SEVENTEENTH BIENNIAL REPORT

OF THE

STATE ENGINEER

TO THE

GOVERNOR OF NORTH DAKOTA

1935-1936

E. J. THOMAS
State Engineer

LETTER OF TRANSMITTAL

The Honorable
William Langer,
Governor of North Dakota.

Sir:

In compliance with the provisions of State statutes, I have the honor to transmit herewith the Seventeenth Biennial Report of the State Engineer.

Respectfully submitted,

E. J. THOMAS,

State Engineer.

Bismarck, North Dakota.
January 15, 1937.

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INTRODUCTION

On May 5, 1935, Mr. R. E. Kennedy resigned from the office of State Engineer to accept a position with the Bureau of Reclamation. On July 9th the present State Engineer was appointed as State Engineer.

The State Engineer has endeavored to conduct the affairs of his office efficiently and to that end has co-operated with the United States Geological Survey, the United States Reclamation Service, United States Bureau of Public Roads, the F. E. R. A., W. P. A. and various other Governmental Agencies.

DUTIES AS OUTLINED BY LAW

The duties of the State Engineer are fully set forth in the State Law and include the following:

> Custodian of Government plats; examination as to the existence of coal on state lands; general supervision of the waters of the state and the supervision of the measurement and appropriation thereof. Also, to make hydrographic surveys and investigations of stream basins; adjudicating water rights; making surveys of state lands.
>
> The State Engineer represents the state on matters pertaining to interstate and international water problems, he encourages and gives assistance in the matter of construction of dams and other control devices by individuals, Federal Agencies and communities, such assistance including the furnishing of information and data concerning stream flow. The State Engineer prepares reports to the Governor with recommendations for Legislation, formulates rules and regulations for carrying into effect the duties of the office.
>
> The State Engineer acts as Water Conservation Commissioner, Secretary of the Missouri River Commission and has control of lands within ordinary high water level on meandered bodies of water.

The activities of the office of State Engineer have included many of the duties above enumerated. Additional duties for the office were provided for in the Water Conservation Act passed at the last session of the legislature. Some work has been done under this law. A law creating the State Planning Board was also passed at the last session of the legislature. Under such law it is the duty of such Planning Board to make recommendations as to the best methods for the conservation, utilization and development of the water resources of the state. The State Engineer, as a member of the Water Resources Committee of such Board, has submitted reports giving information and data for the guidance of said Board.

This office has done much work in connection with the development of flood irrigation projects on the Mouse River and to a considerable extent this effort has resulted in a contract being recently let for the construction of the Eaton project, involving the irrigating of 8,700 acres of land. Over fifty farmers will be benefitted by this project. A Mouse River Committee has been appointed for supervising the utilization, control and development of the Mouse River in North Dakota. The State Engineer is Chairman of this Committee.

At a meeting of the Tri-State Conference on the Red River of the North, held at St. Paul, Minnesota, on November 25, 1935, for the purpose of obtaining immediate action in connection with the construction of projects affecting the flow in said river and for initiating studies for a long-range plan for the proper development of said stream, the State Engineers of the three states affected were asked to assist in the speeding up of such construction work by Federal Agencies and to furnish basic data to be used in formulating such long-range plan. A considerable amount of work has been done in this regard. Much work has been done by the State Engineer in encouraging of water conservation projects by federal agencies. He has also assisted individuals and communities in the preparing and submitting of applications for such projects. The State Engineer is cooperating with the National Resources Committee by furnishing to such Committee detailed information with regard to the water resources of the state.

This investigation of the National Resources Committee will no doubt result in intensive studies of the water resources in the state and will very likely result in the construction of many Water Conservation projects. There is an increased interest in water resources development within the state and to take care of this increased development, the facilities and funds to be provided for the use of the State Engineer's office should be increased to conform with such development. The attention of the Governor is called to the fact that while the salary of the State Engineer was formerly $3,000 per year, the last two budgets provided only $1,920 per year. This salary allowance should be increased to conform with the importance of the office and with the extent of the duties to be performed.

