drainage area.—135 square miles.

Records available.—October 1938 to September 1949.

Average discharge.—11 years, 18.7 second-feet.

Extremes.—Maximum discharge observed during year, 681 second-feet Apr. 11; maximum gage height observed, 3.60 feet Apr. 9 (affected by ice); minimum discharge not determined.

1938-49: Maximum discharge, 1,300 second-feet Apr. 21, 1948 (gage height, 4.38 feet); no flow for several months in some years.

Remarks.—Records good Apr. 10 to June 11; poor at other times. Gage read once daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	157.7	7.9	1.5	5.09	313
November	120.3	8.9	1.5	4.01	239
December	94.0	3.1	3.0	3.03	186
January	69.6	2.8	1.0	2.25	138
February	17.0	1.0	.5	.59	34
March	26.9	2.2	.5	.87	53
April	8,190.6	1,100	2.2	273	16,250
May	1,996	138	25	64.4	3,960
June	460	24	10	15.3	912
July	613.7	56	6.0	19.8	1,220
August	236.4	21	3.8	7.63	469
September	61.6	3.8	1.1	2.05	122
Water Year 1947-48	12,043.8	1,100	.5	32.9	23,900

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	93.4	5.2	.7	3.01	185
November	92.2	6.9	1.5	3.07	183
December	31.0	.....	....	1.0	61
January	15.5	.....	.....	.5	31
February	2.8	.....	....	.1	5.6
March	45.6	6.9	.1	1.47	90
April	5,275.5	676	5.2	176	10,460
May	698	41	13	22.5	1,380
June	263.3	21	3.1	8.78	522
July	77.5	3.8	.7	2.50	154
August	40.3	3.1	.4	1.30	80
September	43.4	3.8	.4	1.45	86
Water Year 1948-49	6,678.5	676	.1	18.3	13,240

RED RIVER OF THE NORTH BASIN
Souris River near Sherwood, N. Dak.
(International gaging station)

Location.—Water-stage recorder and concrete control, lat. 48°59′, long. 101°58′, in NE¼ sec. 33, T. 164 N., R. 87 W., three-quarters of a mile south of international boundary and 16 miles northwest of Sherwood. Datum of gage is 1,604.00 feet (revised) above mean sea level, datum of 1929.

Drainage area.—9,570 square miles.

Records available.—March 1930 to September 1949.

Average discharge.—15 years (1934-49), 95.9 second-feet.

Extremes.—Maximum discharge during year, 2,720 second-feet Apr. 11 (gage height, 20.56 feet); minimum 1 second-foot Jan. 22-28, Feb. 4, 5, 15-22; minimum gage height, 1.39 feet Sept. 18-19.

1930-49: Maximum discharge, 7,400 second-feet Apr. 28, 1948 (gage height, 23.80 feet); no flow for periods in most years.

Remarks.—Records good except those for period of ice effect, which are fair.

Cooperation.—This is one of the international gaging stations maintained by the United States under agreement with Canada.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	295.5	14	7.5	9.53	586
November	459.7	27	9.7	15.3	912
December	228	12	3	7.4	452
January	76	4	1	2.5	151
February	67	6	1	2.4	133
March	147	8	3	4.7	292
April	24,675	2,700	7	822	48,940
May	2,386	180	41	77.0	4,730
June	1,614	116	30	53.8	3,200
July	567	39	11	18.3	1,120
August	356.2	21	5.2	11.5	707
September	111.1	5.2	2.1	3.70	220
Water Year 1948-49	30,982.5	2,700	1	84.9	61,440

RED RIVER OF THE NORTH BASIN
Souris River near Foxholm, N. Dak.

Location.—Water stage recorder and artificial control, lat. 48°22′, long. 101°30′, in SW¼SE¼ sec. 34, T. 157 N., R. 84 W., 3 miles east of Foxholm. Datum of gage is 1,560.73 feet above mean sea level, datum of 1929.

Drainage area.—10,100 square miles.

Records available.—June 1904 to November 1905, April 1937 to September 1949.

Average discharge.—12 years (1937-49) 93.3 second-feet.

Extremes.—Maximum discharge during year, 690 second-feet Apr. 15; maximum gage-height, 10.63 feet about Mar. 22 (high water mark; affected by ice); maximum reverse flow, 25 second-feet April 4; minimum gage height, 5.05 feet Aug. 9, 10.

1904-05, 1937-49: Maximum discharge, 3,040 second-feet May 16, 1948 (gage height, 14.79 feet); maximum reverse flow, that of Apr. 4, 1949.

Remarks.—Records good. Flow completely regulated by Lake Darling and several smaller reservoirs.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	340.5	91	0.2	11.0	675
November	4.6	.3	.1	.15	9.1
December	4.4	.3	0	.14	8.7
January	4.7	.3	.1	.15	9.3
February	2,301.6	200	.1	82.2	4,570
March	13,400	600	250	432	26,580
April	9,275.0	681	—5	309	18,400
May	6,161.2	614	2.0	199	12,220
June	306.2	37	2.0	10.2	607
July	130.3	25	.1	4.20	258
August	393.8	26	0	12.7	781
September	380.5	24	.8	12.7	755
Water Year 1948-49	32,702.8	681	—5	89.6	64,870

RED RIVER OF THE NORTH BASIN
Souris River above Minot, N. Dak.

Location.—Water-stage recorder and concrete control, lat. 48°14′45″, long. 101° 22′15″, near center of sec. 17, T. 155 N., R. 83 W., 3½ miles west of Minot. Datum of gage is 1,545.75 feet above mean sea level, datum of 1929.

Drainage area.—11,300 square miles.

Records available.—May 1903 to March 1924, April 1927 to September 1928, and October 1929 to September 1934 at site at Minot, 10 miles downstream, and October 1934 to September 1949 at present site, in reports of Geological Survey. May 1903 to September 1949 in reports of State Engineer. Records equivalent except those for periods of low flow, when considerable industrial and sanitary waste enters river between the two sites.

Average discharge.—36 years (1913-49), 121 second-feet.

Extremes.—Maximum discharge during year, 2,250 second-feet April 6 (gage height, 16.56 feet, backwater from ice); minimum, 1 second-foot Jan. 20 to Feb. 18.

1903-49: Maximum discharge, 12,000 second-feet Apr. 20, 1904 (gage height, 21.9 feet at site at Minot), from rating curve extended above 8,100 second-feet; no flow at times in many years.

Maximum stage known at present site, about 23 feet in April 1904.

Remarks.—Records good except those for periods of ice effect or no gage height record, which are fair. Flow of Souris and Des Lacs Rivers completely regulated by Fish and Wildlife Service dams above station.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	828.0	97	9.8	26.7	1,640
November	390.0	20	7	13.0	774
December	117.8	7	2	3.80	234
January	50	------	------	1.6	99
February	1,818	200	1	64.9	3,610
March	12,950	600	200	418	25,690
April	24,275	2,200	265	809	48,150
May	7,673	646	45	248	15,220
June	2,032	158	39	67.7	4,030
July	728	37	14	23.5	1,440
August	457.8	31	2.3	14.8	908
September	320.6	21	1.8	10.7	636
Water Year 1948-49	51,640.2	2,200	1	141	102,400

RED RIVER OF THE NORTH BASIN
Souris River near Verendrye, N. Dak.

Location.—Water-stage recorder, lat. 48°09′, long. 100°44′, in NW¼SW¼ sec. 17, T. 154 N., R. 78 W., 3 miles northeast of Verendrye and 7½ miles southwest of (19 miles upstream from) mouth of Wintering River. Datum of gage is 1,464.87 feet above mean sea level, datum of 1929.

Drainage area.—12,200 square miles.

Records available.—February to June 1933 (gage heights only), April 1937 to September 1949 (winter records incomplete prior to 1945).

Extremes.—Maximum discharge during year, about 4,200 second-feet Apr. 8 (gage height, 17.7 feet, high water mark, backwater from ice); minimum not determined.

1937-49: Maximum discharge, that of Apr. 8, 1949; minimum discharge recorded, 0.3 second-foot Aug. 11-19, 1937, Oct. 10-21, 1939.

Remarks.—Records good except those for Apr. 6-26, Sept. 15-30, which are fair, and those for Dec. 1 to Apr. 5, which are poor. Flow regulated by Fish and Wildlife Service dams on Souris and Des Lacs Rivers.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	1,448	97	21	46.7	2,870
November	830	38	16	27.7	1,650
December	268	15	5	8.6	532
January	219	15	4	7.1	434
February	84	------	------	3	167
March	10,510	500	5	339	20,850
April	43,154	4,000	500	1,438	85,590
May	10,426	599	104	336	20,680
June	4,164	342	80	139	8,260
July	1,591	76	35	51.3	3,160
August	993	52	15	32.0	1,970
September	515	24	14	17.2	1,020
Water Year 1948-49	74,202	4,000	------	203	147,200

RED RIVER OF THE NORTH BASIN
Souris River near Bantry, N. Dak.

Location.—Water-stage recorder, lat. 48°30′, long. 100° 45′, in SE¼ sec. 14, T. 158 N., R. 76 W., 8 miles east of Bantry.

Drainage area.—13,400 square miles.

Records available.—March 1937 to September 1949 (no winter records prior to 1945).

Extremes:—Maximum discharge during year, 4,760 second-feet Apr. 10 (gage height, 13.76 feet, high water mark); minimum not determined; minimum gage height, 1.03 feet Sept. 26, 27.

1937-49: Maximum discharge, that of Apr. 10, 1949; no flow at times in each year 1937-40.

Remarks.—Records good except those for Apr. 6-11, June 19-28, Aug. 2-17, Aug. 28 to Sept. 7, which are fair, and those for Nov. 2 to Apr. 5, which are poor. Water diverted for irrigation at Eaton Dam about 42 miles above station. Flow regulated by Fish and Wildlife Service dams on Souris and Des Lacs Rivers.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	2,290	106	47	73.9	4,540
November	1,378	65	25	45.9	2,730
December	463	25	8	14.9	918
January	289	15	6	9.3	573
February	144	----	----	5.10	286
March	7,244	500	5	234	14,370
April	57,420	4,560	500	1,914	113,900
May	18,767	1,230	198	605	37,220
June	7,160	440	116	239	14,200
July	2,334	109	54	75.3	4,530
August	1,227	60	21	39.6	2,430
September	599	40	12	20.0	1,190
Water Year 1948-49	99,315	4,560		272	197,000

RED RIVER OF THE NORTH BASIN
Souris River near Westhope, N. Dak.
(International gaging station)

Location.—Water-stage recorder and concrete control, lat. 49°00′, long. 100°57′, in SW¼SE¼ sec. 30, T. 164 N., R. 79 W., 1,200 feet upstream from International Boundary, 1 mile downstream from Fish and Wildlife Service dam 357, and 7 miles northeast of Westhope. Datum of gage is 1,401.74 feet above mean sea level, datum of 1929.

Drainage area.—17,600 square miles.

Records available.—October 1937 to September 1949. July 1929 to September 1937, at site 6¼ miles upstream.

Average discharge.—14 years (1935-49), 145 second-feet.

Extremes.—Maximum discharge during year, 6,400 second-feet Apr. 18, maximum gage height, 16.9 feet (floodmark) Apr. 20; minimum discharge, 7 second-feet Mar. 11-25, minimum gage-height, 5.24 feet July 15, 16.

1929-49: Maximum discharge, that of Apr. 18, 1949; maximum gage height, that of Apr. 20, 1949; no flow during several periods.

Remarks.—Records fair. Flow regulated by Fish and Wildlife Service dams on Souris and Des Lacs Rivers.

Cooperation.—This station is one of the international gaging stations maintained by the United States under agreement with Canada.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	618	30	17	19.9	1,230
November	1,409	80	10	47.0	2,790
December	2,065	80	50	66.6	4,100
January	1,000	50	20	32.3	1,980
February	377	18	9	13.5	748
March	233	8	7	7.5	462
April	96,696	6,300	9	3,223	191,800
May	45,143	3,400	550	1,456	89,540
June	18,374	900	345	612	36,440
July	1,221.5	247	9.5	39.4	2,420
August	1,224	44	36	39.5	2,430
September	971	38	18	32.4	1,930
Water Year 1948-49	169,331.5	6,300	7	464	335,900

RED RIVER OF THE NORTH BASIN
Long Creek near Crosby, N. Dak.

Location.—Wire-weight gage, lat. 48°58′30″, long. 103°15′40″, in NW¼ sec. 3, T. 163 N., R. 97 W., on county highway bridge 5 miles northeast of Crosby.

Records available.—March to April 1943, April 1944 to September 1949.

Extremes.—Maximum discharge during year, about 500 second-feet Apr. 3; maximum gage height, 10.5 feet Apr. 1 (affected by ice); no flow during several months.

1943-49; Maximum discharge, 6,240 second-feet Apr. 23, 1948; maximum gage height, 16.10 feet Apr. 22, 23, 1948; no flow during part of each year.

Remarks.—Records fair. Gage read once daily.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	0	0	0	0	0
November	1.3	.2	0	.04	2.6
December	1.6	.6	0	.05	3.2
January	0	0	0	0	0
February	0	0	0	0	0
March	252	200	0	8.1	500
April	3,883	480	15	129	7,700
May	197.3	14	.8	6.36	391
June	69.5	11	.1	2.32	138
July	0	0	0	0	0
August	0	0	0	0	0
September	0	0	0	0	0
Water Year 1948-49	4,404.7	480	0	12.1	8,730

RED RIVER OF THE NORTH BASIN
Des Lacs River at Foxholm, N. Dak.

Location.—Water-stage recorder, lat. 48°22′, long. 101°34′, in NW¼ sec. 2, T. 156 N., R. 85 W., at county highway bridge in Foxholm. Datum of gage is 1,632.98 feet above mean sea level, datum of 1929. Prior to Aug. 31, 1948, staff gage at same site and datum.

Drainage area.—973 square miles.

Records available.—June 1904 to July 1906, October 1945 to September 1949.

Extremes.—Maximum discharge during year, 2,000 second-feet Apr. 4 (gage height, 18.04 feet, backwater from ice); minimum not determined.

1904-6, 1945-49: Maximum discharge, that of Apr. 4, 1949; no flow at times in most years.

Flood in June 1944 reached a stage of 19.0 feet, from floodmarks.

Remarks.—Records fair.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	289.5	15	4.5	9.34	574
November	206.6	11	4.5	6.89	410
December	68.2	5.2	.8	2.20	135
January	8.1	.5	.1	.26	16
February	2.8	----	----	.1	5.6
March	5.0	1	---	.16	9.9
April	10,822	1,800	5	361	21,470
May	1,340	63	19	43.2	2,660
June	1,284	76	30	42.8	2,550
July	530.8	25	9.8	17.1	1,050
August	127.9	10	1.2	4.13	254
September	23.1	1.5	.4	.77	46
Water Year 1948-49	14,708.0	1,800	----	40.3	29,180

RED RIVER OF THE NORTH BASIN
Wintering River near Karlsruhe, N. Dak.

Location.—Water-stage recorder and concrete control, lat. 48°10′, long. 100°32′, on line between secs. 10 and 11, T. 154 N., R. 77 W., 80 feet upstream from highway bridge, 4 miles upstream from mouth, and 7 miles northeast of Karlsruhe.

Drainage area.—675 square miles.

Records available.—March 1937 to September 1949 (no winter records prior to 1945).

Extremes.—Maximum discharge during year, 3,000 second-feet Apr. 7; maximum gage height, 12.0 feet Apr. 7 (affected by ice); no flow Jan. 16 to Feb. 28.

1937-49: Maximum discharge, that of Apr. 7, 1949; maximum gage height, that of Apr. 7, 1949; no flow at times in many years.

Remarks.—Records fair except those for period of ice effect, which are poor.

Month	Second Foot Days	Maximum	Minimum	Mean	Run-off in Acre-Feet
October	131.8	7.6	2.9	4.25	261
November	155.0	7.6	4	5.17	307
December	49.8	4	.6	1.61	99
January	3.9	.5	0	.13	7.7
February	0	0	0	0	0
March	3.1	.....	.....	.1	6.1
April	11,591.7	2,500	.1	386	22,990
May	834	67	15	26.9	1,650
June	420.8	36	9.0	14.0	835
July	176.5	7.9	4.5	5.69	350
August	84.0	4.0	2.1	2.71	167
September	88.5	3.6	2.2	2.95	176
Water Year 1948-49	13,539.1	2,500	0	37.1	26,850

RED RIVER OF THE NORTH BASIN
Devils Lake near Devils Lake, N. Dak.

Location.—Temporary staff gage, lat. 48°03′45″, long. 98°56′30″, in SW¼ sec. 18, T. 153 N., R. 64 W., at Lakewood, on east bank at mouth of Creel Bay and 6 miles southwest of city of Devils Lake. Creel Bay, which is half a mile wide, is an arm of Devils Lake and extends 2 miles to the north of the lake. Datum of present gage is 1,400.00 feet above mean sea level, datum of 1929.

Drainage area.—3,940 square miles (including lake surface).

Records available.—1867, 1879, 1883, 1887, 1890, 1896 (one gage height for each year) and 1901-48 (fragmentary).

Extremes.—1867-1948: Maximum elevation observed, 1,438.40 feet in 1867, present datum; minimum observed, 1,400.87 feet Oct. 24, 1940.

Remarks.—Elevations of lake determined from temporary gage. To refer elevations obtained during period 1867 to 1938 to datum of 1929, subtract 0.56 foot.

Elevation, in feet, 1947-48

1947		1948		1948	
Oct. 13	1402.98	June 11	1405.25	Aug. 31	1404.65
		July 3	1405.22	Sept. 28	1404.44
		Aug. 2	1404.97		

RED RIVER OF THE NORTH BASIN
Devils Lake near Devils Lake, N. Dak.

Location.—Temporary staff gage, lat. 48°03′45″, long. 98°56′30″, in SW¼ sec. 18, T. 153 N., R. 64 W., at Lakewood, on east bank at mouth of Creel Bay and 6 miles southwest of city of Devils Lake. Creel Bay, which is half a mile wide, is an arm of Devils Lake and extends 2 miles to the north of the lake. Elevations are referred to mean sea level, datum of 1929.

Drainage area.—3,940 square miles (including lake surface).

Records available.—1867, 1879, 1883, 1887, 1890, 1896 (one gage height for each year) and 1901-49 (fragmentary).

Extremes.—1867-1949: Maximum elevation observed, 1,438.40 feet in 1867, present datum; minimum observed, 1,400.87 feet Oct. 24, 1940.

Remarks.—Elevations of lake determined from temporary gage. To refer elevations obtained during period 1867 to 1938 to datum of 1929, subtract 0.56 foot.

Elevation, in feet, 1948-49

1948		1949		1949	
Oct. 2	1404.37	May 10	1405.58	Aug. 9	1407.02
Oct. 17	1404.22	May 26	1405.88	Aug. 22	1406.89
Oct. 24	1404.17	June 4	1406.26	Aug. 31	1406.77
		June 17	1406.58	Sept. 14	1406.57
		June 28	1406.88	Sept. 25	1406.42
		July 9	1407.20		
		July 16	1407.25		
		July 29	1407.18		

Note.—Readings other than those shown above were made.

RED RIVER OF THE NORTH BASIN
Lake Darling near Foxholm, N. Dak.

Location.—Staff gage, lat. 48°27′, long. 101°35′, in NE¼NE¼ sec. 1, T. 157 N., R. 85 W., on control dam of Lake Darling, reservoir of Fish and Wildlife Service on Souris River, about 6 miles north of Foxholm. Datum of gage is 1,577.00 feet above mean sea level (Fish and Wildlife Service bench mark).

Records available.—April 1937 to September 1949.

Extremes.—Maximum gage height observed during year, 18.40 feet Apr. 19, 22; minimum observed, 12.21 feet Mar. 31, Apr. 4.

1937-49: Maximum gage height observed, 22.83 feet Apr. 23, 24, 1943; minimum observed, 1.53 feet Mar. 1, 1938.

Remarks.—Reservoir is formed by concrete dam; storage began in April 1936; dam completed in July 1936. Capacity 128,500 acre-feet between gage heights 0.0 foot (sill of control gates) and 23.0 feet (top of 2-foot flashboards). Dead storage 3,500 acre-feet. Water is used during periods of low flow at wildlife refuges downstream. Gage read from 1 to 15 times per month.

Cooperation.—Gage height record furnished by Fish and Wildlife Service.