TRI STATE COMMITTEE ON THE RED RIVER OF THE NORTH

One of the first basin studies undertaken in the United States by the Water Resources Committee of the National Resources Committee was a study of the Red River of the North. This study was done under the direction of W. W. Horner of St. Louis, consulting Engineer for the National Resources Committee. Mr. Horner is the Chairman of a committee which was appointed by

Governor Walter Welford as presiding officer, at a meeting of the Tri-State conference on the Red River of the North, held at St. Paul on November 25, 1935. Included as members of such a committee in addition to Mr. Horner, were the Chairman and Federal Consultants of Planning Boards of the states of Minnesota, North Dakota and South Dakota. Dr. Irvine Lavine, Federal Consultant for the North Dakota Planning Board has been in active charge of the collection of data and formulation of reports for the North Dakota area of the drainage basin. Dr. Lavine was assisted by the members of the Water Resources Committee of the State Planning Board in the gathering and tabulation of data for the North Dakota area. The State Engineer is a member of the Water Resources Committee of the State Planning Board.

The study of the water program for the whole drainage area was taken up by sub-basins. An outline of the program for conducting the study in each sub-basin was proposed and approved by the committee at their St. Paul meeting on January 10, 1935. Some of the studies were carried out by the State Planning Boards, using the augmented staff under W. P. A., allocations, certain specialized studies were carried on by the State Engineers, the State Sanitary Engineer, and the State Geologist.

The report on the Red River Survey was completed July 8, 1936. The completeness of the report was so highly satisfactory to the National Resources Committee that it adopted it as a model from which to develop an outline for reports in connection with the National Water Plan.

The report to the President recommended a water plan for the Red River of the North which must involve the reorganization of the handling of the water supply as follows:

1. The improvement of facilities for storage of water.
2. The stabilization and control of natural lake levels.
3. Provisions for improved, dependable, low water stream flow.
4. The improvement of low water channels.
5. The regulation of the construction of small dams.
6. The correction of flood flow.
7. The readjustment of land drainage.
8. The reduction of stream pollution.
9. The installation of new water works and improvements of existing water treatment plants and distribution systems.
10. The improvement of conditions for the generation of hydroelectric power.

To carry out this long range water development plan as outlined a list of projects was prepared which would carry out the provisions of the plan. The projects listed were classified into 3 classes as follows:

Class A.	$ 8,608,200
These projects are recommended for immediate attention. They are listed in two major groupings: (a) Major water storage, streamflow and flood control projects are arranged geographically under numbers 1 to 11 inclusive; (b) Widely scattered dams for conservation are listed under 12, municipal water supplies are numbered 13, and sewage projects are numbered 14.	
Class B	1,507,700
These projects demand immediate survey and prompt consideration if shown to be practicable.	
Class C	1,725,200
These projects are parts of the complete plan but lack the urgency of Classes A and B.	
GRAND TOTAL	$11,841,100

The recommendations made to the President were as follows:

1. The conference respectfully urges the President of the United States to provide relief within the basin insofar as practicable, by putting into action the program recommended and approved with a view of implementing the water plan for the basin. Relief work may thus be given enduring value; measures may be carried out that will conserve and augment the available supply of water and thus provide effective insurance against recurrence of grave distress in future periods of drought.

2. The conference respectfully urged the W. P. A. Administrators of Minnesota, North Dakota and South Dakota, to take such steps as are necessary to put into operation such of these proposed water projects as can be adopted to their programs.

3. The Governors of the three states of Minnesota, North Dakota and South Dakota be urgently requested to appoint immediately a Tri-State Committee to consider possible organization for the implemently and control of the coordinated water plan just adopted by this conference.

As a result of the studies and report the President has allotted $50,000 from the W. P. A. to the War Department for surveys in the Red River of the North Drainage Basin.

These surveys include:

1. Completion of survey of Baldhill reservoir, $5,000.
2. Completion of survey of Walhalla reservoir, $5,000.
3. Completion of survey of Steele County reservoir, $5,000.
4. Completion of survey of Dakota Wild Rice floodway to Sheyenne River, $5,000.
5. Completion of survey of Sheyenne-Dakota Wild Rice diversion ditch, $5,000.
6. Completion of survey of Park River levee and channel straightening, $5,000.
7. Preparation of construction plans for municipal sewage and sewage treatment plants, and municipal water supply and water treatment plants throughout the basin. No estimate of cost now available.

The main questions to be covered in the report to be submitted to the Chief Engineers are as follows:

A. The merit of the entire plan.
B. The feasibility of the individual projects which are included in the program and the estimated cost thereof.
C. The order of priority in which individual projects should be undertaken.
D. The projects which are of such nature that they might be undertaken by the Works Progress Administration at this time.

NATIONAL WATER PLAN

Following the initiation of studies of a few stream basins in December 1935, which, preliminary studies included the Red River of the North. The development of a National Water plan was undertaken by the Water Resources Committee of the National Resources Committee.

The services of a group of seventeen consultants under the direction of a Director and Assistant Director was secured for a special study of the Water Recources of the United States and to outline a developed or long range plan of water conservation, flood control, erosion and water pollution; to the uses of water for domestic purposes, irrigation and power, and to drainage of water logged and overflowed lands.

The study which has already been completed by this committee is in line with the general recommendations made in the

Committee Report to Congress in January 1935. A complete report of the National Water Plan proposed by this committee was delivered to the President December 1, 1936.

This committee has worked with State and Regional Planning Boards to get the views of the State authorities with respect to the needs of the various sections of the country. The consultants were responsible for the conduct of field work necessary for the preparation of the water plan in groups of states, these groups being selected according to major drainage areas.

The Director of this special study is Frederick H. Fowler, of San Francisco, a consultant on flood problems and a former member of the Technical Board of Review of P. W. A. The Assistant Director is Merton L. Emerson of Boston, a consultant engineer and a former member of the Technical Board of Review. The Water Committee of the National Resource Committee will outline and conduct the study through the special organization which has been set up under Mr. Fowler's general direction.

Mr. Donald Baker, a consulting Engineer of Los Angeles, California, is Coordinator for the Special study in all states west of the Mississippi River. All of North Dakota not included in the Red River Basin was grouped with other drainage basins, tributary to the Missouri River, this group of drainage basins comprising an area equal to about four states and to which S. T. Harding, an Irrigation and Hydraulic Engineer, of Berkeley, California, was assigned as consultant. Mr. Harding was assigned to this particular area because of his special knowledge of Missouri River drainage basin problems.

In order to assist and advise the consultants and staff directors the National Resources committee in gathering basic data for North Dakota, a water Resources committee of the State Planning Board was appointed by J. P. Cain, Chairman. Members of this committee are as follows:

T. G. Plomasen, State Project Director W. P. A.
A. D. McKinnon, Conservator, Soil Conservation Service.
E. J. Thomas, State Engineer.
M. D. Hollis, State Sanitary Engineer.
H. E. Simpson, State Geologist.
Howard Wood, Resettlement Administrator.
O. W. Roberts, U. S. Meteorologist.
E. F. Chandler, Dean Emeritus, College of Engineering, University of N. Dak.
Carl A. Taubert, Inspector, National Park Services.
M. O. Ryan, Secretary, N. Dak. State Planning Board.
Burnie Maurek, Project Director, Biological Survey.
M. O. Steen, Project Administrator, Biological Survey.

Dr. Irvin Lavine, Federal Consultant for the North Dakota Planning Board was in active charge of the collection of data and the formulation of reports for the North Dakota areas of the drainage basins. He also is the Director of the W. P. A. Project sponsored by the North Dakota Planning Board, to gather the data and information in North Dakota for the National Water Resources Board.

The various state officials and federal agencies concerned with water problems in the state were asked to co-operate to the fullest extent in the carrying on of this study. The State Planning Board also asked that County Planning Boards, City and Village Planning Boards, County Engineers, City Engineers and all other boards and engineers concerned with a water plan for the state, co-operate to the fullest extent.