LAKE DARLING NEAR FOXHOLM, N. DAK.
Monthly gage heights and contents, water year October, 1948 to September, 1949

Date	Gage-height (feet)	Contents (acre-feet)	Change in Contents during mo. or year (acre-feet)
Sept. 30	16.96	75,200	.....
Oct. 31	16.68	72,800	—2,400
Nov. 30	16.80	73,800	+1,000
Dec. 31	16.80	73,800	0
Calendar year 1948	.....	.....	.....
Jan. 31	16.80	73,800	0
Feb. 28	16.68	72,800	—1,000
Mar. 31	12.21	41,300	—31,500
Apr. 30	18.08	84,700	+43,400
May 31	17.46	79,400	—5,300
June 30	17.76	82,000	+2,600
July 31	17.58	80,400	—1,600
Aug. 31	17.26	77,700	—2,700
Sept. 30	16.70	73,000	—4,700
Water year 1948-49	.....	.....	—2,200

North Dakota Research Foundation

GEOGRAPHICAL DATA CONCERNING NORTH DAKOTA

By Alex Burr

I. Boundary Lines (to nearest tenth mile).

A. North—310.0 miles—Approximately the 49° parallel.
B. East—213.5 miles—air-line-river boundary approximately 416 miles.
C. South—360.6 miles—7th Standard parallel.
D. West—210.8 miles—27th Standard meridian.

II. Boundary Corners (to nearest second of latitude or longitude).

A. Northeast—49° 00′ 02″ N. Lat.; 97° 13′ 41″ W. Long.
B. Southeast—45° 56′ 07″ N. Lat.; 96° 33′ 41″ W. Long.
C. Southwest—45° 56′ 43″ N. Lat.; 104° 02′ 17″ W. Long.
D. Northwest—49° 00′ 00″ N. Lat.; 104° 02′ 53″ W. Long.

III. Areas

A. Of State ..... 70,665 Square Miles
1. Land area ..... 70,054 Square Miles
2. Water area ..... 611 Square Miles
B. Of Basins (Based on line of Bureau of Reclamation)
1. Red-Souris-Devils Lake to Hudson's Bay 29,500 Square Miles (Approximately)
2. Missouri to Gulf of Mexico ..... 41,200 Square Miles (Approximately)

DRAINAGE BASIN AREAS—NORTH DAKOTA

(Approximate areas in square miles)

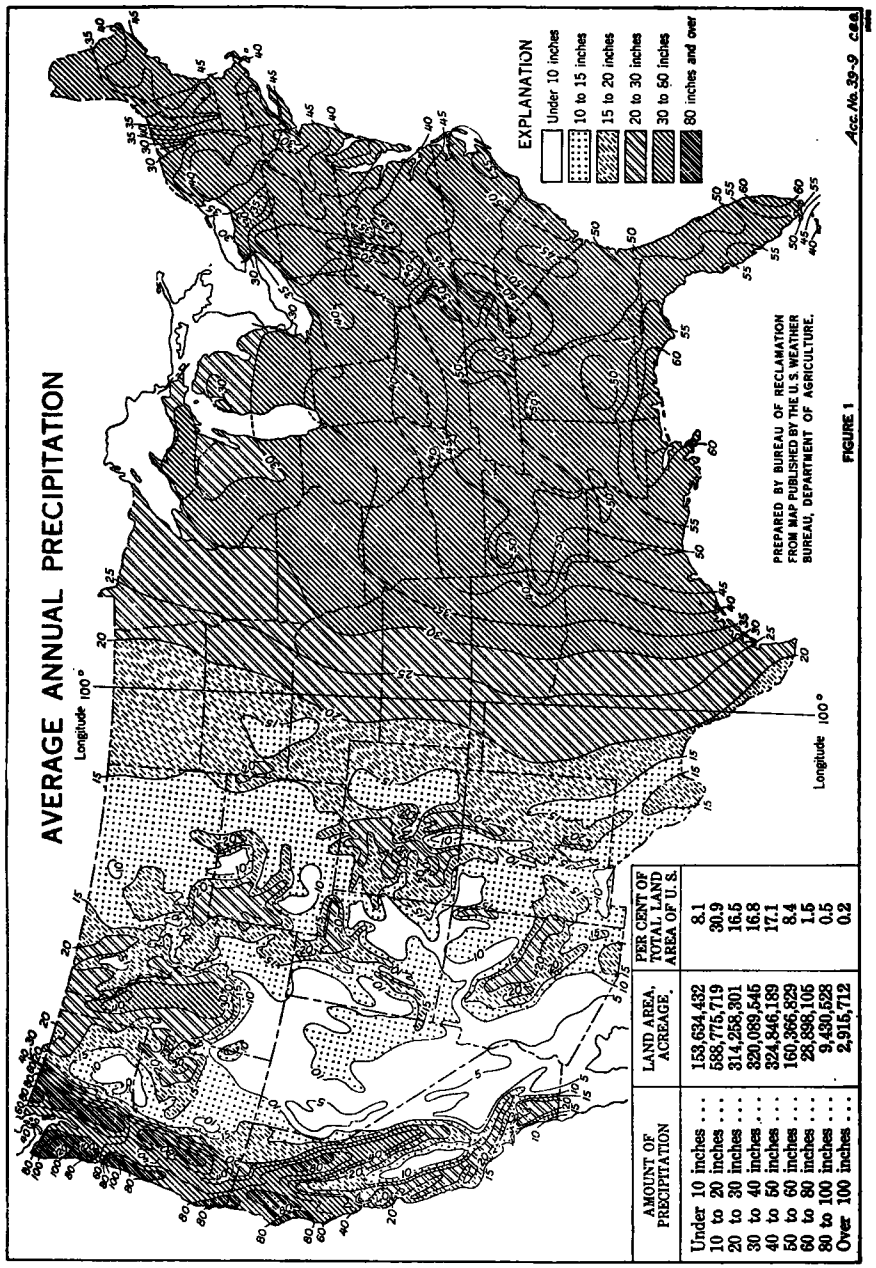
I. Hudson Bay Drainage Basin			
a. Devils Lake	3,450 sq. mi.	5%	
b. Lower Red River	7,850 " "	11%	
c. Sheyenne River	7,350 " "	10%	
d. Souris River	8,550 " "	12%	
e. Wild Rice River	2,050 " "	3%	
		41%	29,250 sq. mi.
II. Missouri River Drainage Basin			
a. Cannonball River	4,550 sq. mi.	7%	
b. Grand River	950 " "	1%	
c. Heart River	3,150 " "	4%	
d. James River	7,200 " "	10%	
e. Knife River	2,600 " "	4%	
f. Little Missouri River	4,650 " "	7%	
g. Missouri River (main stem)	17,700 " "	25%	
h. Yellowstone River	600 " "	1%	
		59%	41,400 sq. mi.
TOTAL			70,650 sq. mi.

MOTOR FUELS AND OILS FROM LIGNITE

Laboratory tests at the North Dakota State University chemical department, working in cooperation with the University of Minnesota, had proved that motor fuels and oils can be produced from lignite coal, of which it is estimated that western North Dakota has six billion tons. The decreasing production of motor fuels and oils, with threatened rationing during times of emergency, and the great need of larger production in case of war, induced Congress to authorize funds for the construction of a $750,000 laboratory at the State University of North Dakota to continue making investigations, studies and tests of lignite coal on a commercial basis, as a practical demonstration to encourage commercial plants of the feasibility of producing byproducts of lignite coal at a profit. Large oil companies have been and are experimenting in synthetic fuels and oils produced from natural gas and coal. In North Dakota the Lehigh Briquetting Plant furnished an oil extracted in the briquetting process from lignite coal, to make a test run of a Diesel-powered train during the summer of 1950. The test proved very satisfactory.

Millions of Tons of Lignite Stored at the Garrison Dam

In excavating for the eight tunnels and spillway section at the Garrison dam army engineers estimate that close to four million tons of lignite coal would be removed. Only a very small percentage of this may be used in the dam embankment. The major portion is stored in large stock piles where it will be available for use to state and private institutions and in conducting tests in the University lignite laboratory and in the heating plant at Riverdale.



AMOUNT OF PRECIPITATION	LAND AREA, ACREAGE.	PER CENT OF TOTAL LAND AREA OF U. S.
Under 10 inches . . .	153,634,432	8.1
10 to 20 inches . . .	588,775,719	30.9
20 to 30 inches . . .	314,258,301	16.5
30 to 40 inches . . .	320,089,546	16.8
40 to 50 inches . . .	324,846,189	17.1
50 to 60 inches . . .	160,366,829	8.4
60 to 80 inches . . .	28,898,105	1.5
80 to 100 inches . . .	9,430,528	0.5
Over 100 inches . . .	2,915,712	0.2

FIGURE 1

UNITED STATES WEATHER BUREAU

F. J. Bavendick, State Meteorologist

As of 1950 there are four first order Weather Bureau stations in North Dakota and ~~six~~ 3 Airway stations, all rendering 24 hour service. There are also ~~100~~ 200 cooperative weather observers in North Dakota, supervised by the Bismarck office. One hundred of these cooperative weather observers take daily readings, recording the high and low temperatures, 24-hour precipitation, sky condition and wind. The others record only precipitation. Observers are scattered over the state, usually two or three to the county. They receive no pay for their work, but there are many public-spirited citizens interested in the weather in all counties so that little difficulty is experienced in finding efficient observers. Beginning with July, 1948, weather records were put on punch cards with International Business machines. With this method, much more data are available with less work.

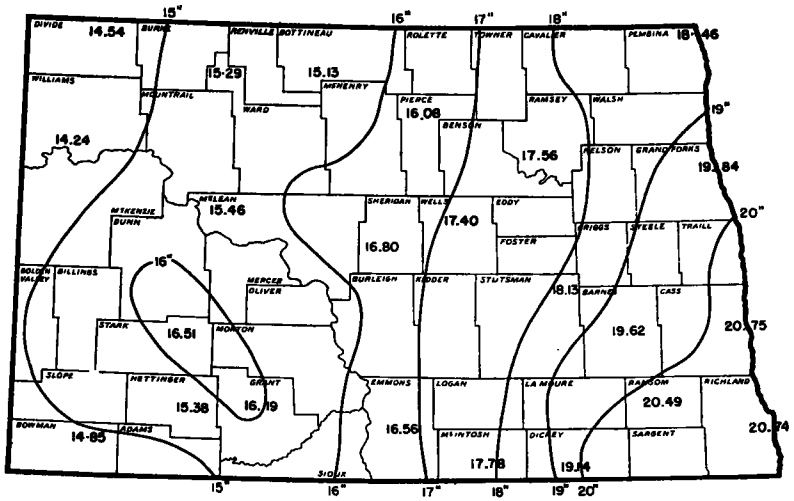
There are also records kept from more than 100 rain gages owned by state agencies, individuals, companies and federal agencies. About 35 of the cooperative observers have recording gages which indicate the time and rate of fall besides the amount. The rate of fall is important for determining the run-off per hour. One-half an inch of rain falling slowly over a period of six hours is worth more to the state than an inch that falls in an hour. Fortunately, rainfalls of more than one inch per hour occur only twice in the average year in North Dakota. The recording gages were installed in cooperation with the U. S. Reclamation Bureau and the Corps of Army Engineers.

Evaporation stations are in operation at Dickinson, Mandan and Riverdale. Such stations will also be installed at Bowbells, Devils Lake and Edgeley during 1950.

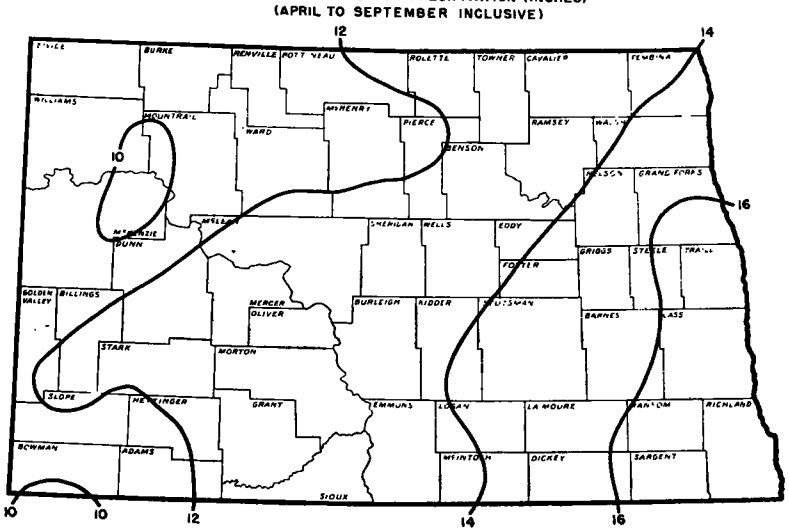
The first weather records in North Dakota were made by Lewis & Clark in 1804-5. The army began regular observations in 1860, but a good distribution of stations was not secured until 1892 when 40 were in operation. Complete records for more than 60 years are available to the public and they include precipitation, temperature, sunshine, wind, humidity, state of the sky, etc. Records made to a distance of 12 miles above the earth's surface by means of recording instruments sent up by helium filled balloons are also available. Weather maps showing weather conditions in all parts of the United States are drawn four times daily and forecasts are issued every six hours.

In an examination of North Dakota weather records for the past seventy-five years, there is found no evidence of any progressive change in temperature or in the amount of rain and snow, an outstanding period of extremes occurred between 1936 and 1945. During this decade, North

NORTH DAKOTA
AVERAGE ANNUAL PRECIPITATION (INCHES)
1898–1949 INCLUSIVE



NORTH DAKOTA
AVERAGE WARM-SEASON PRECIPITATION (INCHES)
(APRIL TO SEPTEMBER INCLUSIVE)



Dakota experienced its highest and lowest temperatures and its driest and wettest years.

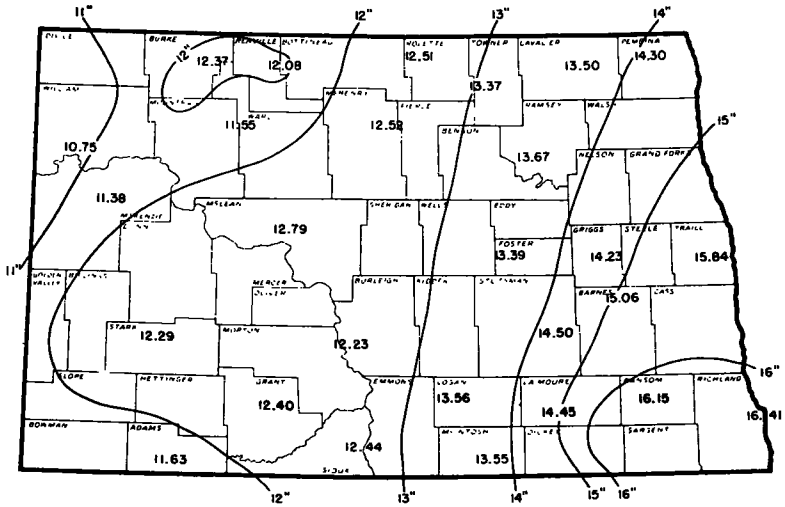
It will require many more years of records in the center of the North American continent before a good knowledge of our weather is available. Much unusual weather has already been experienced in North Dakota in 1950. Nearly twice the normal amount of snow fell in January and March, and three times the normal fell in April. Little or no melting occurred during the unusually cold winter with the result that more flooding occurred in April and May than in any previous year.

Climate is a natural resource that cannot be exhausted by exploitation as in the case with most natural resources such as soils, forests and mines. As civilization has become more complex, our dependence upon an intimate knowledge of climate and weather has increased. Today this knowledge is so indispensable that every civilized country has an extensive weather service. While it is impossible for man to change the climate materially, it is possible for him to plan his activities in such a manner that he wll realize the maximum benefit from the forces of nature.

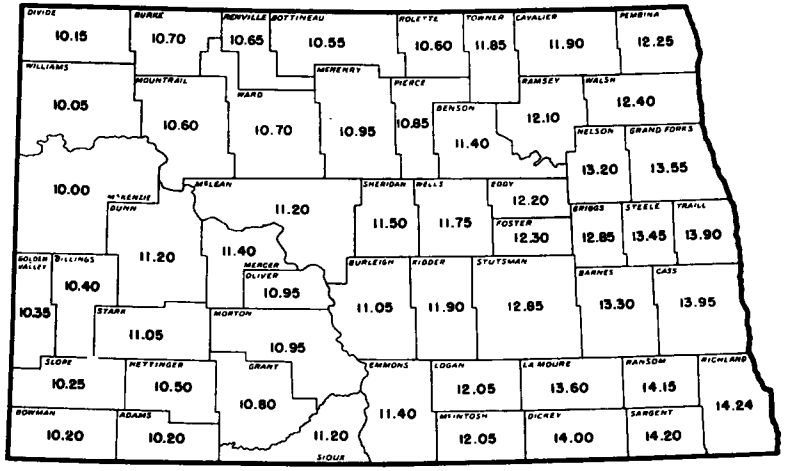
"Climate and Weather in North Dakota," prepared by Meteorologist Frank J. Bavendick and published by the State Water Conservation Commission, contains a digest of records for seventy-five years. It notes unusual and unfavorable weather conditions to prepare residents for possible recurrence in future years. This booklet contains a wealth of information of the vagaries of North Dakota weather, includes floods, blizzards, drought, dust storms, hail, precipitation, snowfall, sunshine, etc. A charge of $1. is made to cover a part of the cost. The first issue of 1,000 was exhausted and a second issue printed to meet the demand.

Rainfall has been above normal for seven out of the past 10 years, and need for irrigation has not been so apparent, and dry-farming methods have been satisfactory. However, Weather Bureau records for the past 75 years indicate that on the average six out of 11 years have had insufficient rainfall to produce a paying crop in Western North Dakota. The only other long period of continued good moisture supply during the 75 years recorded was in 1899 to 1904. A drouth preceded and followed this period, hence it seems safe to conclude that this area is approaching a period of drouth years.