The work was carried on under a special WPA project being sponsored by the State Planning Board. Dr. Irvin Lavine is the director of this project, which was first set up for the study of the Red River of the North Drainage Basin. The staff engaged on the Red River study was continued on these further studies. Information and data on the ground water resources of the state being collected by the office of the State Geologist under a WPA project was made available for these studies, Mr. Frank Foley is the Acting State Geologist during the absence of Dr. Simpson from the state. Mr. Frederick W. Voedish was in direct charge of the WPA project collecting and tabulating this data. Precipitation and other climatology studies for this water plan were made by Mr. Voedish in cooperation with Mr. O. W. Roberts, of the United States Weather Bureau in Bismarck.

Data on water supplies for municipalities and data on water pollution for the various stream basins were collected and tabulated by M. D. Hollis, State Sanitary Engineer. Mr. Hollis also made an extensive study of the existing conditions with respect to such water supplies and water pollution and from such data and study prepared a report with recommendations for a long range plan. In the case of municipal water supplies from wells, Mr. Hollis has collaborated with the office of the State Geologist. Chemical analysis of public water supplies were made by Dr. A. G. Abbott, head of the Chemistry Department of the University of North Dakota, under a WPA project of which he is the Director.

Under a cooperative arrangement between the State and the National Resources Committee, the State Engineer was assigned to this special WPA water plan project as Senior Technician. He made necessary inspections and studies in connection with the development of a plan and the listing of projects for the several stream basins in the state. His work in the project was principally in connection with surface waters. Mr. Oscar Becker assisted on this work.

Mr. Charles Hobbs of Northwood, North Dakota, who had been working on the Red River study for several weeks as Junior Technician, continued in such capacity on these further studies. Mr. Hobbs tabulated run-off and stream gaging data for surface waters in the drainage basins and made the hydrological calculations in connection with the listing of proposed projects for the execution of the plan. Reports on field and office studies of surface waters were made jointly by Mr. Thomas, Mr. Hobbs and Mr. Becker.

At a conference held at the office of Dr. Lavine in Grand Forks on May 1st, it was determined that for the purpose of this state-wide study of the water plan, the following sub-basins which together with the Red River Basin would comprise the entire area of the State will be studied.

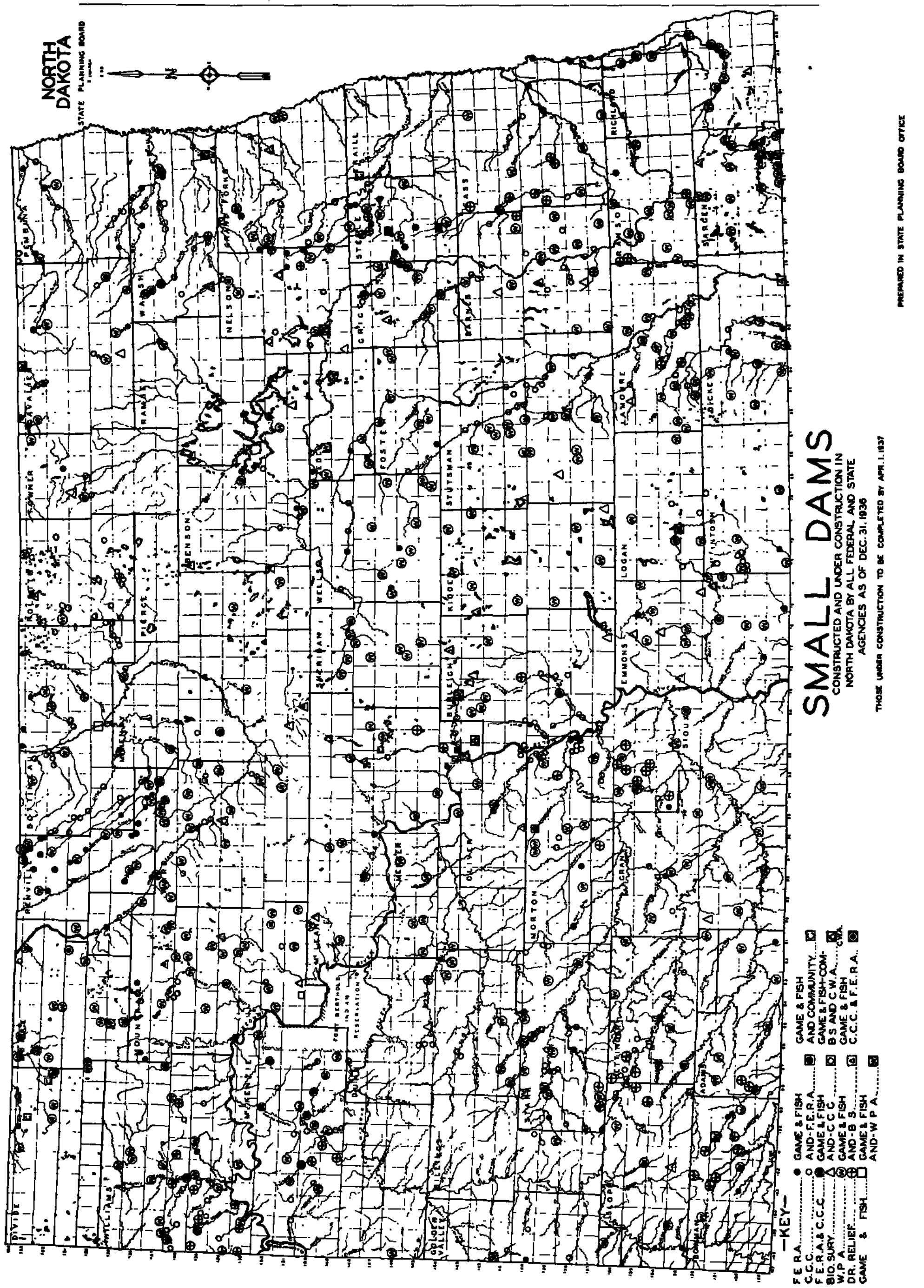
1. James River	6. Little Missouri River
2. Devils Lake Area	7. Knife River
3. Mouse River	8. Heart River
4. Missouri River	9. Cannon Ball River
5. Yellowstone River	10. Grand River