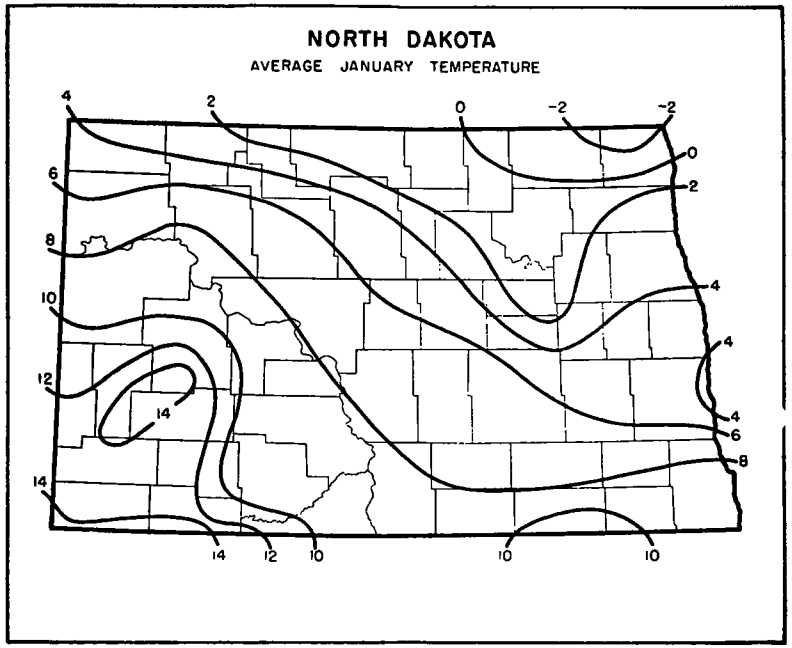
NORTH DAKOTA
AVERAGE WARM-SEASON PRECIPITATION (INCHES)
(APRIL TO SEPTEMBER INCLUSIVE)



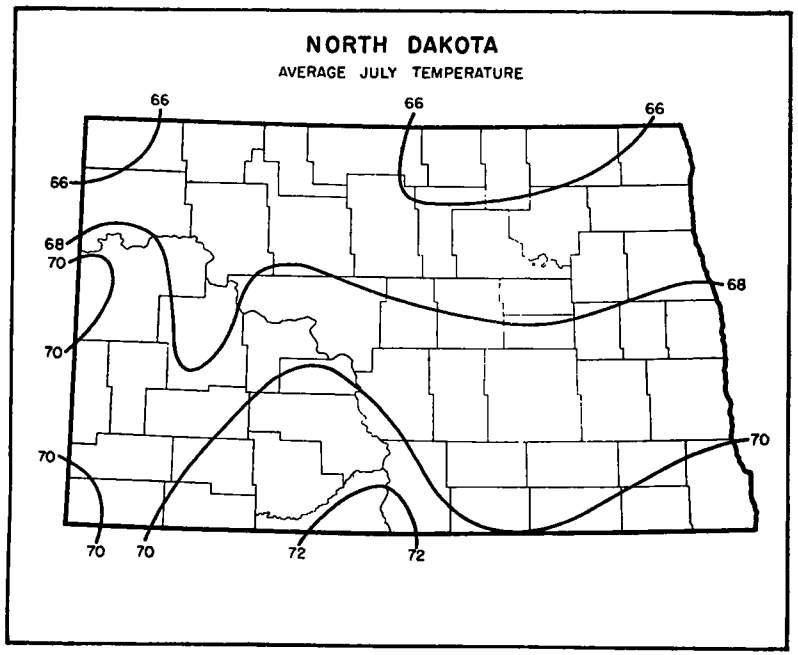
NORTH DAKOTA
AVERAGE PRECIPITATION BY COUNTIES
APRIL-AUGUST INCLUSIVE (1898-1949)

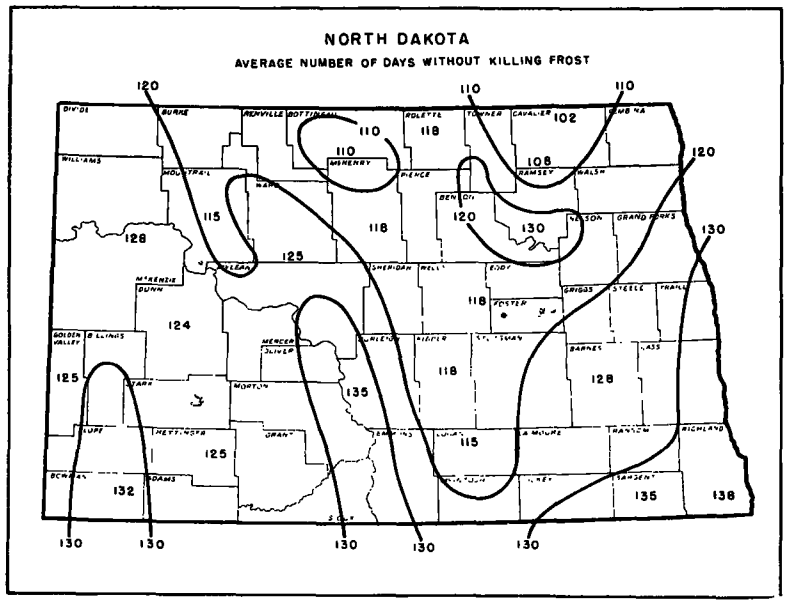


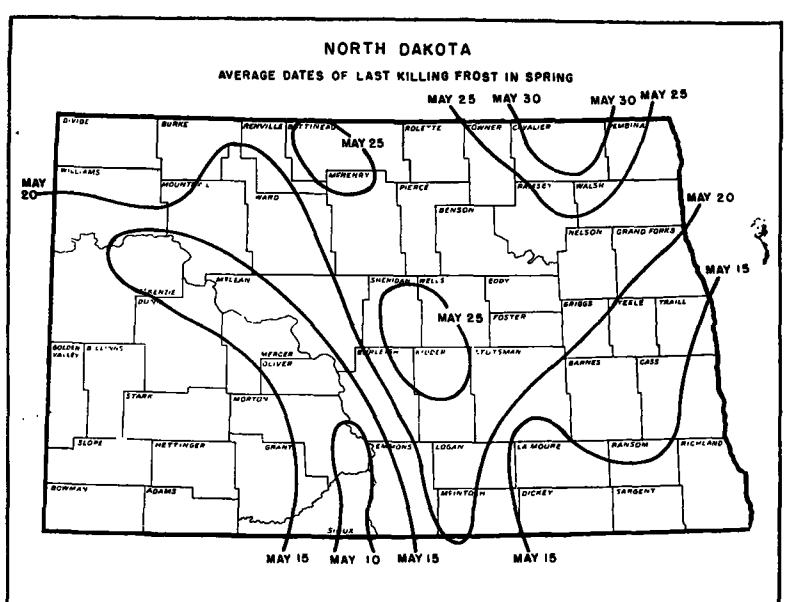
NORTH DAKOTA
AVERAGE JANUARY TEMPERATURE



NORTH DAKOTA
AVERAGE JULY TEMPERATURE




NORTH DAKOTA
AVERAGE NUMBER OF DAYS WITHOUT KILLING FROST
120
110
110
110
110
118
102
108
120
115
118
120
130
130
128
125
118
124
125
118
135
128
125
115
132
135
138
130
130
130
130
130


NORTH DAKOTA
AVERAGE DATES OF LAST KILLING FROST IN SPRING
MAY 25
MAY 30
MAY 30
MAY 25
MAY 25
MAY 20
MAY 20
MAY 15
MAY 25
MAY 15
MAY 10
MAY 15
MAY 15

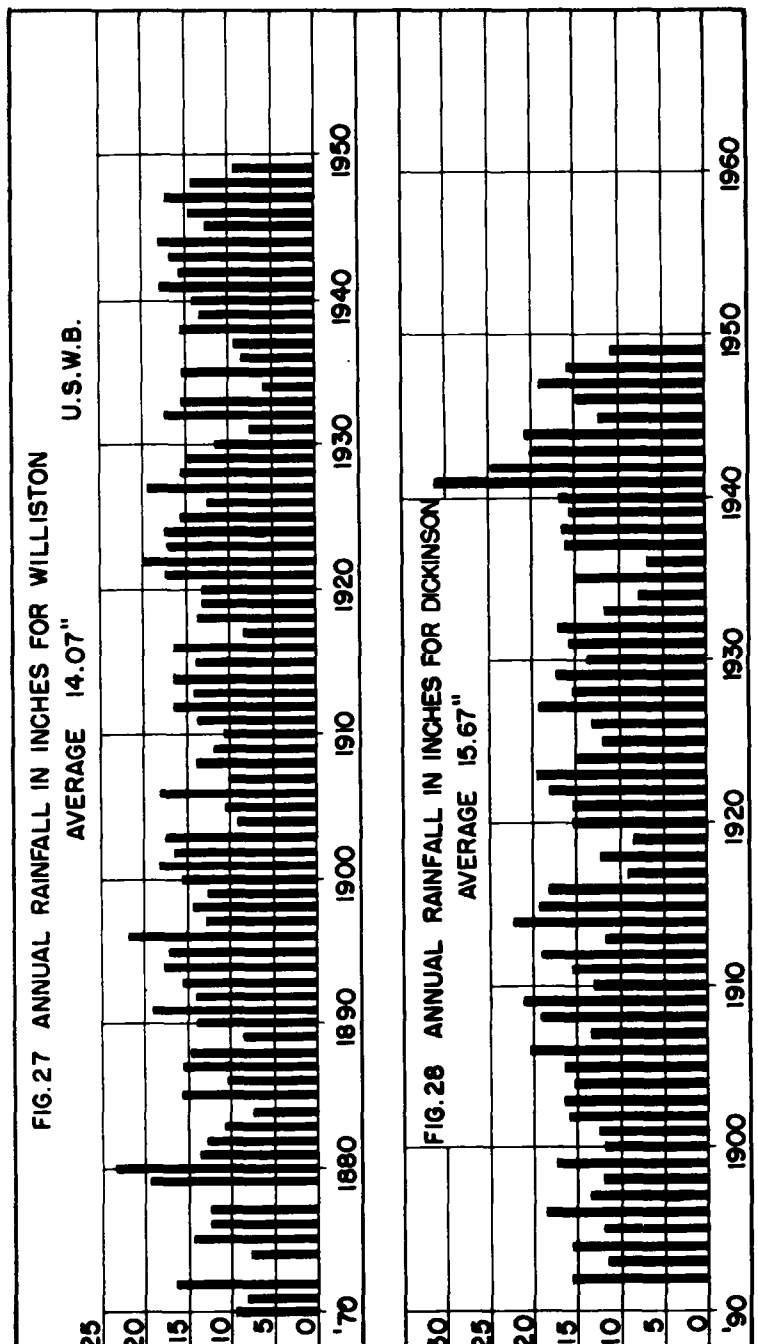


FIG. 27 ANNUAL RAINFALL IN INCHES FOR WILLISTON
AVERAGE 14.07"
U.S.W.B.
25
20
15
10
5
0
'70
1880
1890
1900
1910
1920
1930
1940
1950
FIG. 28 ANNUAL RAINFALL IN INCHES FOR DICKINSON
AVERAGE 15.67"
30
25
20
15
10
5
0
'90
1900
1910
1920
1930
1940
1950
1960

FIG. 29 ANNUAL RAINFALL IN INCHES FOR MOTT
U.S. WEATHER BUREAU
AVERAGE 16.21"

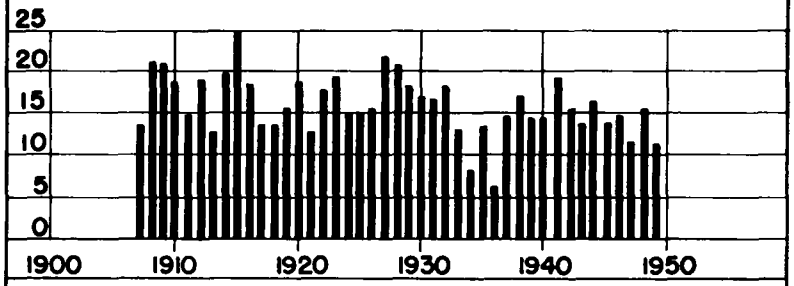


FIG. 30 ANNUAL RAINFALL IN INCHES FOR BOWMAN
U.S. WEATHER BUREAU
AVERAGE 15.24"

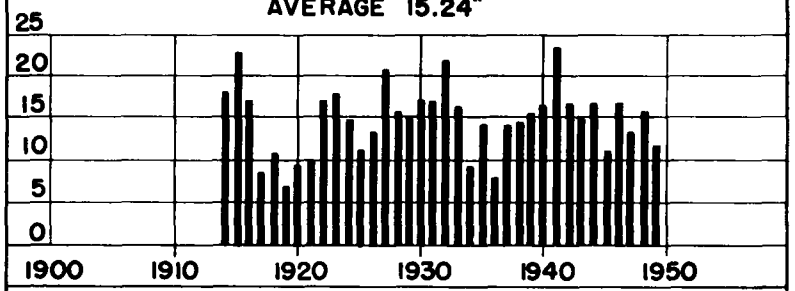


FIG. 31 ANNUAL RAINFALL IN INCHES FOR BEACH & GOLVA
U.S. WEATHER BUREAU
AVERAGE 15.21"

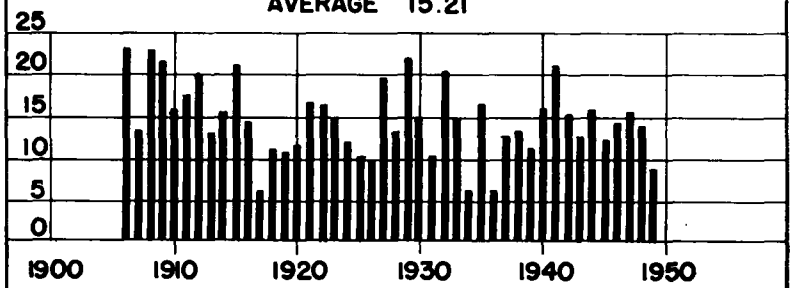


FIG. 32 ANNUAL RAINFALL IN INCHES FOR MINOT
AVERAGE 15.48"

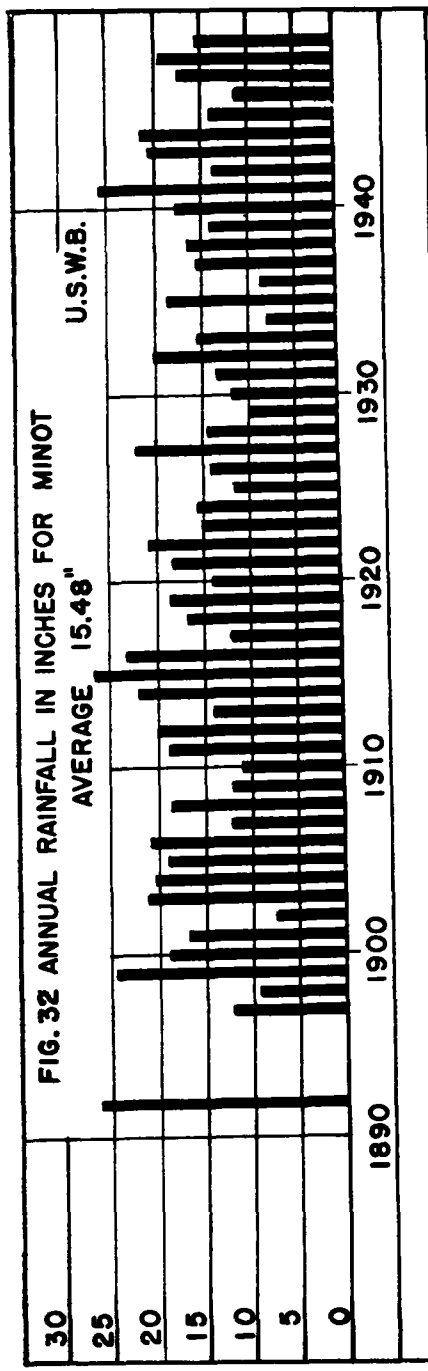
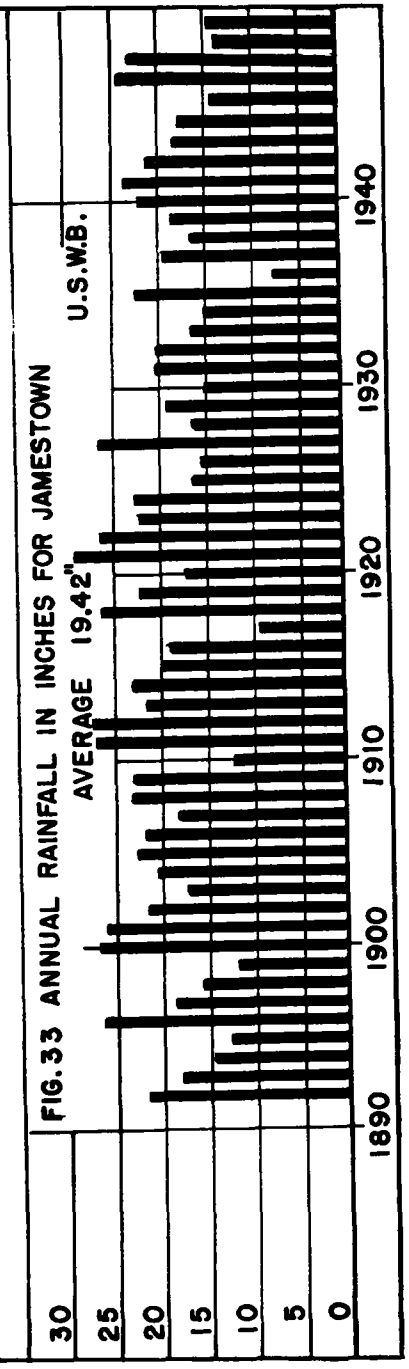


FIG. 33 ANNUAL RAINFALL IN INCHES FOR JAMESTOWN
AVERAGE 19.42"



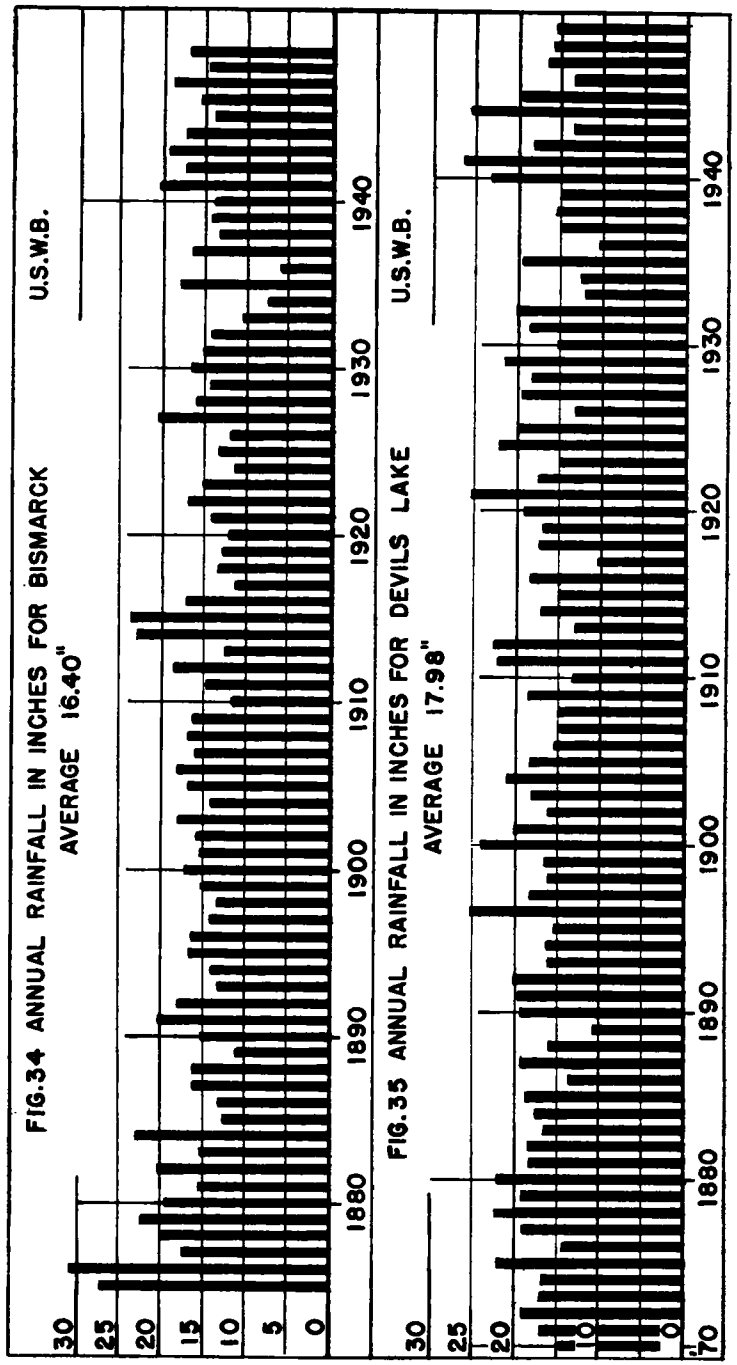


FIG.34 ANNUAL RAINFALL IN INCHES FOR BISMARCK
AVERAGE 16.40"

FIG.35 ANNUAL RAINFALL IN INCHES FOR DEVILS LAKE
AVERAGE 17.98"

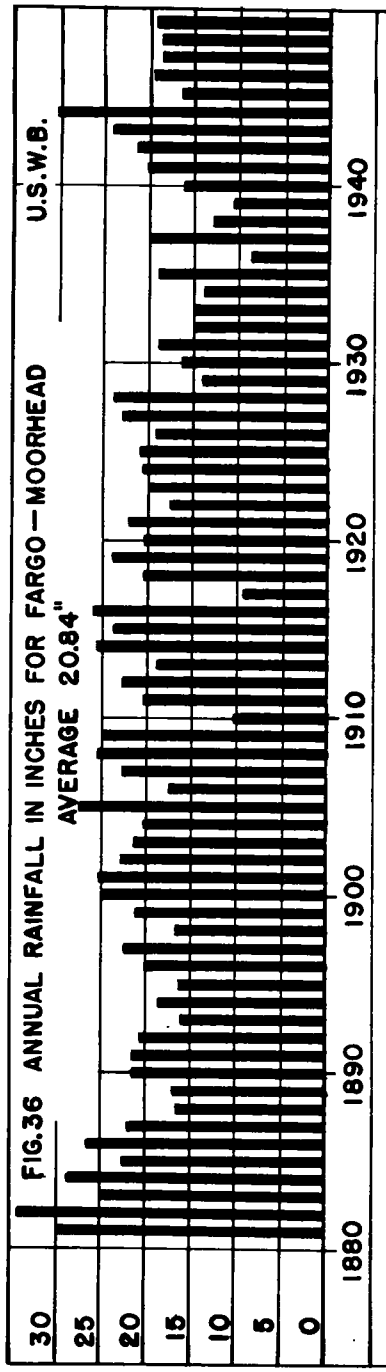


FIG.36 ANNUAL RAINFALL IN INCHES FOR FARGO—MOORHEAD
AVERAGE 20.84"