Work on the Red River report by the North Dakota office staff workers was completed July 8th, 1936. Work on the new program was started immediately thereafter. Office staff workers on the enlarged project were stationed at the office of Dr. Irvin Lavine, at the University of North Dakota, Grand Forks; the offices of the State Planning Board and the State Engineer at Bismarck.

A STATE-WIDE WATER PLAN

By authority of the Water Resources Committee of the National Resources Committee, the work of this special W. P. A. project has been continued to make further studies and to formulate a State Water Plan. These stream basin studies for the several stream basins of the State have been co-ordinated to form this State Water Plan. This plan will be submitted to the State legislature for its approval.

This State wide water plan will be of very great value to the Water Conservation Department of the State. It will mean that the Water Resources of the State will be developed in an orderly manner and to the best interest of the people of the State.


NORTH DAKOTA
STATE PLANNING BOARD
SMALL DAMS
CONSTRUCTED AND UNDER CONSTRUCTION IN
NORTH DAKOTA BY ALL FEDERAL AND STATE
AGENCIES AS OF DEC. 31, 1936
THOSE UNDER CONSTRUCTION TO BE COMPLETED BY APR. 1, 1937
PREPARED IN STATE PLANNING BOARD OFFICE
—KEY—
F E R A
C.C.C.
F.E.R.A. & C.C.C.
BIO. SURV.
W.P.A.
DR. RELIEF
GAME & FISH
GAME & FISH AND-F.E.R.A.
GAME & FISH AND-C.C.C.
GAME & FISH AND-B S.
GAME & FISH AND-W P A.
GAME & FISH AND COMMUNITY
GAME & FISH-COM-B.S. AND C.W.A.
GAME & FISH C.C.C. & F.E.R.A.

DAM CONSTRUCTION

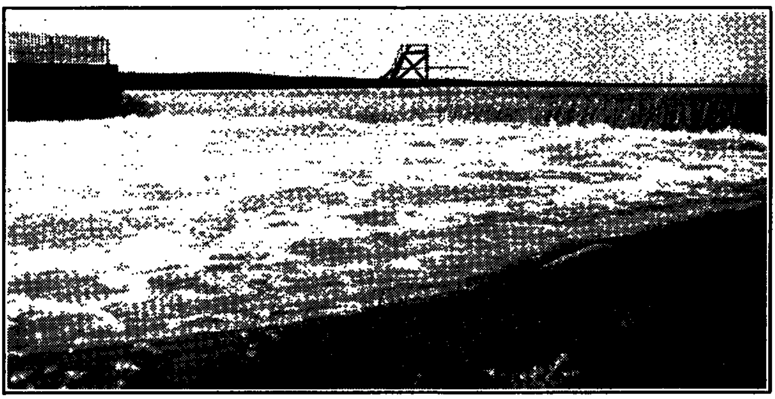
On the preceding page of this report is a map prepared by the State Planning Board, showing the location of all dams constructed in North Dakota by Federal and State Agencies. These Federal Agencies include the C.W.A., F.E.R.A., W.P.A., Civilian Conservation Corps, Drouth Relief section of the Soil Conservation Department, the Biological Survey and the Resettlement Administration. The State Game and Fish Department has cooperated with the Federal Agencies and has participated in the construction of a number of dams. A total of 905 dams is shown on the accompanying map.

The State laws as now on our statute books give authority to the State Engineer for the approval of the construction of dams and for the issuance of permits for the storage and use of impounded waters. In the granting of such permits and approvals for the construction of dams it will be necessary that developments be made to conform as nearly as possible to the State-wide water plan. Because of limited funds and staff personnel, the office of the State Engineer has been able to perform these duties only to a limited extent. If additional funds and facilities are provided, it is the purpose of the State Engineer to obtain this record for all existing dams and to hereafter require the proper applications, water rights and permits before construction is started. A study of the existing laws with respect to the construction of dams in the State is being made and if deemed advisable, revisions prescribing more definitely the duties of the State Engineer in this regard, will be proposed for passage by the legislature.

The Water Conservation District Act passed in the 1935 legislative session provides for the construction of dams by Water Conservation Districts, plans for such construction to be approved by the State Engineer as ex-officio State Water Conservation Commissioner. This Act further provides that all dams and water control devices heretofore or hereafter constructed by or with the assistance of Federal Agencies and having no one responsible for their maintenance and operation, and outside of a Water Conservation District, shall come under the jurisdiction of the Board of County Commissioners of the county in which such dams and water control devices are located and the board of county commissioners are authorized to exercise control and supervision over the same and may make such provisions as they deem necessary or desirable for the proper maintenance thereof.

This Water Conservation District law will also be studied with a view to remedying defects and coordinating its provisions with those of the State Water Code.

Dam and Reservoir
Subsistance Homestead Project, Burlington



Park Dam at Crosby

Typical Biological Survey—Dam Under Construction

Typical W.P.A. Dam Under Construction

C.C.C. Dam at Park River

IRRIGATION

If Agriculture in North Dakota is to be stabilized and balance and dependability is to be brought about to farming, it will be necessary to develop our water resources to the fullest extent. To do this it will require the supplementing of present farming methods with irrigation.

Very extensive opportunities are presented for irrigation in North Dakota. The Missouri River offers one of the prime requisites for irrigation, namely, an abundant water supply. The Missouri River bottoms offer another important requisite in that there are large compact areas of irrigable lands. It will be necessary to divert the waters on these lands by means of pump ng.

A listing of projects on the bottom lands of the Missouri River has been made and a copy of such listing follows these general statements with respect to irrigation in the State. Preliminary estimates indicate that such projects would include approximately 200,000 acres. A listing has also been made of irrigation possibilities on the smaller streams of the State. Projects in 23 stream basins are included in a listing showing a total of 170,000 acres. The type of irrigation generally used on these smaller streams would be flood irrigation.

In connection with the proposed irrigation, the areas irrigated by any one land owner should be limited. Land in excess of the unit assigned to each farmer should be sold to farmers moving from purchase projects that are being returned to grazing or to farmers living on the uplands to supplement dry farming and insuring feed for their stock during drought years. Farmers, to a distance of 20 or 25 miles, could profitably farm these irrigated tracts. It would be desirable that the Federal Government purchase lands on these irrigation projects and resell the same to new settlers and to farmers on the uplands.