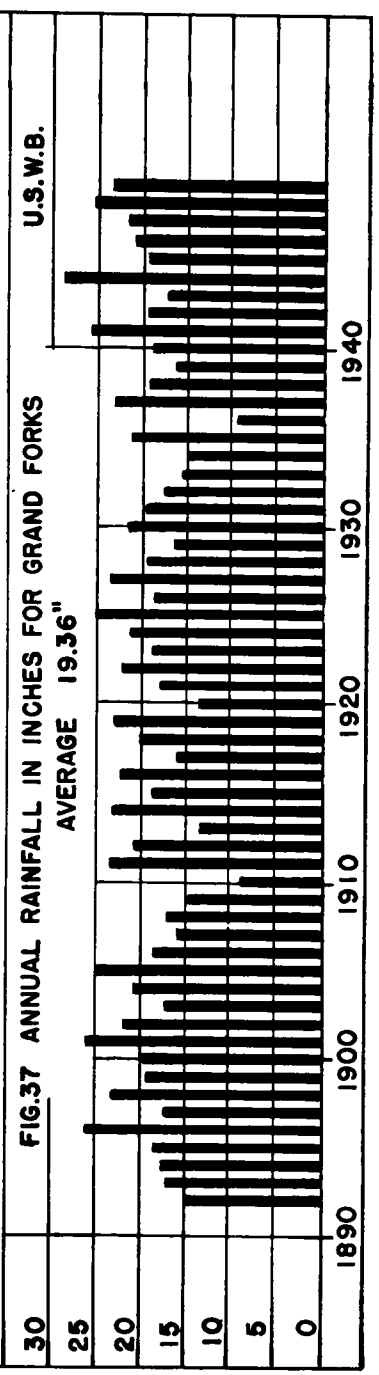
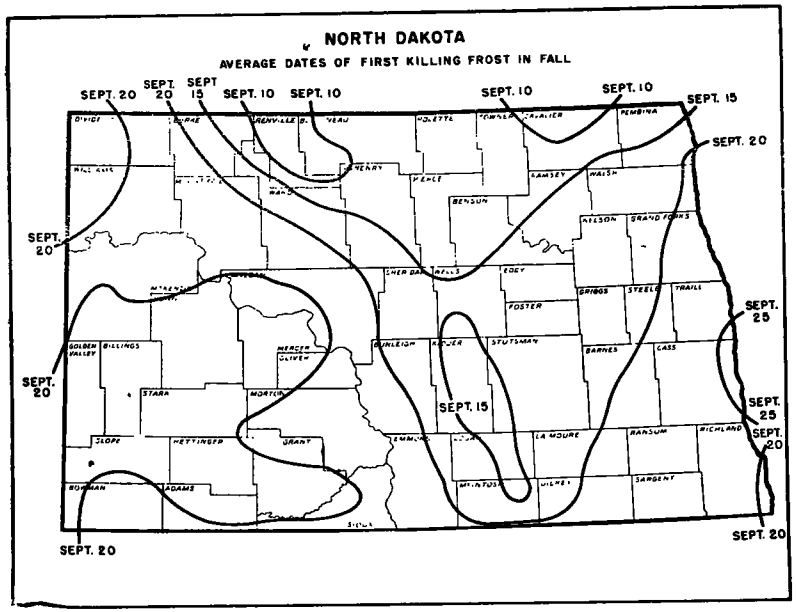


FIG.37 ANNUAL RAINFALL IN INCHES FOR GRAND FORKS
AVERAGE 19.36"



RURAL ELECTRIFICATION IN NORTH DAKOTA

Rural Electrification made remarkable gains in North Dakota during the period from July 1, 1948, to June 30, 1950. The two preceding years had seen unprecedented growth with the aid of government REA loans.

In the State of North Dakota up to 1936 only 1,968 farms had electricity. By June 30, 1949, this had increased through REA organizations to 25,384, and an estimated 44,186 farms were without electric energy. By March 31, 1950, the last available figures, additional loans to REA organizations had been approved which would bring electricity to a total of 60,593 rural consumers.

In the mean time, the monthly average farm consumption on REA lines in North Dakota had increased from 91 kilowat hours in December, 1941, to 178 kilowat hours in December, 1949. This reflects the greater use of electrical equipment to save time and labor in performing farm and household tasks and to bring about a more comfortable rural living condition. The national average was 141 kwh, indicates that North Dakotans were making more than the average use of the electric energy when available.

Government REA loans are made for the full cost of constructing power lines and other electrical facilities to serve rural areas, with 2 per cent interest, and are repaid over a maximum period of 35 years, out of the monthly revenues. Part of each consumer's monthly payment for electricity goes to pay off the government loans.

INDUSTRIAL DEVELOPMENT IN NORTH DAKOTA

There will be a great demand for low cost power from the Garrison dam plant from industrial firms, for manufacturing and processing plants for products grown and raised in North Dakota, for chemical plants and in the development and manufacture of lignite coal byproducts.

The North Dakota Research Foundation is aiding in this development and reports that the following eight industries have been established to process North Dakota materials, and are well distributed over the state. They involve the processing of both agricultural and mineral raw materials, including potatoes, flax, alfalfa, sodium sulphate and lignite.

One is a flax crushing plant, state-owned and operated. The others, dealing with lignite and sodium sulphate, are financed by out-of-state money. The other five are financed by private capital within the state. The total investment is conservatively estimated at $365,000. Employment is provided for 74 people. Wages paid amount to $175,000 per year. The value of the raw materials processed per year is estimated at $425,000. The value of the processed products manufactured by these plants is estimated at $850,000.

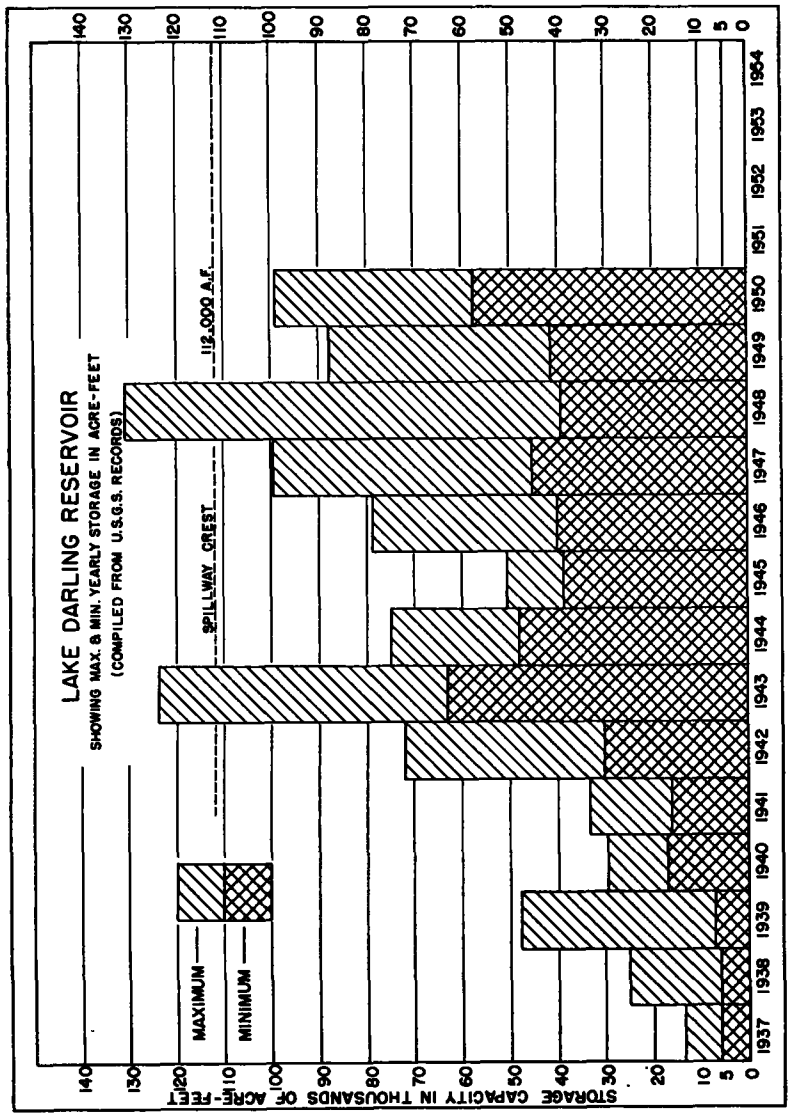
POPULATION TRENDS IN NORTH DAKOTA

The 1950 census is showing a loss of population in the last ten years in North Dakota for many communities and counties, and for the state as a whole. This trend began during the drouth of the thirties when more than 50,000 people moved to other areas of the United States where they could make a living. This loss has never been regained.

A still further loss of population showing up in the 1950 census is attributed to the change to tractor farming and the trend toward larger sized farms to enable the farmer to keep his power machinery busy for as long a period as possible during the cropping season, and thus spread the cost of operation over more acres. The result is that in many counties the average size farm has increased to about a section of land per family.

It is commonly estimated that about one acre in ten of the cultivated land will be under irrigation in possibly ten years, and that this will mean an increase of population in the irrigated areas; that this will require three to four families per section of land as compared to one family under dry-land tractor farming.

This would mean an increase of population in the areas which will be irrigated, both rural and urban. Also, the fact that even in the most severe drouth years, there will always be feed available on the irrigated areas within easy trucking distance for most farmers to enable them to make livestock and dairying the base of their farm program, with sufficient income to pay expense of operation and maintain the family on the most severe drouths.



U. S. FISH AND WILDLIFE SERVICE

The first area established in North Dakota as a National Wildlife Refuge was Stump Lake which is 27 acres in area and was established by Presidential Proclamation on March 9, 1905. Chase Lake was the next area to be established. It consisted of 375 acres and was established by Presidential Proclamation on August 28, 1908. On March 3, 1931 the Sullys Hill Game Preserve was established being an area of 994 acres.

Since that time many new areas have been added and at present the Service administers approximately 173,000 acres of Government-owned land in North Dakota as National Wildlife Refuges and in addition to sizeable acreage is under its administration as Refuge areas under easements from the land owners.

Aside from the Sullys Hill Game Preserve, which was established mainly to preserve a small native herd of buffalo before this species became extinct in the State, the Refuges in the State serve principally as nesting areas and sanctuaries for migratory waterfowl.

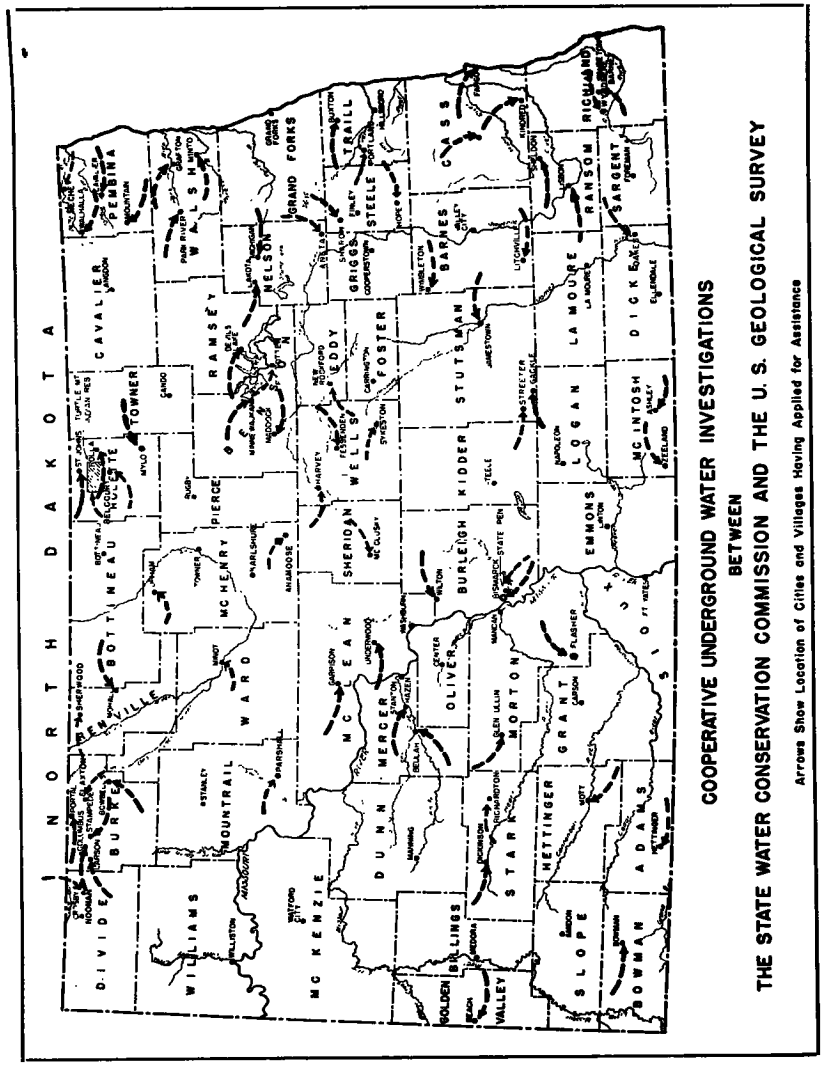
Fishing is provided on several of these Refuge areas and most of them are equipped with recreational areas for public use.

The Lake Darling reservoir on the Souris River serves effectively in controlling the flood waters of the Souris River that originate in Saskatchewan. The City of Minot has been saved from having disastrous floods by means of this installation and its operation.

The conservation of our water resources is of interest to the U.S. Fish & Wildlife Service as a means of providing for the conservation of our wildlife resources. Their part in this program is carried out through the construction of dams, primarily for reservoirs for game and fish conservation; the study, planning and development of our water resources for production and protection of fish and wildlife; the creation and maintenance of wildlife refuges and numerous other related means.

At the present time the U.S. Fish and Wildlife Service has in operation many refuges, the first being Stump lake, created in 1905. Among the other phases of their program is the maintenance and operation of Lake Darling dam and reservoir, on the Souris river, which has not only provided a means for wildlife conservation but also has provided protection for the city of Minot from floods; the operation of the Valley City Fish Cultural Station on the Sheyenne river near Valley City, which provides over two million spiney rayed fish each year for North Dakota lakes and streams, and the study and evaluation of the agricultural drainage program and its effects on wildlife.

The Valley City Fish Cultural Station which was established in 1938 is located along the banks of the Sheyenne River near Valley City on a 58-acre tract of Government owned land. Water for the 13 fish rearing ponds, that vary in size from ¾ to 3½ acres in size, is pumped from the Sheyenne River.



REPORT OF THE STATE GEOLOGIST

Dr. Wilson M. Laird

During the past six years ground-water investigations by the Ground Water Branch of the United States Geological Survey have been in progress in various parts of the State. These investigations are being made in financial cooperation with the North Dakota State Water Conservation Commission, under the general supervision of the State Geologist who acts as technical advisor for the State Water Conservation Commission in their program.

The ultimate aim of the program is to obtain an overall knowledge of the ground-water resources in the entire State which would be adequate for effectively directing the optimum development of this resource for domestic, municipal, industrial and irrigation purposes and for effectively programming conservation and administrative measures which may be necessary or desirable in connection with its development and use.

However, there currently is a great need for adequate and perennial ground-water supplies for numerous communities throughout the State which are attempting to construct public water-supply and sewage facilities for the first time or which have experienced shortages under present facilities. Therefore, the bulk of the investigational work has been directed toward securing data on the ground-water resources that would be within reach of these communities.

Through contacts with the State Geologist and the State Water Conservation Commission, about 80 communities have expressed interest in receiving assistance under this program. However, because of the limitations imposed on the program by available equipment, personnel and funds, it has not been possible to give assistance to all of these communities up to the present time. Consequently, many of the communities have temporarily solved many of their problems on their own initiative or with nominal assistance from the State Geologist and the State Water Conservation Commission and no longer appear to be actively interested in obtaining the benefits of an area investigation at the present time. On the other hand, many communities are much interested in this work but have not taken the necessary preliminary steps to obtain an investigation in their area because of the length of time before work could actually get under way.

At the present time, investigations have been completed or are under way in 28 areas in the State and arrangements have been completed to do work in one other area. Reports have been released on 15 areas and four other reports have been completed but not officially released as yet. It is expected that the field work will be completed on all of these projects that are now under way during the forthcoming field season and that all reports will be completed during the following winter. In all, the reports will present information for more than 3,000 square miles of area.

The reports on the investigations may be had free of charge unless the supply for distribution has been exhausted, in which case copies may be examined in any of the State College libraries, the North Dakota Research Foundation library in Bismarck, offices of the State Water Conservation Commission in Bismarck, United States Geological Survey in Bismarck, North Dakota Geological Survey and the United States Geological Survey both at the University of North Dakota in Grand Forks.. Requests for reports should be made to one of the following agencies:

North Dakota State Water Conservation Commission
Bismarck, North Dakota

North Dakota Geological Survey
University Station
Grand Forks, North Dakota

United States Geological Survey
University Station
Grand Forks, North Dakota

The following list shows the reports that have been completed and whether or not they are currently available:

No. 1. Ground Water in the Fessenden Area, Wells County, North Dakota, by Leonard Filaseta, 1946. (Edition exhausted)

No. 2. Ground Water in Beach Deposits of Glacial Lake Agassiz near Mountain, Pembina County, North Dakota, by P. D. Akin, 1946. (Edition exhausted)

No. 3. Ground Water at Dickinson, North Dakota, by T. G. McLaughlin, 1946.

No. 4. Ground Water in the Deposits of Ancient Lake Dakota, Dickey County, North Dakota, by William C. Rasmussen, 1947. (Edition exhausted)

No. 5. Ground Water near Buxton, Traill County, North Dakota, by P. E. Dennis, 1947.

No. 6. Geology and Ground Water Conditions at Minot, North Dakota, by P. D. Akin, 1947.

No. 7. Ground Water in the Aneta Area, Nelson County, North Dakota, by P. E. Dennis, 1947.

No. 8. Ground Water in the Sharon Area, Steele County, North Dakota, by P. E. Dennis, 1947.

No. 9. Ground Water in the Hope Area, Steele County, North Dakota, by P. E. Dennis, 1948.

No. 10. Ground Water in the Wimbledon Area, Barnes and Stutsman Counties, North Dakota, by P. E. Dennis, 1948.

No. 11. Geology and Ground Water Resources of Parts of Cass and Clay Counties, North Dakota and Minnesota, by P. E. Dennis, P. D. Akin and G. F. Worts, 1949.

No. 12. Ground Water in the Zeeland Area, North Dakota, by Wilson M. Laird, 1948.

No. 13. Ground Water in the Wyndmere Area, Richland County, North Dakota, by P. E. Dennis, P. D. Akin and Suzanne L. Jones, 1950.

No. 14. Ground Water in the Kindred Area, Cass and Richland Counties, North Dakota, by P. E. Dennis, P. D. Akin and Suzanne L. Jones, 1950.

No. 15. Ground Water in the Portland Area, Traill County, North Dakota, by P. E. Dennis and P. D. Akin, 1950.

Ground Water in the Fargo-Moorhead Area, North Dakota and Minnesota, by A. C. Byers, L. K. Wenzel, W. M. Laird and P. E. Dennis, 1946. (Edition exhausted)

Reports completed but not released:

No. 16. Ground Water in the Neche Area, Pembina County, North Dakota, by Quentin F. Paulson, 1950.

No. 17. Ground Water in the Mohall Area, Bottineau and Renville Counties, North Dakota, by P. D. Akin, 1950.

No. 18. Ground Water in the Litchville Area, Barnes County, North Dakota, by P. D. Akin, 1950.

No. 19. Geology and Ground Water Resources in the Minnewaukan Area, Benson County, North Dakota, by Saul Aronow, P. E. Dennis and P. D. Akin, 1950.

In addition to the project type of investigation referred to above, a continuing program of obtaining water-level records in observation wells throughout the State is being maintained. At the end of 1949 water levels were being measured in 153 wells in the State. Of these, 7 were equipped with automatic water-stage recorders to give a continuous record of the water-level fluctuation and 29 were being measured weekly by local observers who are paid a small fee for their service. The remainder of the wells are measured at least twice a year.