The bottom lands of basins of the tributary streams are well adapted for flood irrigation. Hay crops would be raised on these flood irrigation projects. While the value of hay crops are generally small the construction is correspondingly inexpensive and would involve the construction of only such structures as channel diversion dams and dikes for ponding. The most extensive opportunities for flood irrigation are along the Mouse River. The Eaton Flood Irrigation Project involving 8,000 acres is now being constructed.

Districts are being formed for irrigation for the Buford and Trenton Projects along the Missouri River at Williston. Interest is also shown in developing a project on the Nesson Valley near Ray, North Dakota. This is the largest compact irrigable area along the Missouri River in the State. Special interest has also been shown in connection with proposed projects at Garrison, Washburn and Bismarck.

The present irrigation developments in North Dakota consist of 15,000 acres on the Lower Yellowstone project and 2,000 acres by individuals in various parts of the State.

Land owners on many of the projects are interested in the development of irrigation projects but are unable to take initial steps in connection with such developments due to lack of funds. The matter of making preliminary investigation and surveys has been taken up with the Bureau of Reclamation and Department of Agriculture. The Bureau of Reclamation is desirous of co-operating in this connection but has stated that it had no funds for the purpose. The Resettlement Administration is providing no assistance on surveys and construction plans in connection with loans and grants for irrigation Projects. This is also true of the Public Works Administration. The Department of Agriculture has promised to give assistance. However, they have informed us that their funds are very limited for this purpose. Considerable engineering work is necessary in connection with the forming of an Irrigation District and before application is made to Federal Agencies for financing.

It would appear to me that in order to supplement the engineering assistance of the Department of Agriculture and to speed up developments it would be desirable that preliminary loans or grants be made by the Federal Government to Districts of Co-operative Associations for this engineering work. In the case of loans arrangements might be made to have the Federal Government reimbursed from funds assessed in connection with the costs of such projects.

It is urged that liberal appropriations be made by the State to match Federal funds for engineering investigations of proposed irrigation projects. This Federal assistance can be obtained from the Extension Division of the Agricultural College. Included with irrigation projects on which investigations and surveys should be made and plans prepared are on lands of State Institutions on which irrigation can be practiced. These State Institution lands include those at Jamestown, Bismarck, Grafton and Mandan. It is recommended that funds be appropriated for supplementing the present irrigation works on Penitentiary lands and that the same by a demonstrational project with operation of the same under the general direction of the Extension Division of the Agricultural College.

In connection with the proposed Missouri River Diversion it may be possible to irrigate large areas along the route of the proposed diversion. The irrigable lands along any route that may be adopted would possibly involve 100,000 acres. In any case, the number of acres of irrigable land is probably far in excess of the amount of water available for irrigation from this source.

It has generally been considered that pumping onto the bottom lands of the Missouri River to a height not to exceed 25 feet would be economically feasible. However, with possible development of power at Fort Peck, Montana, the cost of pumping may be reduced sufficiently to make it feasible to irrigate lands on the higher bench levels.

Good reservoir sites exist on tributaries flowing onto the bottom lands of several of the Missouri Projects. The impounding of waters in these reservoirs will result in lower cost of pumping equipment and lower cost of power because of pumping over a longer period of time. It is probable that there is sufficient run-off on these tributaries to take care of evaporation in the reservoirs.