Because of the great increase in the use of ground water for municipal and industrial purposes during the past five to ten years, due largely to expansion or new construction of municipal facilities, there is a great need for considerable expansion of the observation-well program. Along with this expansion, a program for obtaining current data on the amount of water being used is needed for correlation with the water-level data. In many instances, this type of data will be very valuable in determining whether certain aquifers would be able to produce more water or whether they are overdeveloped at the present time. In many cases, forewarning of depletion of certain aquifers could be given before serious water-supply shortages result.

Test drilling with the state-owned drilling machine is an important part of the work being done in the State. During the past drilling season 124 holes were drilled with a total footage of 14,485 feet. At the end of 1949, 64,220 feet of test drilling had been done under the cooperative

program. All of the samples obtained from the test drilling have been preserved and are on file for public inspection at the North Dakota Geological Survey in Grand Forks.

As indicated in the last biennial report, as soon as current municipal problems are fairly well settled, the project investigations should be expanded to a more regional scale so that general information over broader areas can be made available to the general public. Aside from domestic and municipal needs, there is considerable interest in certain areas in the possibility of obtaining ground-water supplies for irrigation and heavy industrial purposes.

As soon as possible, studies of the waters of the Dakota sandstone and other special aquifers in the State should be undertaken. Such a study on a rather small scale was made several years ago in the Ellendale-Jamestown area. These new studies should be carried on with a view to making recommendations to the well owners as to proper conservation procedures. At the present time many wells are being allowed to flow in such fashion that not only is it ruining good land on which the rather salty artesian water flows, but it is also diminishing the artesian pressure so that some wells which formerly flowed no longer do so. It would be wise if a complete study of these formations were made so that recommendations as to conservation of this very valuable natural resource might be made.

STATUS OF GROUND WATER INVESTIGATIONS ON MUNICIPAL PROBLEMS

(Field Work)

Investigations completed:

Aneta	Lakota	Neche
Buxton	Litchville	New Rockford
Cavalier	Maddock	Portland
Dickinson	Michigan	Oakes
Fessenden	Minnewaukan	Sharon
Fargo-Moorhead	Minot	Wimbledon
Hope	Mchall	Wyndmere
Kindred	Mountain	Zeeland

Investigations in progress:

Bowbells	Richardton	St. John
Devils Lake	Rolla	Streeter
Mylo		

Investigations to be started:

Fairmount

IRRIGATION FROM UNDERGROUND WATERS

Large areas in the arid southwestern states are being irrigated from underground waters by pumping. In some areas it has been found that increased use of this type of irrigation has exhausted and lowered the level of ground waters to a point where it is no longer possible and economical to pump from great depths, as the water table continues to lower each succeeding year.

Underground water surveys being made by the U. S. Geological Survey in cooperation with the North Dakota Water Conservation Commission indicate that some areas of the state are underlaid with sufficient water supplies to warrant some irrigation by pumping from wells.

A recent groundwater survey in the vicinity of Streeter indicates there may be sufficient groundwater available to irrigate large areas of land by pumping.

Other areas investigated have shown sufficient ground water deposits that would be ample for small irrigation tracts. The introduction of irrigation sprinkler systems has greatly widened future possibilities for this type of irrigation over the state.

Mandan Nursery Irrigates From Well

Recent reports show the Heart River unit of the Mandan soil conservation service nursery is now using water from a 100-foot well for irrigation.

A pump with capacity of 900 gallons of water per minute is being used. This nursery was formerly irrigated with water pumped from the Heart river. After the 1950 spring run-off floods subsided, it was found that the Heart river had changed its course and the new channel was about 1,000 feet from the former pump site.

This well is one of the first of its type in this area, and so far is giving satisfactory results. SCS officials state the well and pump cost $2,450.

STATE COOPERATING AGENCIES

STATE HEALTH DEPARTMENT

The State Department of Health, through the Division of Sanitary Engineering, cooperates closely with the Water Commission and the State Engineer on problems of mutual concern. Thirty plans and specifications for water and/or sewerage installations, or extensions thereto have been examined by the Health Department. These plans require the joint approval of the Water Conservation Commission and the State Health Department before construction can be initiated.

The Sanitary Engineering Division has been represented at Army hearings on flood control projects. This representation has provided information on stream pollution, and on the water requirements of certain municipalities for water supply, and for sewage dilution purposes.

The Interstate Sanitation Committee, organized in May, 1944, and comprised of Health and Conservation Department officials from Minnesota, South Dakota and North Dakota, has continued to function during the biennium. This Committee established certain policies specifying the degree of waste treatment required of municipalities or industries, which disposes of their effluents in the waters of the Red River Basin. A policy of joint reviewal of plans and specifications of proposed waste treatment plants, industrial or municipal, has been established.

In response to requests initiated by interested parties along the Mouse river and directed to the State Water Conservation Commission, investigations of the stream pollution problems of that watershed will be performed. This project will be conducted by the State Health Department, with the Water Commission supplying information on past and future stream flows and uses. Preliminary work on the studies are under way at present.

AGRICULTURAL COLLEGE

The vast Missouri river development program will have a tremendous effect on North Dakota agriculture and materially alter the role of the North Dakota Agricultural College, in the opinion of Dean H. L. Walster. He stated that both irrigation and dam building phases of the project will affect the work of the College because of the changes which will be brought about in North Dakota agriculture, and in the social and economic status of the people of the state.

It is estimated that the Garrison dam and hydroelectric plant will probably be able to furnish power over the whole state about 1954, which will bring electricity to most farms at low rates in addition to the present city users, and should bring additional industries.

All these developments will call for much research at the college, such as the use of irrigation on glacial soil, marketing of intensive farming products and other activities.

A plan for an educational campaign reaching into every county, by the county agents, with assistance from the state leaders and others, will bring to the people more of a realization of the great changes and the increased security for agriculture and stock-raising as a result from the planned water utilization. The long-range program will endeavor to conserve and improve the lands, build up and protect forest resources, enlarge and improve agriculture by irrigation and drainage, stabilize and improve farm income, reduce flood and sediment damage and enhance recreation and wild life.

BANK OF NORTH DAKOTA

This state-owned bank acts as trustee for all the issues of bonds of the State Water Conservation Commission, to aid in the securing of funds for the construction and development of irrigation.

The best of cooperation has been given by the officials of the Bank on all the transactions it has handled for the Water Commission. It is carrying $63,000 unpaid balance on outstanding bonds, but has collected more than $42,000 which is deposited in a sinking fund from which payment of bonds or interest is made when due, and has collateral bonds which when collected will provide funds to pay off all the Water Commission bond obligations.

OTHER COOPERATING AGENCIES

GREATER NORTH DAKOTA ASSOCIATION

One of the greatest forces working for the betterment of all of the people of North Dakota, is the Greater North Dakota Association. Its officials have always been ready to give this Commission any assistance requested for the water development program. It recognizes that income from livestock and dairying must be the foundation of agriculture, and that the western two-thirds of the state must have irrigation to raise feed for the stock in drouth years or suffer great losses and the steady income which is necessary to pay the running expenses of the farmer.

Its accumulation of movie pictures of scenes along the routes of the water development program in North Dakota, and the showing of these films to community gatherings of the people has been a great contribution to the educational program on what the water development program will mean to the future of North Dakota.

FARM ORGANIZATIONS

The officers of the North Dakota farmers organizations have cooperated in the distribution of information through its leaders and members regarding diversion of the Missouri river and the development of irrigation. They recognize the necessity of farmers having ample feed for livestock so as to have enough income to at least pay running expenses of the farm on drouth years, and that irrigation is the only way to be assured that the feed is available within easy trucking distance. Members of these farm organizations have given outstanding service in promoting the development of the state's natural resources.

IRRIGATED PASTURE COMPARED WITH DRY LAND

John Sura, wife and son write of their experiences for twenty-five years on a 960-acre dry-farmed land near Glendive, Montana, and the hardships and uncertainties, and then changing eight years ago to a 103-acre irrigated farm on the Buffalo Rapids Irrigation Project, only

six miles from their former location, and the happiness and home comfort and security they found there.

Under irrigation, they raise most of the feed for a dairy herd of 38 head, on a little over 2½ acres of land per head, while on the former dry land it required ten times the acreage per head. Now they have a beautiful lawn around the house, with flowers and trees in the garden, and it is much nicer living.

He states he purchased the irrigated farm on a 40-year contract but has had some better-than-average years and expects to get the farm paid for in just a few more years, after 8 years of operation.

CROP YIELDS ON IRRIGATED TEST FARM

Despite major hail losses, the experimental irrigated farm near Mandan yielded nearly three times the average dry land farm results in 1949 gross value. Hail damage cut the flax yield an estimated 25 per cent and the oats and barley yields 70 per cent. But the gross value of the crops harvested was $5,805.80 as compared to $2,019.87 under dry-farming conditions on lands in the Heart river valley, according to Daniel J. McClelland, Morton County Agent. The experimental farm includes 71.5 acres and is operated cooperatively by the State Training School and the Bureau of Reclamation.

INCREASED YIELDS UNDER IRRIGATION

While the Bureau of Reclamation reports that yields under irrigation average over the 17 western states two and a half to three times as much as under dry land farming methods, and in many cases are 10 to even 50 times as much, Robert M. Salter, Chief of Soils and Agricultural Engineering, U. S. Department of Agriculture. reports in the "Reclamation Era" magazine states "There may be far higher crop yields and profits in an acre-foot of water than is now generally obtained."

That in 1947, 162 bushels of corn an acre were obtained in the Columbia River Basin where irrigation usually gets about 40 bushels; that in parts of the West, as much as 40 tons of sugar beets an acre, and 10 tons of alfalfa have been harvested; oats yields went to 114 bushels; potato yields to almost 600 bushels and grain sorghums to 174 bushels to the acre. He states, "Conditions which secured these yields can be duplicated on most irrigated farms."

The irrigation farmer can control the water. Other factors which control the growth are the amount of nutrients, how thick the crop is planted, time of planting, amount of available water, crop variety, control of weeds, and cultural practices, with control of insects and disease. Research systems of crops, soil, and water management will develop the best combination for each type of soil and locality.

SOURCES OF NORTH DAKOTA FARM INCOME

Statistics show that wheat provided 45 per cent of the 1947 income from farms in North Dakota, flax 9 per cent, barley 9 per cent, oats 3 per cent, other crops 6 per cent, cattle 12 per cent, dairying 7 per cent, hogs 5 per cent, poultry and eggs 3 per cent and sheep 1 per cent. In comparison, Minnesota, Montana and South Dakota show less wheat and more cattle, hogs, dairying, poultry and eggs. Irrigation and more assured feed crops will tend to reduce wheat acreages and increase stability of farm income.

INTERSTATE RIVER COMPACTS IMPORTANT

It is recognized now that there is an imperative need for conservation and control of the waters in our rivers and streams in order to provide adequate supplies for municipal, domestic and industrial uses; for the prevention of stream pollution and for adequate sewage disposal as well as for irrigation.

It is of much concern to the State of North Dakota that it shall not be deprived of its reasonable and equitable share of the waters of interstate streams; that is, the waters of the Red River of the North, the Souris River, the James river, the Grand river, the Little Missouri river, the Yellowstone river and the Missouri river.

Compacts between states is generally recognized as the best method of making an equitable division between or among states of the waters of interstate streams, rather than by court decisions which sometimes involves endless litigation and much expense. The following reports on compacts pending shows what progress has been made in each case.

LAKE TRAVERSE AND BOIS DE SIOUX RIVER

Probably the earliest project completed to aid in the control of flood waters on the Bois de Sioux and Red River, was the Lake Traverse dam and flood control works. It is located at the source of the Red river. By placing a dam at the outlet, surplus flood waters are held back during flood periods and released as the river channel is able to carry it without flooding adjoining farm lands. The Bois de Sioux river bed was straightened and deepened in places to aid in the disposal of released waters. It has been in successful operation since 1941.

TRI-STATE WATERS COMMISSION

A compact was made by the states of South Dakota, North Dakota and Minnesota in June, 1937, and congress gave its approval on April 2, 1938, providing for the organization of the Tri State Waters Commission of nine members, three from each of the three states, to supervise the drainage area of the Red river except the Otter Tail river and its tributaries. It has power to maintain and control lake levels, stream flood and boundary waters in cooperation with state, federal and municipal

agencies; to make studies and surveys for construction, maintenance and operation of water projects within the scope of its jurisdiction. Meetings of the Commission are called as matters come up in the area it supervises.

THE RED RIVER

Congress has authorized the Corps of Engineers to undertake a broad construction program on drainage of the Red River and its tributaries in Minnesota, North Dakota and South Dakota, to alleviate the damage from flood waters, and for channel improvements on the Sheyenne, Rush and Red rivers in North Dakota. Construction work has been started and will continue over a series of years.

Division and allocation of the waters of the Red river basin are under study by the joint engineering committee of the International Joint Commission, and is expected to make its report and adjudication of the waters in the near future.

SOURIS RIVER

The adjudication and division of waters between the provinces of Saskatchewan and Manitoba and the state of North Dakota, is under the control of the International Joint Commission, composed of three members from the governments of the United States and Canada.

Members of this commission have conducted studies in 1940 covering the regulation of the flow of the Souris (Mouse) river. They recommended that the Province of Saskatchewan and the state of North Dakota continue use of waters of this river as before unless regulations are later qualified or modified by the Commission.

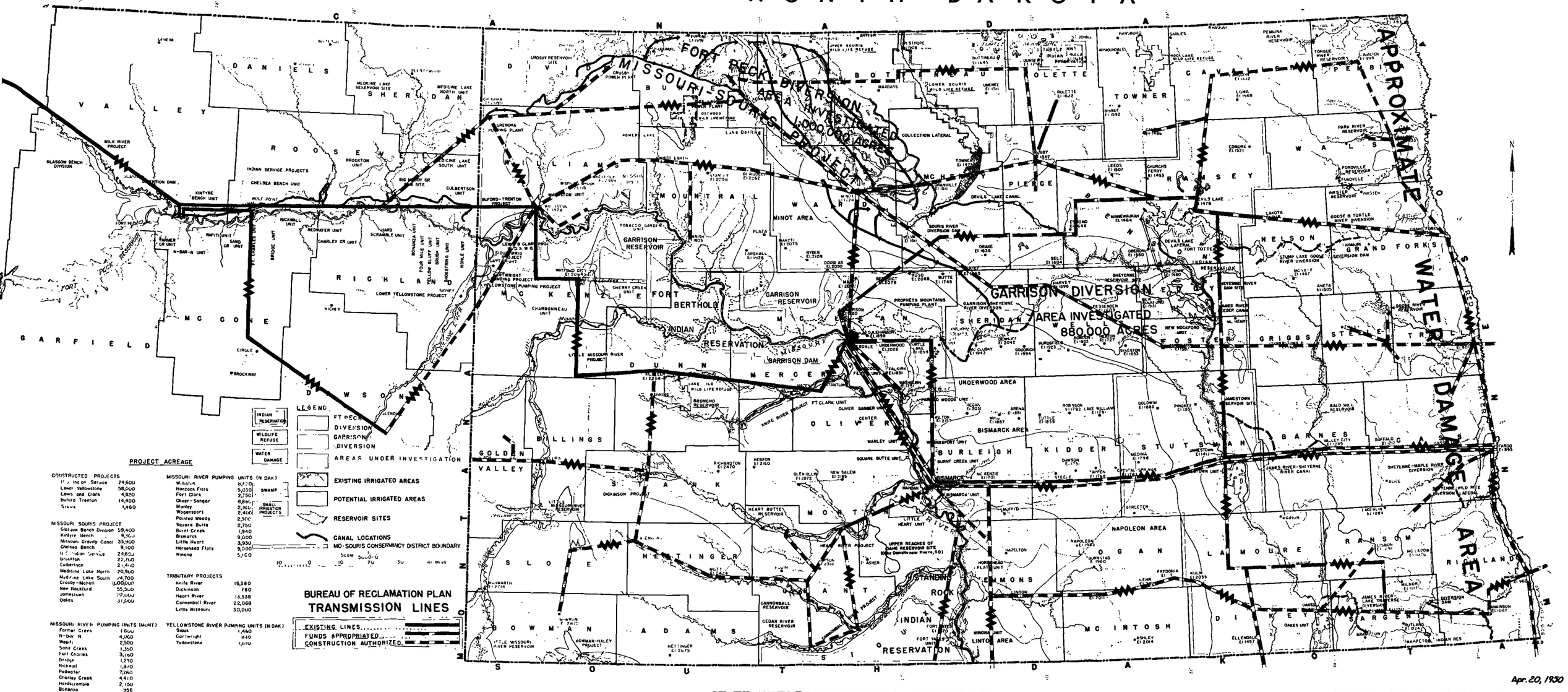
The International Commission authorized a joint board of engineers to make investigation and studies of the uses of the waters of the Souris and Red rivers, in North Dakota. Several meetings have been held by the engineering committee, and it is thought further studies will be necessary before a report is submitted.

COMPACTS UNDER NEGOTIATION

Yellowstone River

The first congressional authorization for a Yellowstone River Compact was in 1932 and included the states of Montana and Wyoming. In 1935 and 1937, negotiations were continued with the result that recommendations for agreements were placed before their respective legislatures, which, however, failed to accept the compact as submitted by the Commission. In 1940 the congressional act of 1937, authorizing the Yellowstone River Compact, was amended to include North Dakota and the time for negotiations extended to June 1, 1943.

NORTH DAKOTA



PROJECT ACREAGE

CONSTRUCTED PROJECTS	
U.S. Indian Service	24,600
Lower Yellowstone	58,600
Lewis and Clark	4,820
Buford Trenton	14,400
Sioux	1,460

MISSOURI SOURIS PROJECT	
Glasgow Bench Division	59,400
Kintyre Bench	9,600
Missouri Gravity Canal	33,900
Chelsea Bench	9,100
U.S. Indian Service	24,600
Brockton	22,700
Culbertson	21,400
Medicine Lake North	20,900
Medicine Lake South	24,700
Crosby-McHall	16,000,000
New Rockford	55,500
Jamestown	72,000
Oakes	31,500

MISSOURI RIVER PUMPING UNITS (MONT)	
Farmer Creek	1,600
N-Bar-N	4,000
Wapiti	2,500
Sand Creek	1,350
Fort Charles	3,160
Bridge	1,210
Nickwall	1,870
Redwater	7,260
Charley Creek	4,410
Hardscramble	2,150
Bonanza	956
Four Mile	900
Yellow Bluff	1,340
Brush	950
Sheestring	1,750
Nohle	1,740

MISSOURI RIVER PUMPING UNITS (N DAK)		
Williston	8,100	SWAMP
Hancock Flats	5,030	
Fort Clark	2,750	
Oliver-Sanger	6,880	SMALL IRRIGATION PROJECTS
Manley	2,160	
Wagensport	2,400	
Painted Woods	2,300	
Square Butte	2,750	
Burnt Creek	1,840	
Bismarck	9,000	
Little Heart	3,930	
Horsehead Flats	9,000	
Winona	5,160	

TRIBUTARY PROJECTS	
Knife River	15,380
Dickinson	780
Heart River	13,538
Cannonball River	22,068
Little Missouri	30,000

YELLOWSTONE RIVER PUMPING UNITS (N DAK)	
Sioux	1,440
Cartwright	1,110
Yellowstone	1,010

Apr. 20, 1950

STATE WATER CONSERVATION COMMISSION

POWER RESOURCES DEVELOPMENT PLAN

MEMBERS OF THE STATE WATER CONSERVATION COMMISSION

EARLE F. TUCKER, BISMARCK
FINAN H. DAHL, WATFORD CITY
A. M. CHRISTENSEN, MINOT

GOVERNOR FRED G. AANDAHL
CHAIRMAN

J. J. WALSH - SECRETARY

S. W. THOMPSON, WARWICK
CURTIS OLSON, VALLEY CITY
MATH DAHL, BISMARCK

In October and December, 1942, a compact was approved by the Compact Commissioners and submitted to the legislatures of the respective states for ratification. It was approved and signed by the governors of Montana and North Dakota but vetoed by the governor of Wyoming.

Further negotiations were not undertaken until in 1949, when congressional authority was granted the states of Wyoming, Montana and North Dakota by Public Law 83 of the 81st Congress, approved on June 2, 1949, to negotiate a Yellowstone River Compact. The act authorizing this compact states:

Yellowstone River Compact for Division of Waters,
Chapter 166—Public Laws 83

An act granting the consent of congress to the states of Montana, North Dakota, and Wyoming to negotiate and enter into a compact or agreement for division of the waters of the Yellowstone River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, that:

The consent of congress is hereby given to the states of Montana, North Dakota, and Wyoming to negotiate and enter into a compact, or agreement, not later than June 1, 1952, providing for an equitable division and apportionment between the states, of the water supply of the Yellowstone River and of the streams tributary thereto, upon condition that one suitable person, who shall be appointed by the president of the United States, shall participate in said Negotiations as the representative of the states and shall make a report to the congress of proceedings and of any compact or agreement entered into; provided, that such compact or agreement shall not be binding or obligatory upon any of the parties thereto unless and until the same shall be approved by the legislatures of each of said states and by the Congress of the United States; provided further, that nothing in this act shall apply to any waters within or tributary to the Yellowstone National Park or shall establish any right or interest in or to any lands within the boundary thereto.

Approved June 2, 1949.

The problem of allocating the waters of the Yellowstone river basin is becoming increasingly important, as its drainage basin includes areas in the states of Wyoming, Montana, and North Dakota, and each of these states is entitled to a proportionate share in the waters. These state rights can be settled either through an action in the supreme court of the United States or by means of a state compact as provided in the federal constitution. Court proceedings of this nature are costly and slow, frequently requiring thousands of dollars. The compact method of agreement between the states is preferable to going through courts.

On November 29, 1949, the Yellowstone Compact Commission authorized by the 81st Congress held its first meeting at Billings, Montana, setting up engineering and drafting committees to draw up a tentative

form of compact. The main obstacle to approval in the past has been between Wyoming and Montana in reaching an agreement of the distribution of the waters of the Powder, Big Horn, Tongue, Clarks Fork and Yellowstone rivers.

Members of the Yellowstone Compact Commission appointed by the Governor of North Dakota are:

Einar H. Dahl, Member of State Water Conservation Commission, Watford City, N. Dak.

I. A. Acker, Special Asst. Att'y General for the State Water Conservation Commission of North Dakota, Member Drafting Committee, Bismarck, N. Dak.

J. J. Walsh, State Engineer, Member Engineering Committee, Bismarck, N. Dak.

Federal agencies are represented by R. J. Newell, commission chairman, appointed by the President, and O. C. Reedy, commission secretary.

North Branch of the Grand River

The apportionment of the waters of the North Branch of the Grand river between North and South Dakota is a problem that will require attention in the near future. At present, the Bureau of Reclamation has under construction the Shadehill dam and reservoir for storage of the major portion of runoff from both forks of the river. The Bowman-Haley irrigation project in Bowman and Adams counties, on the North Fork of the Grand river in North Dakota, was organized in the early 1930's for the irrigation of several thousand acres of river bottom land. Public lands were withdrawn for a reservoir site. North Dakota's rights to the waters originating within the state are protected by our state constitution and a compact is necessary to protect these rights.

James River

Future development of areas in the James river basin will require consideration of a compact between North and South Dakota for the allocation of the waters of the James river. This river originates in central North Dakota and empties into the Missouri river near Yankton, South Dakota.

Before an equitable division of the waters of the James river for domestic, municipal, industrial and irrigation uses is allocated to North and South Dakota, a compact between the two states is essential and should be negotiated before any large development or construction works have been initiated.

Little Missouri River Compact

In 1940, Congress authorized Wyoming, South Dakota, Montana, and North Dakota to enter into compact negotiations for the allocation of the waters of the Little Missouri river. Preliminary surveys were undertaken

but no agreement was reached prior to the expiration date of January 1, 1943. The equitable apportionment of the waters of this stream is a highly complicated problem and it is most important that North Dakota be allotted its equitable share of the waters for irrigation and for general agricultural purposes.

INTERNATIONAL JOINT COMMISSION

On January 11, 1909, the United States and Great Britain entered into a treaty relating to boundary waters and questions arising between these two countries. This treaty provided that an International Joint Commission be created to have jurisdiction over the use of boundary waters by the United States and Canada. This Commission consists of six members, three from each country.

Members of the International Joint Commission representing the United States are: A. O. Stanley, chairman, U.S. Section, Washington, D. C.; R. McWhorter, member, chief engineer of the Federal Power Commission, Washington, D. C. ,and E. W. Weber, member, Army Corps of Engineers, Washington, D. C.

Matters relating to international waters are referred to the International Joint Commission for study and decision. Such studies were titled "References" and may be instituted by the Commission upon application by an interested government or private party. To date there have been two References that effect North Dakota, which are:

Souris (Mouse) River Reference

Souris—Red Rivers Reference

SOURIS (MOUSE) RIVER REFERENCE

The Souris (Mouse) river, an international stream located in the Hudson Bay drainage area, has its source in southern Saskatchewan, Canada, and flows in a loop for a distance of 300 miles through the state, returning to the Province of Manitoba, Canada.

Recommendations of apportionment of the waters of the Souris (Mouse) river, between the Province of Saskatchewan, state of North Dakota and the Province of Manitoba were made by the International Joint Commission in their report approved at Ottawa, Canada, on October 2, 1940. The Commission recommends interim measures pending permanent settlement of the reference as follows:

1. The Province of Saskatchewan shall be permitted to continue its present use of the waters of the Souris river, and in addition, to construct a reservoir with usable capacity not exceeding 4,000 acre feet, for the purpose of providing an adequate water supply for the town of Weyburn and the Mental Hospital at Weyburn.
2. The State of North Dakota shall be permitted to continue its present use of the waters of the Souris river, and in addition, to

construct a small reservoir on Long Creek, with capacity of 200 acre feet, to provide an adequate water supply for the town of Crosby, North Dakota.

3. A regulated flow of not less than 10 cubic feet per second shall be released from the State of North Dakota to the Province of Manitoba during the months of June, July, August, September and October of each year.

4. In the event that the State of North Dakota or the provinces of Saskatchewan or Manitoba should desire to construct any additional storage works, or otherwise make additional use of the waters of the Souris river basin, application shall be made to the International Joint Commission for authority to construct the desired storage works or otherwise to make use of additional waters.

5. The interim measures for which provision is hereinbefore made shall remain in effect unless subsequently qualified or modified by the Commission prior to the adoption of permanent measures in accordance with the requirement of "Questions (1) and (2) of the Reference."

On November 17, 1942, after two years of operation under the terms of original report, the International Joint Commission issued an interim order in the matter of the apportionment of the waters of the Souris (Mouse) river which increased the amount of water released at the Westhope dam in North Dakota from 10 to 20 cubic feet per second. This action was taken in order to augment the original allocation to Manitoba, which was found to be inadequate.

SOURIS-RED RIVERS REFERENCE

In January, 1948, the governments of the Dominion of Canada and of the United States of America initiated a Reference to the International Joint Commission to investigate the use of the waters of the Souris and Red rivers and make recommendations for the apportionment of waters between Canada and the United States.

An Engineering Committee, composed of Canadian and United States engineers, was appointed to review the problems of this Reference and to determine the water requirements of the two countries for municipal, industrial, irrigation, hydro-electric and stream pollution abatement uses. Separate reports are being prepared to cover the Red and the Souris rivers. The reports are to be submitted to the International Joint Commission so it can determine allocation of waters of these rivers.

The Reference is composed of four paragraphs, as follows:

1. To investigate and report on the water requirements arising out of the existing dams and other works or projects located in the waters which are of common interest along, across, or in the vicinity of the International Boundary from the eastern boundary of the Milk River drainage basin on the west up to and including the drainage basin of the Red river of the North on the east.

2. To report whether in the judgment of the Commission further uses of these waters within their respective boundaries by Canada and the United States would be practicable in the public interest from the points of view of the two governments.

3. Having regard to the report made under paragraphs 1 and 2, and for those streams where in the judgment of the International Joint Commission apportionment of the waters is advisable, to make advisory recommendations concerning the apportionment which should be made between Canada and the United States of such of the waters under reference as cross the International Boundary, and with respect to each such crossing of the International Boundary.

4. To conduct necessary investigations and to prepare a comprehensive plan or plans of mutual advantage to the two countries for the conservation, control, and utilization of the waters under reference in accordance with the recommended apportionment thereof.

In the conduct of its investigations, and otherwise in the performance of its duties under this Reference, the International Joint Commission may utilize the services of engineers and other specially qualified personnel of technical agencies of Canada and the United States, and will, as far as possible, make use of information and technical data which have been acquired by such technical agencies or which may become available during the course of the investigation, thus avoiding duplication of effort and unnecessary expense.

LITTLE MISSOURI RIVER IRRIGATION

Preliminary surveys on the Little Missouri river valley are being continued in western North Dakota, to determine where it is feasible to plan irrigation of enough valley land to provide alfalfa and other feeds for the stockmen of that area. Congress appropriated $39,492 for a land resource and economic study for 1950, extending up the river into Wyoming, including surveys and drilling tests at several possible dam sites. Members of the Fish and Wildlife Service, the Park Service, the Game and Fish Department and the North Dakota Water Conservation Commission are assisting. The Water Commission engineers report that several areas along the Little Missouri appear to be irrigable. Additional surveys are planned.

Opposition has been expressed by some of the ranch landowners along the valley to the proposal to build a dam near Bullion Butte in Slope county and thus create a reservoir which would back water to near Marmarth, permitting release of water downstream during drouth periods

Site of Pumping Plant for Fort Clark Irrigation District, Missouri River

and for sprinkler irrigation of bench lands for alfalfa and feeds. This reservoir capacity is estimated to be ample to permit the diversion of some water for irrigation in Slope, Stark and Hettinger counties, where additional feed is much needed in drouth years for stock raisers.

JAMES RIVER

The James river has its source west of Harvey, in Wells County, and flows in a southerly direction through North Dakota and across South Dakota, entering the Missouri river below Yankton.

It is an interstate stream on which major floods have occurred, causing great damage. At times the small stream flow does not provide sufficient water for domestic and municipal purposes to towns and villages along its course in the two states.

Under the plan of development of the Missouri river basin, Garrison reservoir water will be diverted into the headwaters of the James river for domestic use, municipal supplies, irrigation and for other purposes.

The water commission favors a compact between North and South Dakota for the use of the waters of this stream, along which considerable construction work and irrigation has been planned.

BISMARCK IRRIGATED PROJECTS

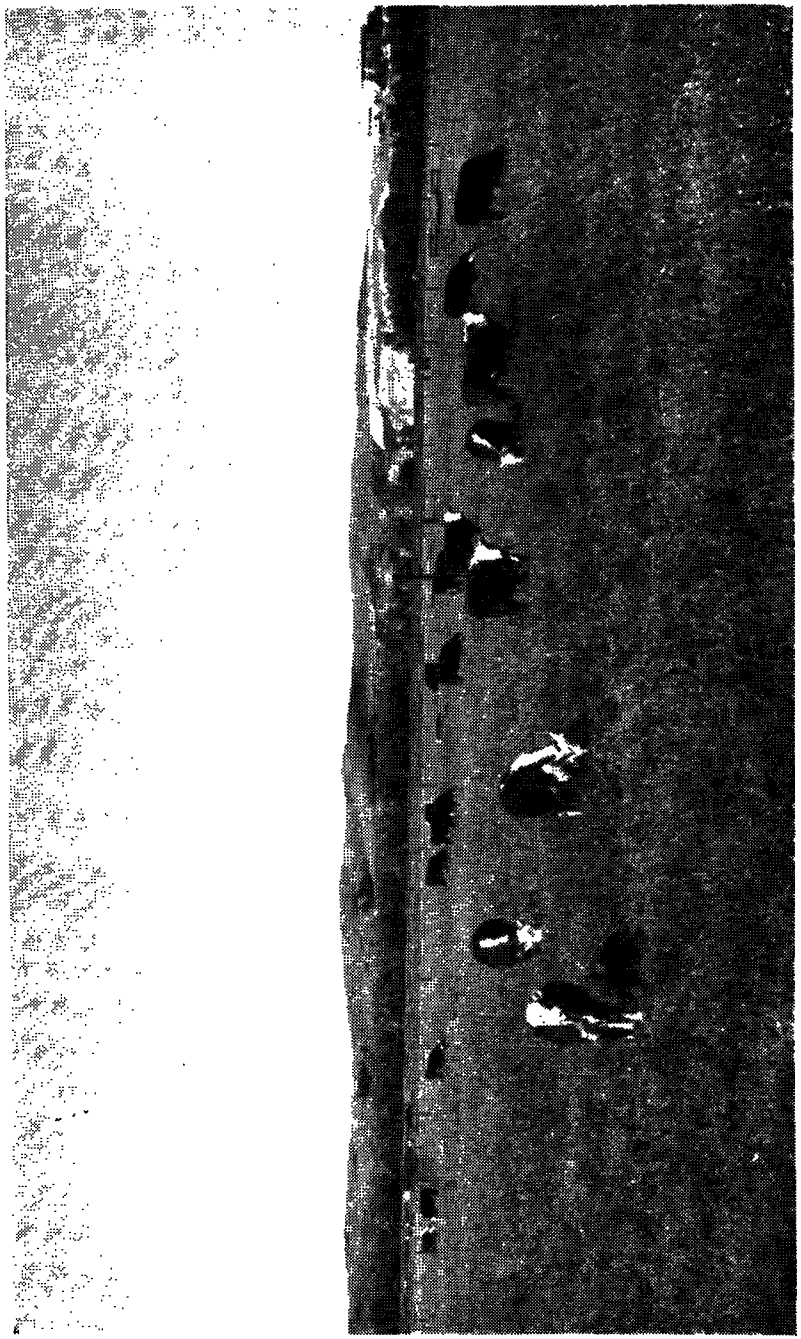
The original Bismarck irrigation project covered about 5,000 acres of bottom lands south of the city. Further surveys found that by lifting the water about an additional 25 ft. that approximately 15,870 acres could be irrigated, part of it up the Apple Creek valley. The Bureau of Reclamation engineers made soil and other surveys and estimated that about 10,000 acres in the area are suitable for irrigation. This federal unit has this project on its program for later development.

Later surveys indicate that it may be found feasible to irrigate a considerable acreage east of Bismarck in the Steele to Tappen area, by bringing water by canal from the diversion near Prophet Mountain from the Garrison reservoir, when construction has proceeded to that point.

IRRIGATED ROTATION PASTURE TRIAL SUCCESSFUL

Twenty long-yearling steers, grazing on 7.6 acres of irrigated mixed grass and legume pasture produced 3,403 pounds of beef during June and July, August and part of September, 1950. No supplemental feed was given.

That's an average gain of a little more than one and a half pounds per day per animal, or the equivalent of 447.7 pounds of beef produced per acre. At 28 cents per pound, it represents a gross income of $125.36 per acre.



Cattle on Irrigated Alfalfa Pasture near Mandan, North Dakota

The pasture is on the Mandan development farm just west of the city, and has been established through the joint cooperation of the Agricultural College, the State Training School and the Bureau of Reclamation.

W. W. Palmer, supervisor, says the purpose is to demonstrate the adaptability of irrigation development in this area and to get practical information.

Each half of the pasture is irrigated about every ten days by about three inches of water. Border dikes or low ridges run lengthwise of the field are placed at 40-foot intervals, and spread the irrigation water.

Cattle graze on only one-half of the pasture at a time, when the other half is being irrigated and allowed to make new growth for the next grazing period.

The pasture was seeded with a combination of grasses and legumes, two pounds each of seed of alfalfa, alsike and red clover, together with eight pounds of brome and four pounds each of Russian wild rye and meadow fescue. All have done well except the wild rye.

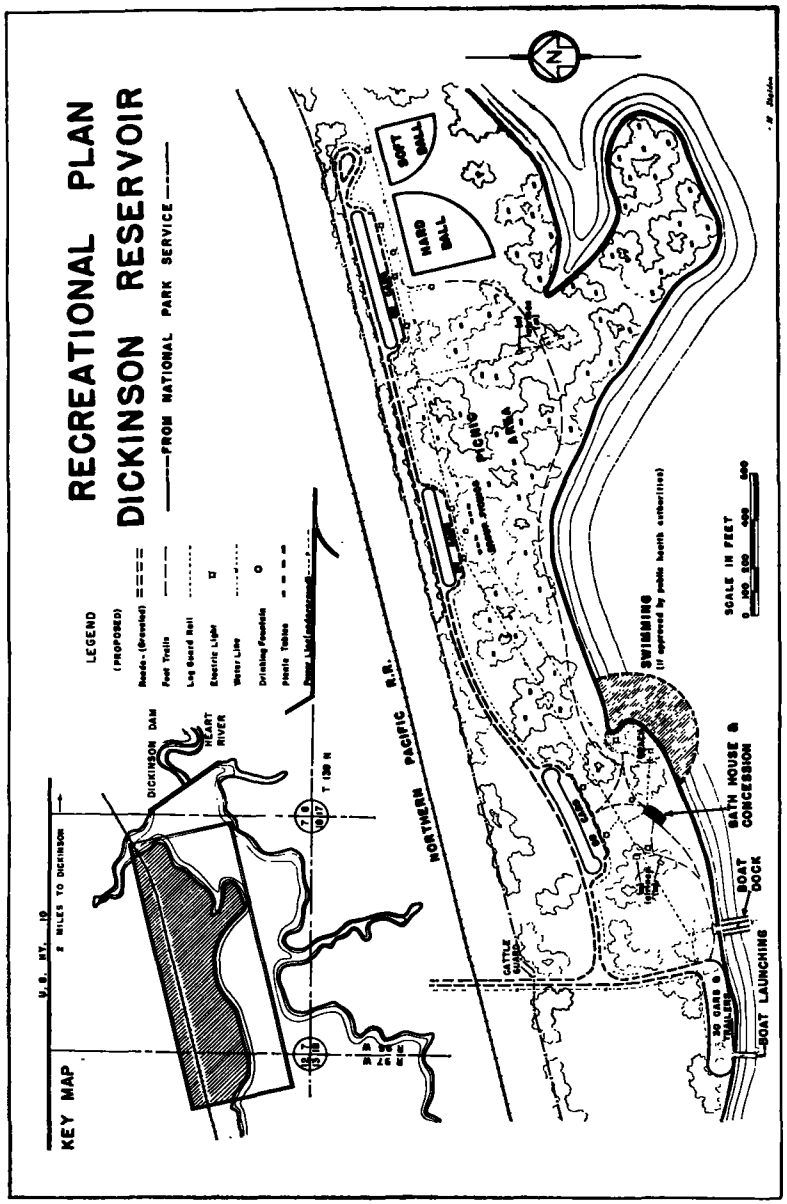
The condition of the pasture has remained good even though it has been stocked with almost three steers per acre. The accompanying picture was taken in August, showing the steers feeding on the pasture.

THE MISSOURI BASIN INTER-AGENCY COMMITTEE

To guide the new basin development, the Missouri Basin Inter-Agency Committee was established April 26, 1945, just four months after passage of the Flood Control Act of 1944. It was founded by resolution of the Federal Inter-Agency Committee in Washington, whose members since December, 1943, had coordinated their respective resources development work on a national level. The new organization, like the parent body, consisted of representatives of the Corps of Engineers, Department of Interior, Department of Agriculture and the Federal Power Commission, with the Department of Commerce added later.

The basin states were invited to designate two representatives to attend regular meetings. Later this number was increased to five, consisting of basin states governors.

The committee is a unique governmental entity—without legal authority or appropriations in its own name. Its members are bound together only by the will and desire to work toward a common end. The Federal Inter-Agency Committee's founding resolution referred to the new group as "providing a means through which the field representatives of the participating federal agencies may effectively interchange information and coordinate their activities among themselves with those of the states in the preparation of reports and in the planning and execution of works for the control and use of the waters of the Missouri river basin."



Under committee procedure, all questions, resolutions or motions must be unanimously adopted. Any irresolvable problems were to be referred to the Federal Inter-Agency body, but this has never been necessary.

Following is a list of the members and representatives of the Committee:

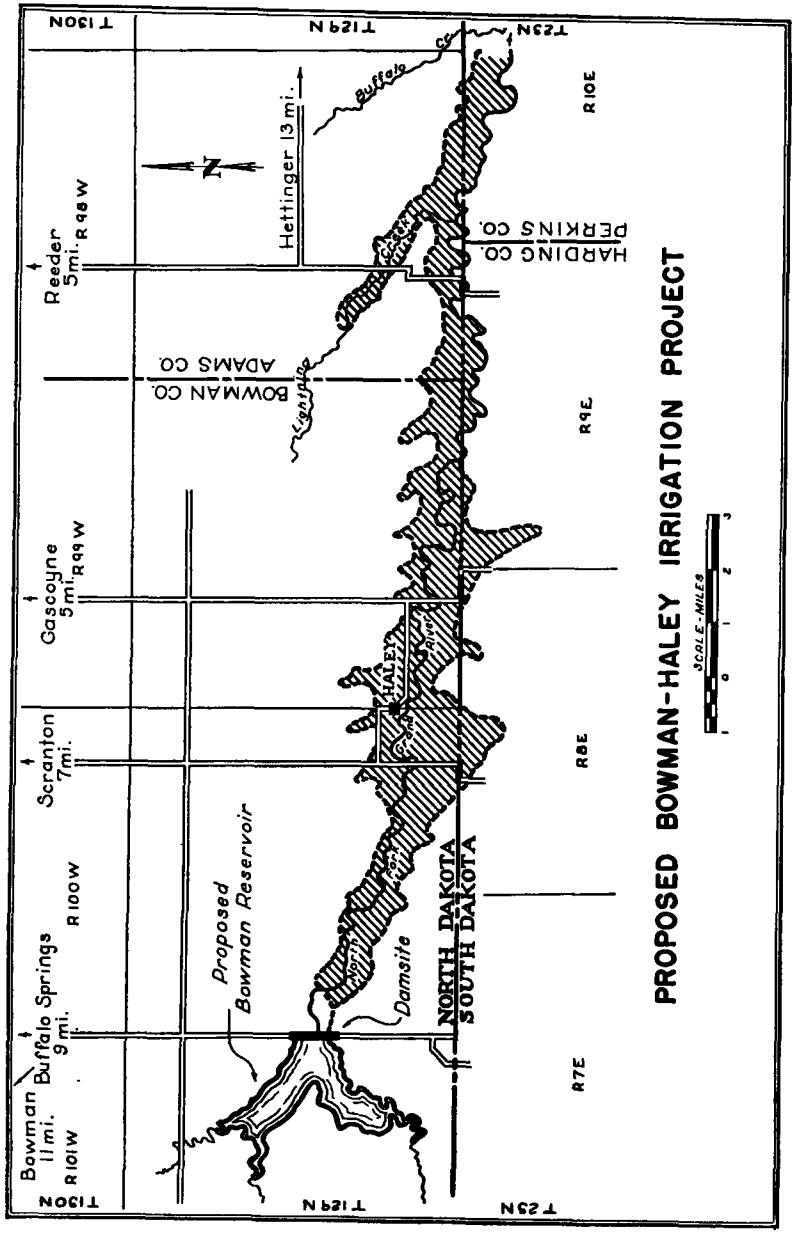
State	Federal
Hon. Val Peterson, Governor of Nebraska	Gladwin E. Young, Department of Agriculture, chairman
Hon. George T. Mickelson, Governor of South Dakota	W. G. Sloan, Department of Interior
Hon. Fred G. Aandahl, Governor of North Dakota	Brig. Gen. S. D. Sturgis, Jr., Corps of Engineers
Hon. John W. Bonner, Governor of Montana	Charles E. Brokaw, Department of Commerce
Hon. Forrest Smith, Governor of Missouri	B. H. Greene, Federal Power Commission

MISSOURI RIVER STATES COMMITTEE

The committee serves in an advisory capacity to the Missouri Basin Inter-Agency Committee and is composed of the governors of the 10 basin states and two other representatives chosen by each governor, meeting at the call of the chairman. This body has as one of its principal duties the naming of five of the governors from among its membership to serve on the Inter-Agency Committee. It also plans state activities and coordinates the work of the two agencies and discusses problems of special concern to states in the plans. North Dakota is represented by the following members: Governor Fred G. Aandahl, Halvor Halvorson, Minot, representing the Missouri-Souris Projects Association, and Curtis Olson, Valley City, Member of the State Water Conservation Commission.

RECREATION PARK PLANS

The National Park Service will cooperate with any community near newly constructed reservoirs in surveying and planning recreational parks like the Dickinson recreational plan map shown on another page of this report. Valley City residents, also Park River residents have also completed elaborate plans for recreational centers and places for summer gatherings with the aid of the National Park Service. As construction of dams and reservoirs are completed over the state, there will be provided delightful recreation centers for family and community gatherings within easy driving distance. Boating and fishing and swimming will naturally add to the enjoyment, and the prospective number of recreational centers may put this state on the map as a tourist center for people from other states seeking to avoid the summer heat.



BOWMAN-HALEY FLOOD AND IRRIGATION PROJECT

Several meetings have been held urging immediate construction of the Bowman-Haley irrigation project, south of Scranton, about 5,000 acres. The former irrigation district has been reorganized and the need for construction stressed in order to assure livestock feed for the area in case of drouth and also to protect settlers from flood damages and possible loss of life. On request, the North Dakota State Water Conservation Commission has created a water right for the district by the reservation of the unappropriated waters of the north fork of the Grand river in Bowman county. Tentative plans would require a 50-ft. high dam across the Grand river near Haley which would impound approximately 20,000 acre-feet of water.

The Bureau of Reclamation, during the summer, conducted an investigation and made surveys of the area for the purpose of determining the feasibility of the project. The State Water Conservation Commission has recommended the construction of the project.

KNIFE RIVER FLOOD CONTROL—IRRIGATION—POWER

Appropriation was made by Congress for flood control works near Beulah, $87,000 and Hazen $35,500 on the Knife river. Contract for this work was completed under the direction of the Corps of Engineers in 1949.

Congress also appropriated $102,700 for a sub-station at Beulah on the Fort Peck to Garrison dam transmission line, which was completed.

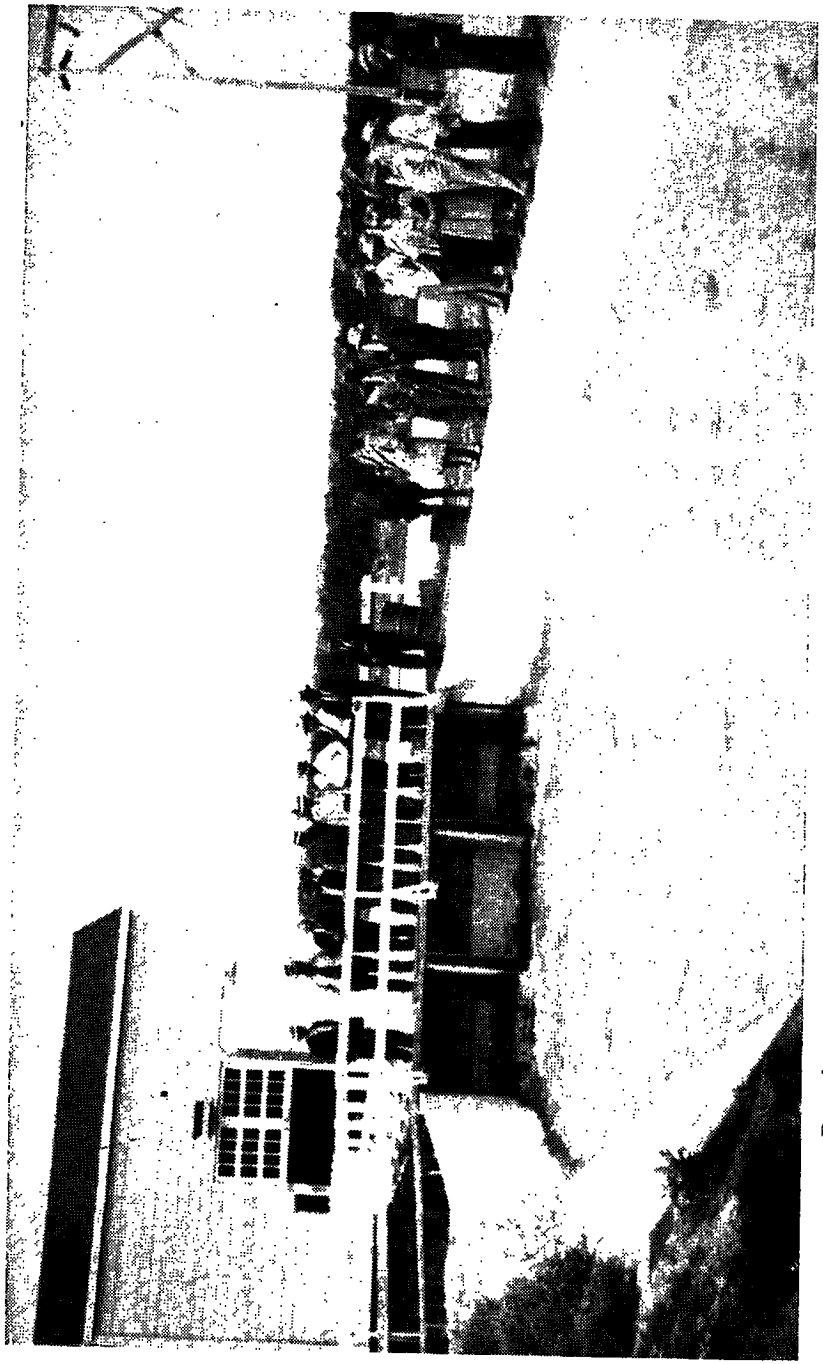
Some surveys, plans and specifications on the Broncho dam and Knife river irrigation are continuing. Further construction is awaiting appropriation by Congress.

APPROPRIATIONS EXPLAINED

North Dakotans should keep in mind that Congress has approved the great Missouri river diversion and water development plan, involving the expenditure of an estimated six billion dollars over a period of years. About thirty million dollars was appropriated by Congress for construction and surveys and planning on North Dakota projects in 1948; about thirty-five million for 1949 and about forty million for 1950. Each year the tempo is stepped up, and it is expected that as the work progresses it may require seventy five millions per annum for North Dakota projects until completed, which is a part of similar construction in nine other states of the Missouri Basin.

WATER COMMISSIONERS' EXPENSES

Appropriations under this item, include per diem salaries to members of the State Water Conservation Commission while attending official meetings, including state and federal conferences, and per diem, travel and maintenance expenses incurred during regular commission meetings in the state.



Pumping Station on Buford-Trenton Irrigation District, west of Williston, N. D.

ADMINISTRATION

Administration of the Water Commission activities do not include costs that may be charged to any specific item, but cover general operating administration expenses, salaries of office personnel, office supplies, purchase and maintenance of transportation equipment used for field inspection work, repair and maintenance of office equipment not otherwise covered in the appropriation for the development of the state water program.

Maintenance of Existing Dams

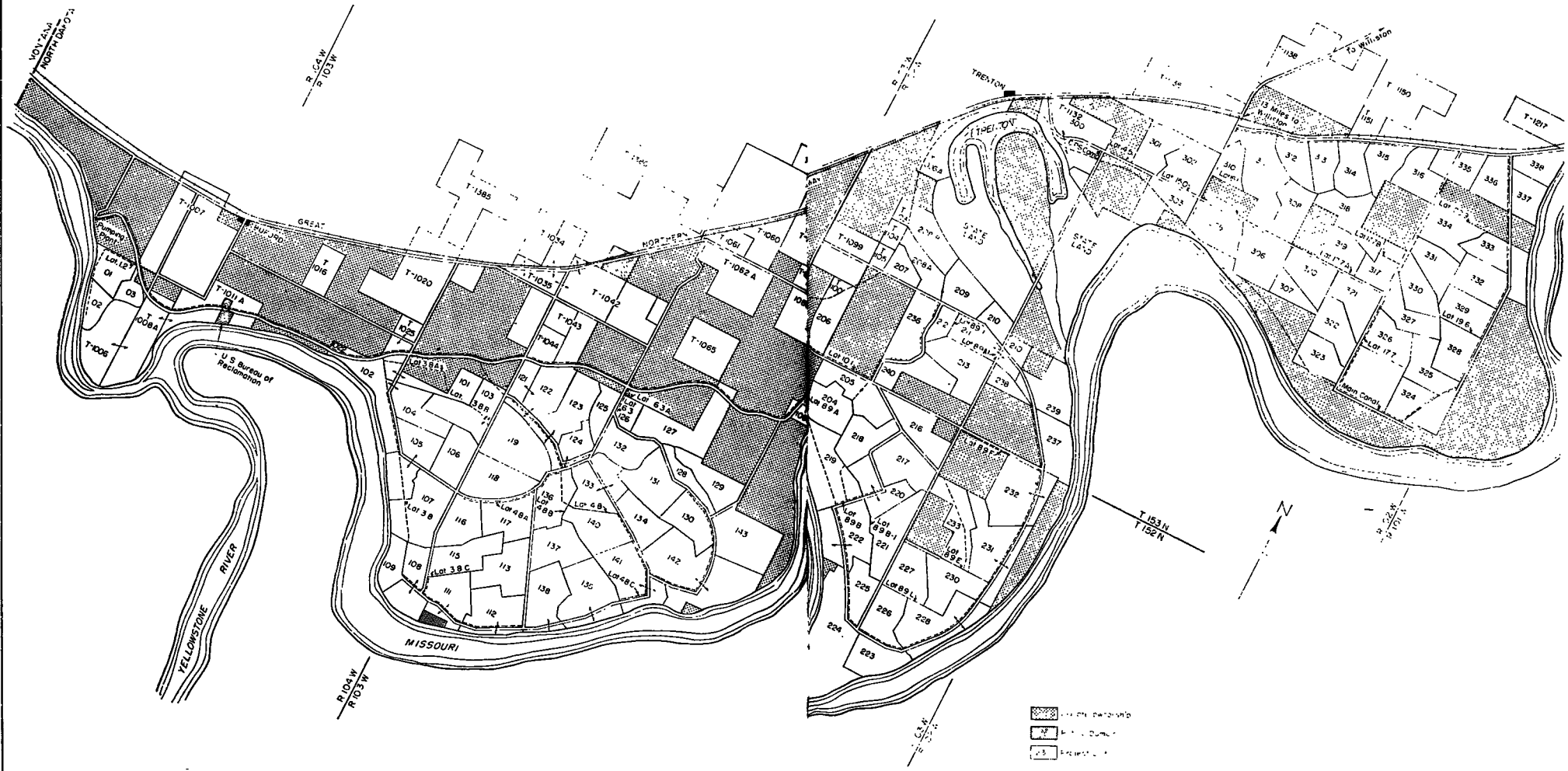
Different Federal agencies built numerous dams during the drought years of the thirties to conserve water for farmers, stockmen, municipal use, and to provide places for recreation and conservation of wild life. Maintenance of these dams has been a cooperative project of the counties, nearby municipalities or wildlife associations, and the State Game and Fish Department when the reservoirs are deep enough to propagate fish and other wildlife. Spillways were not constructed strong enough to withstand continuous undermining of the waters, hence rebuilding and strengthening are commonly necessary to save these valuable water impounding structures, which are a real asset to the communities. The engineers of the Water Commission inspect and design and supervise repairs needed. The State Game and Fish Department has cooperated on those dams which they can utilize on their work.

International and Interstate Compacts

As construction progresses on the Missouri river basin water development program, it has been found more and more important where streams being used cross state boundaries to have conferences between the state authorities regarding a proper distribution of the stream waters between the states, and that compacts be made covering the agreement to avoid future controversies. This entails considerable travel and transportation expense for members of the Water Commission. It includes occasional appearances before Congressional committees when consideration of appropriations are being made for these joint projects. It is necessary to protect the interests of North Dakota as between states. Continued appropriations will mean much to the future stability of agriculture, stockraising, hydro-electric power, municipal water supplies, flood control, recreational centers, etc.

Topographic and Conservation Branches in Cooperation With U. S. on a 50-50 Basis

The surveying and preparation of topographic maps over a large portion of the U. S. has been completed by the Geological Survey engineers. The State Water Conservation Commission contracts for the continuation of this mapping in North Dakota to cover areas where water development construction is proposed. The expense of this work being paid on a 50-50 basis by the two agencies. This mapping covers



Partly Constructed Buford-Trenton Irrigation District

Located West of Williston, North Dakota in Williams County

the areas where irrigation is planned by diversion of waters from the Garrison dam and down the two sides of the Missouri river, as well as the tributaries west of the Missouri. The areas of the million-acre Missouri-Souris project are being mapped in cooperation with the Bureau of Reclamation. It is important that these topographic maps be completed before irrigation construction planning begins because of the saving of time and expense and the increase in speed of construction resulting from the mapped information.

Hydrographic Surveys, Also in Cooperation With U. S. Geological Survey on 50-50 Basis

Reliable information giving stream flow measurements over a long period of time is essential before engineers can produce reliable plans and specifications for dams, reservoirs, water power, irrigation and flood control. These records of minimum and maximum flow of streams are necessary to determine the size needed on proposed reservoirs to hold back flood waters, and what acreage can be irrigated by the available waters.

Salary, State Engineer

The Executive Secretary and Chief Engineer of the State Water Conservation Commission is also designated as the State Engineer. He is supervisor of the use of all of the waters of the state. He makes agreements with the approval of the Water Commission for cooperative surveys and plans and specifications for the construction of dams and irrigation works.

Reconstruction Drains or Irrigation

Loss from flooding of crop lands in the Red River valley in 1943-44 was estimated at more than twenty-four million dollars. The legislatures have been appropriating drainage funds to the Water Commission for allocation to the different counties as needed to pay a part of the cost of repair and cleanout of drainage ditches. This work is continued in cooperation with the Department of Agriculture Soil Conservation Service and will greatly reduce the loss to crops and property which has been experienced on former years. Smaller irrigation districts also need emergency aid at times to cover repairs of damage by storms and floods.

Engineering and Geological Surveys and Demonstrations

More than seventy communities in North Dakota requested assistance from the State Water Conservation Commission to find suitable potable water for their needs. This appropriation is used mostly for supervision of this work by the State Geologist, representing the Water Commission. All state funds are being matched on a 50-50 basis by government funds of the U. S. Geological Survey in making necessary investigations and test drilling with the state-owned rotary drill. Each municipality is

required to make a proportionate payment of the expense. About one-half of the communities requesting aid in finding more and better water have been served, with remarkable success in most cases. It appears that this work should be continued indefinitely because of the increasing number of communities finding water supplies diminishing and insufficient for their needs.

Post-War Projects, in Cooperation With U. S. Departments, and for Organizing Conservation and Irrigation Districts

This appropriation has been used on a 50-50 basis with government funds in cooperation with the Bureau of Reclamation on studies, investigations and preliminary surveys where there is a prospect of developing additional acreages under irrigation. This type of work will increase as the Missouri river diversion construction work proceeds and new possibilities open up, as well as in assisting in the organization of irrigation and conservency districts.

Other Investigations, Surveys, etc.

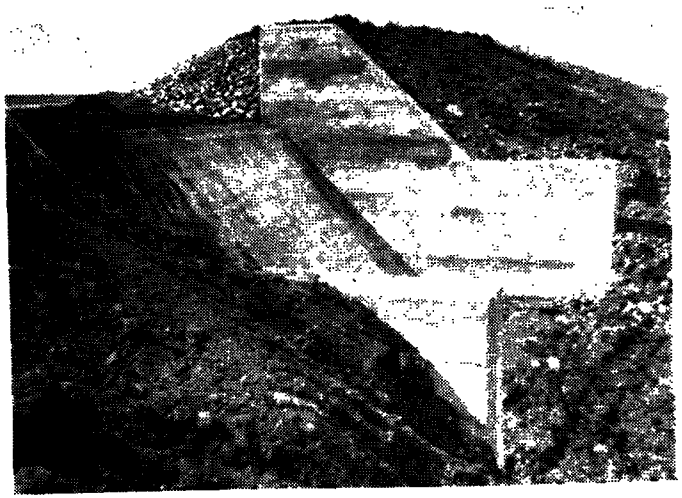
This appropriation makes it possible for the Water Conservation Commission engineers to make surveys, investigations and plans for prospective irrigation of additional areas not included in the original plan of the Bureau of Reclamation. In the case of the Heart and Cannonball river areas, Water Commission engineers made the detailed mapping. Other areas are now being mapped where it is thought to be possible to expand irrigation.

Construction Bond Guaranty Fund

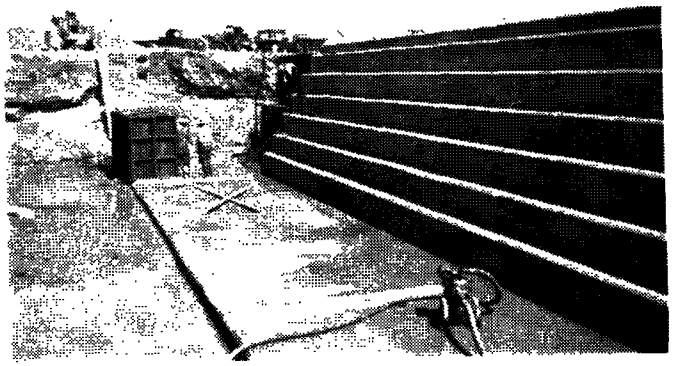
The legislature provided a revolving fund to enable the Water Commission to give additional security to its bond issues to raise funds for irrigation construction when needed, thus making the bonds more readily marketable at a lower rate of interest, because of the added security. No losses have been incurred and it is expected that the full amount so far used will be returned to the fund. It is expected that in the future there will be many small irrigation districts needing financing for future construction.

MAINTENANCE OF EXISTING DAMS

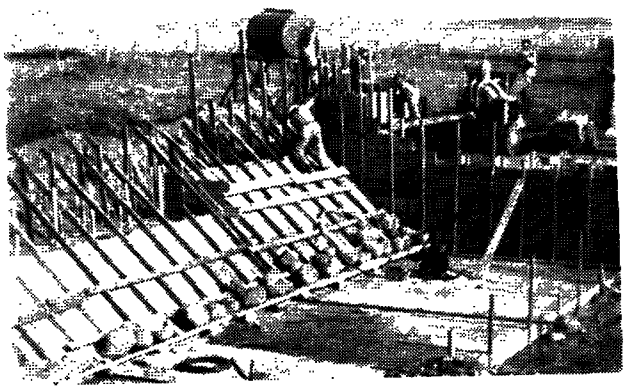
During the drouth years some 1,200 dams were built in North Dakota by Federal agencies. The reservoirs created served a number of conservation needs. They provided water for small irrigation projects; water for stock; water for municipal supplies, and recreation areas for picnicking, swimming, boating and fishing; also provide areas beneficial to wildlife.



Wilson Dam No. 343, near Edgeley, LaMoure County



Jackson Dam Spillway in McKenzie County, near Alexander



Coal Mine Lake Dam in Sheridan County, Near Harvey

At the termination of the Federal Works program no state or federal departments were charged with the responsibility of the maintenance and repair works required to keep the structures repaired, and the counties were delegated to assume responsibility for maintenance in cases where such projects were outside of water conservation districts. This work could be financed by money budgeted for that purpose in any county, but no special levies could be made for this purpose unless authorized by the legislature. This difficulty of financing, together with a lack of trained engineering personnel, makes the dam maintenance repair work too difficult for the counties to manage. In order to meet the requirements, the state legislature has appropriated funds to the State Water Commission to carry on the work.

This program provides for investigation, survey, design and supervision of construction by the Water Commission. Nearly all the maintenance work is done by construction crews from the Water Commission, using state owned equipment. These projects are being financed on a cooperative basis, with counties and locally interested groups sharing with the Water Commission in the cost of the project. The State Game and Fish Department participates in financing of projects in which wildlife benefits prevail.

The maintenance work involved under this program is quite wide in scope. It may consist of reconstructing new spillways, to small repair jobs on slightly damaged spillways. The work consists mainly of repairs to spillway structures, including placement of steel sheet piling or concrete cutoff walls, the reconstruction or replacement of part of an overflow section with either rubble, plain, or reinforced concrete materials, and, wherever required, the replacement of riprap.

During the period of the biennium 33 spillways were reconstructed and repaired, 16 were main reconstruction projects, 17 others ranged from small to large repair jobs. These repair and reconstruction works ranged in costs from $64.50 to $9,364.19. Thirty-three dams were repaired in 22 counties spread over the state, showing the work is fairly evenly distributed.

There is still a large number of dams and spillways that need repairs and replacements, where the structures have been washed away by flood waters during the recent years of extremely heavy snowfall, or where maintenance work has been neglected and water is gradually wearing away small sections of the structures.

The following tables show a list of dams, their names, location by counties, distribution of expenditures by participating agencies and total cost of works.

MAINTENANCE OF DAMS—October 1, 1948 to June 30, 1950

Project No.	Name of dam	County	Water Commission	Game and Fish	Community	Total Repairs
267	Bathgate	Pembina	$ 204.43	$ 201.43	$ 204.43	$ 613.29
488	Benzi	McLean	137.50		137.50	275.00
221	Burlington	Ward	3,424.06			3,424.06
353	Cedar	Slope	64.50		64.50	129.00
384	Coal Mine Lake	Sheridan	1,639.24	1,639.24	1,639.24	4,917.72
402	Danielson dam	Morton	333.82	333.82	333.82	1,001.46
476	Faust	Barnes	524.50		524.50	1,049.00
389	Fessenden	Wells	1,184.40	1,184.39	956.05	3,324.84
257	Green river	Stark	1,579.01	639.80		2,218.81
484	*Hoskins Lake	McIntosh	1,928.97		1,210.00	3,138.97
317	Hebron	Morton	204.68	204.68	204.68	614.04
253	*Jackson	McKenzie	4,926.69			4,926.69
242	Jund	McIntosh	4,501.06		1,125.00	5,626.06
467	Kiwanis	Foster	588.10	588.10	588.10	1,764.30
316	Lisbon	Ransom	3,630.31	3,630.30	1,500.00	8,760.61
445	Mike Olson	Grand Forks	430.92	430.92	430.91	1,292.75
265	Logan Center	Grand Forks	2,665.38	2,625.43	2,625.44	7,916.25
464	Niagara	Grand Forks	364.50	364.50	364.50	1,093.50
394	Odlund	Golden Valley	532.96	532.96		1,065.92
299	Pembina	Pembina	1,800.97	750.00	1,800.97	4,351.94
350	Regent	Hettinger	210.13			210.13
291	Sarnia	Nelson	169.21	169.21	48.00	386.42
417	Squaw Creek	Hettinger	1,814.77	900.00	900.00	3,614.77
311	Sivertson	McKenzie	8,864.19		500.00	9,364.19
431	Strawberry Lake	McLean	64.70	64.70		129.40
450	Sykeston	Wells	2,417.05	1,500.00	2,417.05	6,334.10
441	Temvik	Emmons	979.95	859.94	859.94	2,699.33
472	Underwood	McLean	416.58	416.58	416.58	1,249.74
477	Valley City	Barnes	1,693.94		1,693.94	3,387.88
140	Watford City	McKenzie	5,512.09			5,512.09
380	Williams Creek	Golden Valley	4,088.98	2,000.00	2,000.00	8,088.98
343	Wilson	LaMoure	2,990.75	1,645.37	300.00	4,936.12
359	Wolf Butte	Adams	3,180.17	1,000.00	1,000.00	5,180.17
			$63,068.51	$21,684.37	$23,845.15	$108,598.03

*Work in progress June 30, 1950—Costs not complete.

PRELIMINARY INVESTIGATIONS AND SURVEYS OF DAM REPAIRS

Project No.	Name of dam	County	Cost
264	Braddock	Emmons	$ 62.13
330	Lake Metigoshe	Bottineau	339.82
342	Hansen	Barnes	13.83
361	Wilhelm	Dunn	55.02
445	Fish Lake	Stutsman	237.57
453	Berger	Barnes	98.49
463	Rush Lake	Cavalier	1.25
475	Golden Lake	Steele	389.93
478	New England	Hettinger	14.13
479	Fish Creek	Morton	71.62
483	Skedsvold	McKenzie	18.93
443	Lake Juanita	Foster	604.81
485	Twin Lakes	Williams	17.02
353	Cedar	Slope	763.14
		Total	$2,687.69

SUMMARY OF MATERIALS USED DURING THIS BIENNIUM

For Repair and Maintenance of Dams

Corrugated Sheet steel piling	4,072 sq. ft.
Rubble concrete placed	2,005 cu. yds.
Cement used	13,661 sacks
Sand used	1,755 tons
Reinforced concrete placed	1,013 cu. yds.
Plain concrete placed	122 cu. yds.
Gravel used	2,455 tons
Field stone used	962 cu. yds.

COMPLETE WATER RIGHT SUPPLEMENT "A"

Accompanying this Seventh Biennial Report of the State Water Conservation Commission and the State Engineer, is a supplement covering a complete corrected list of Water Rights granted, brought down to July 13, 1950. In the early days of statehood, there were different ways of securing water rights from the government and the state, which were filed and recorded in the counties where the land was located in which the water was to be used. The law was changed later and the granting of water rights added to the duties of the State Engineer, who in 1938 was made the Executive Secretary of the State Water Conservation Commission. These changes in the law have resulted in much confusion and made it difficult to compile a water right list from the many counties and government agencies.

STATE WATER CONSERVATION COMMISSION
FINANCIAL STATEMENT
As of June 30, 1950
1949-1951 Appropriations

Appropriation for	July 1949	Expended	Balance
Commissioner's Per Diem and Expenses	$ 4,000.00	$ 2,079.03	$ 1,920.97
Administration	30,000.00		
Plus Refunds and Collections	3,472.55	18,317.87	* 15,154.68
Maintenance of Existing Dams	100,000.00		
Plus Refunds and Donations for Dam Repairs	21,506.94	58,020.76	63,486.18
International and Interstate Compacts	12,000.00	5,606.77	6,393.23
Topographic and Conservation Branches, Cooperation with U. S. Geological Survey, plus collections	33,085.60	10,477.76	* 22,607.84
Hydrographic Surveys, Cooperation with U. S. Geological Survey, plus collections	20,090.87	9,474.21	10,616.66
State Engineer's Salary	5,400.00	2,700.00	2,700.00
Reconstruction of Drains or Irrigation	150,000.00	21,423.33	*128,576.77
Engineering and Geological Surveys and Demonstrations	30,000.00	18,220.04	* 11,779.96
Postwar Projects, Cooperation with U. S. Departments	135,000.00	2,940.73	*132,059.27
Other Investigations, Surveys, Etc., plus collections	90,036.76	52,747.55	* 37,289.21
Construction Bond Guaranty Fund	70,541.00	Nil	70,541.00
	$705,109.02	$202,007.95	$503,101.07

*Current bills pending and balances mostly pledged.

EDUCATIONAL EXHIBITS

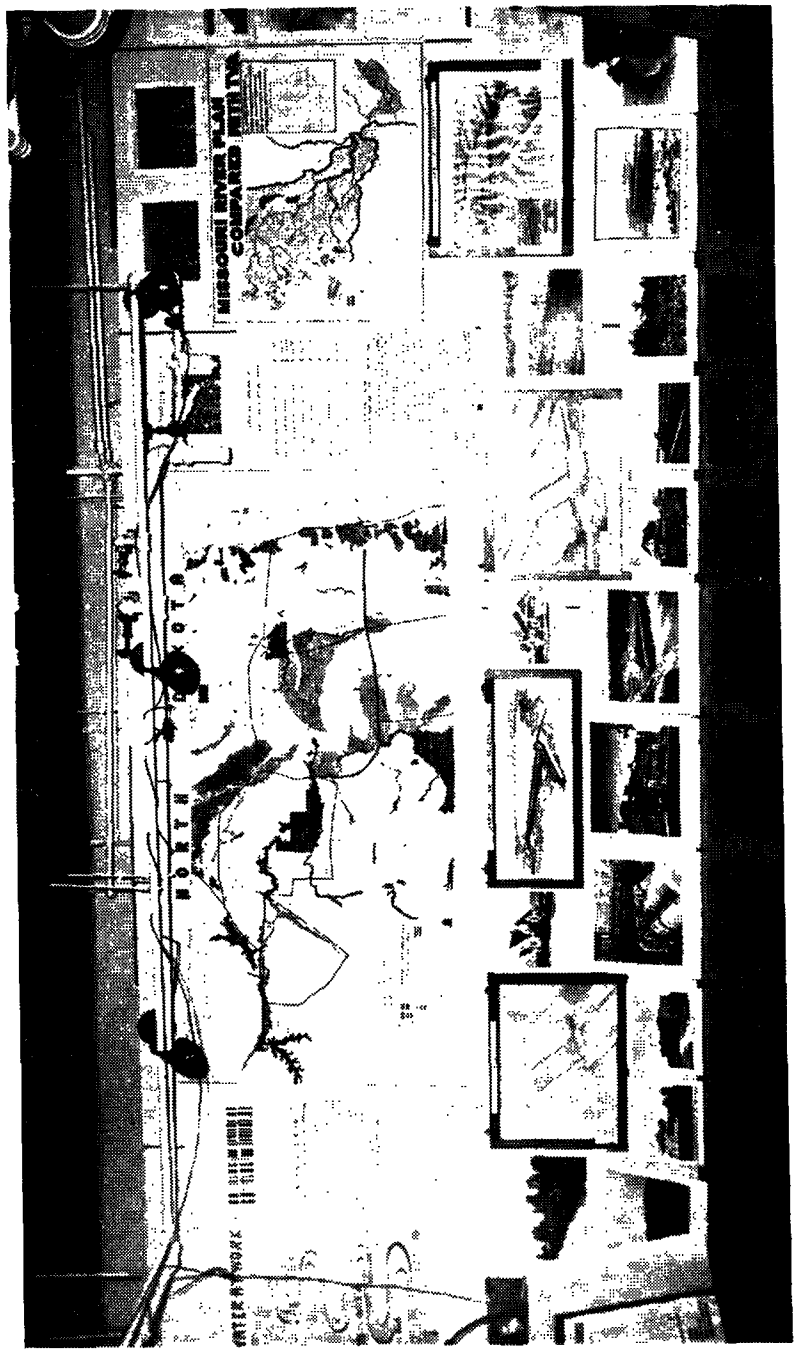
Since construction began on the Missouri river development plan, there has been an increasing demand on the Water Commission for information regarding the program and how it will affect the different localities in the state. Informational maps and circulars and copies of addresses and radio talks have been mailed to interested people. Exhibits which show by maps, graphs, bulletins and pictures the plans and the construction progress have been shown on request at many fairs, conventions and other gatherings, as follows:

Jan. 19-21	1949	Bismarck	Isaak Walton convention
Jan. 27-28	1949	Jamestown	County Agricultural Institute
Feb. 1-2-3	1949	Steele	County Agricultural Institute
Feb. 27-28	1949	New England	Farmers Institute and Seed Show
Mar. 7-12	1949	Valley City	Winter Stock Show
Apr. 7-8	1949	Mohall	County Agricultural Institute
June 2-4	1949	Kenmare	Harvest Festival
June 12-19	1949	Fargo	Boys State at Agricultural College
June 21	1949	Minot	State Teachers College Classes
June 23-25	1949	Crosby	Divide County Fair
June 27-29	1949	Bottineau	County Fair
July 11-15	1949	Fessenden	Wells County Fair
July 25-30	1949	Minot	State Fair
July 22-25	1949	Bismarck	Western States Engineers
Aug. 28-3	1949	Fargo	Red River Valley Fair
Sept. 14-15	1949	Amidon	Slope County Fair
Sept. 21-24	1949	Bismarck	State Conservation Show
Feb. 8-9	1950	Lakota	County Agricultural Meeting
Feb. 16-17	1950	New England	Farmers Institute and Seed Show
March 6-11	1950	Valley City	Winter Stock Show
March 14-16	1950	Bismarck	Hardware Dealers Convention
Apr. 14-15	1950	Fargo	North Dakota Press Association
Apr. 27-29	1950	Minot	College Rural Life Conference
May 5-6	1950	Bismarck	Young Citizens League convention
June 8-10	1950	Bismarck	Stockmens Association convention
June 18-25	1950	Fargo	Boys State at Agricultural College
July 11-15	1950	Fessenden	Wells County Fair
July 24-29	1950	Minot	State Fair

DROUTH PERIODS IN NORTH DAKOTA

The annual growth rings of trees, revealed at the stump when a tree is sawed down, give a faithful and clear record of weather in years in the past. When the annual rings are close together the weather was dry, and where the rings are farther apart the seasons were wet.

Dr. Rainer Schickele, economist with the N. D. Agricultural College, has used the tree ring study of George Will as depicted by the accompany-



Water Commission Educational Exhibits Show Planned Water Conservation

ing graph as basis for his belief that North Dakota always has had series of dry years and series of wet years.

The graph shows that during a period of 536 years there were 22 dry periods and 24 wet periods of three or more years. The longest dry period lasted 16 years while the longest wet period was 39 years. During the whole 536 years there were only five dry and five wet periods of only one or two years duration. The cycle of five to ten years was common.

Schickele maintains that "the whole economy of the Great Plains must be able to expand and contract in accordance with weather and demand for certain crops. Tillage practices, soil conservation programs, feed storage capacities, crop insurance, mortgage amortization practices, bankruptcy, foreclosure and credit policies—all must be geared to fit this special long-cycle farming area. They must fit a cycle where times of need may continue for five to ten years."

It has been suggested that irrigation of about one-tenth of the cultivated area of the state, with alfalfa and other feed crops, livestock and dairying, as the basis of farm management programs may enable farmers to live through these drouth periods and cover running expenses of the farm and family and thus survive and over a lifetime be quite successful.

SERIES OF DROUTH YEARS MAY BE EXPERIENCED AGAIN

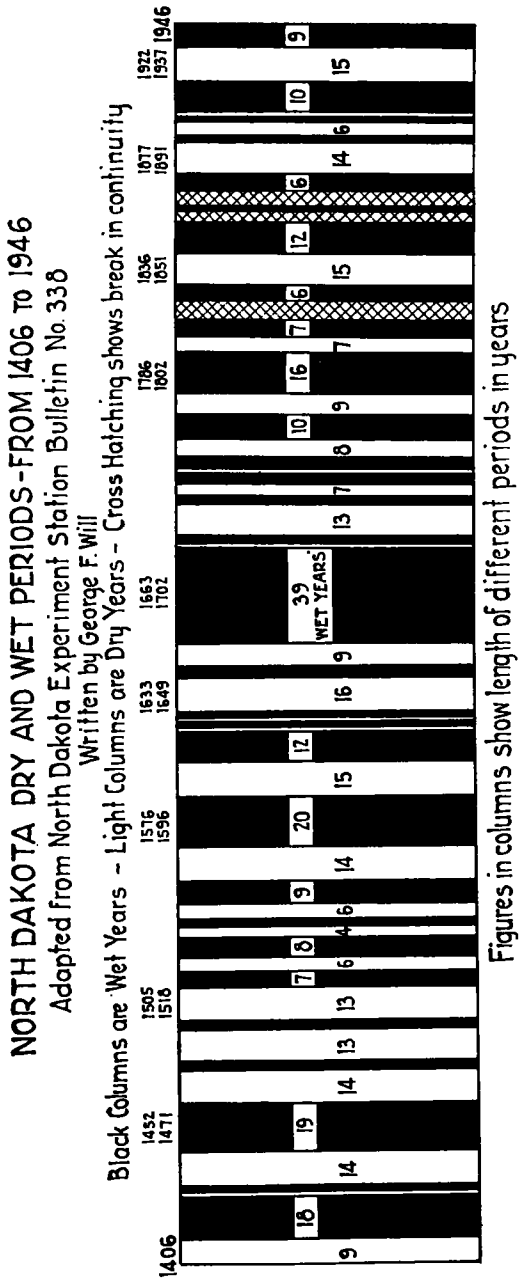
On application of county authorities and supported by Governor Aandahl, the Secretary of Agriculture designated 37 counties in North Dakota in 1950 as disaster loan areas.

Heavy storm damage, drouth and insect outbreaks cut the state's income from farms 32 per cent in 1949, the biggest income drop in the nation.

Farmers in disaster loan areas are thus enabled to obtain emergency loans for cropping expenses from funds formerly used by the Agricultural Credit Corporation, but now from the Farmers Home Administration.

It was reported that about 40 per cent of the farmers in need of emergency loans were World War II veterans.

Loans were made available in the counties of Benson, Pierce, Dunn, McKenzie, Eddy, Foster, Kidder, Sheridan, Stutsman, Adams, Dickey, LaMoure, McIntosh, Billings, Bowman, Golden Valley, Hettinger, Slope, Stark, Burleigh, Emmons, Grant, Morton, Sioux, Logan, Ransom, Sargent, Williams, Mercer, Oliver, McLean, Wells, Ramsey, Cavalier, Nelson, Griggs and Barnes.



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