PROPOSED IRRIGATION PROJECTS ALONG MISSOURI RIVER

No.	County	Vicinity of (Town)	Name of Project	Estimated Irrigable Land (Acres)	Description of Project
1.	Williams	Williston	N. Dak. Pumping Project	26,100	North Dakota Pumping Project on Missouri River at Buford, Trenton, and Williston. This Project consists of rehabilitation of former works and extensions to the original system. Work can start immediately on the rehabilitation portion. Surveys and studies should be made of proposed additions.
2.	Williams	Ray	Nesson Valley Project	16,500	Nesson Valley Irrigation Project on Missouri River, 35 miles east of Williston. Irrigation is to be by pumping.
3.	Williams	Williston	Williston Subsistence Project	1,000	Pumping project at confluence of Little Muddy Creek and Missouri River.
4.	McKenzie	Banks	Tobacco Gardens Project	5,000	At Confluence of Tobacco Gardens Creek and Missouri River.
5.	McKenzie	Independence (little town)	Independence Project	1,000	Irrigation by pumping from Missouri River.
6.	Mountrail	Sanish	White Earth Project	2,000	Pumping from Missouri River on flats at confluence of White Earth River with Missouri River.
7.	Mountrail	Sanish	Sanish Project	2,000	Pumping from Missouri River at confluence of Little Knife River and Missouri River.
8.	Mountrail	Van Hook	Shell Creek Project	18,500	Pumping from Missouri River on flats at confluence of Shell Creek with Missouri River.

PROPOSED IRRIGATION PROJECTS ALONG MISSOURI RIVER (Cont'd)

No.	County	Vicinity of (Town)	Name of Project	Estimated Irrigable Land (Acres)	Description of Project
9.	McLean	Elbowoods	Deep Water Creek Reservoir Project	10,000	Storage reservoir on Deep Water Creek with supplement pumping from Missouri River.
10.	McLean	Elbowoods	Fort Berthold Flats (Old Agency)	4,000	Pumping onto river bottom flats from Missouri River. This project is about fourteen miles east of Elbowoods.
11.	McLean & Mercer	Garrison	Fort Stevenson Flats Project	20,000	Pumping from the Missouri River.
12.	McLean & Oliver	Washburn	Washburn Project	10,000	Pumping from the Missouri River.
13.	Mercer	Stanton	Stanton Flats Project	2,000	Pumping from Missouri River at confluence of Knife River with Missouri River.
14.	Oliver	Hensler	Mandan Lake Project	2,000	Storage of waters from Square Butte Creek in Mandan Lake with supplemental pumping from Missouri River.
15.	Burleigh	Bismarck	Bismarck Irrigation Project	12,000	Pumping from Missouri River for irrigating bottom lands north and south of this point in vicinity of Bismarck.
16.	Morton	Mandan	Mandan Flats Project	3,000	Irrigation of flats between Bismarck and Mandan on West side of river by pumping from Missouri River.
17.	Burleigh	Bismarck	Apple Creek	1,000	Storage of waters of Apple Creek with supplemental pumping from Missouri River.

PROPOSED IRRIGATION PROJECTS ALONG MISSOURI RIVER (Cont'd)

No.	County	Vicinity of (Town)	Name of Project	Estimated Irrigable Land (Acres)	Description of Project
18.	Emmons	Livona	Livona Project	4,000	Irrigation by pumping from Missouri River.
19.	Emmons	Linton	Beaver Creek Basin Project	1,000	Pumping from Missouri River on bottoms at confluence of Beaver Creek with Missouri River.
20.	Emmons	West of Strasburg	Winona Flats Project	5,000	Pumping from Missouri River onto bottom lands of Winona Township in Emmons County.
21.	Emmons	Pollock, S. D.	Emmons Project	2,500	Pumping onto flats from Missouri River at South Dakota line. A similar area adjoining this tract for irrigation is available in South Dakota.
22.	Morton	Schmidt	Little Heart River Project	1,000	Pumping from Missouri River onto flats at confluence of Little Heart River with Missouri River.
23.	Morton	Fort Rice	Fort Rice Project	1,000	Pumping from Missouri River onto bottom lands.
24.	Morton	Mandan	Mandan Flats Project	4,000	Pumping from Missouri River onto bottom lands.
25.	McKenzie	Arnegard	Angus Kennedy Project	4,000	Pumping from Missouri River onto bottom lands.
26.	McKenzie	Banks	Walters Ferry Project	3,000	Pumping from Missouri River onto bottom lands.
27.	McKenzie	Charlson	George Bancroft Project	3,000	Pumping from Missouri River onto bottom lands.

PROPOSED IRRIGATION PROJECTS ALONG MISSOURI RIVER (Cont'd)

No.	County	Vicinity of (Town)	Name of Project	Estimated Irrigable Land (Acres)	Description of Project
28.	McKenzie	Goodall, P. O.	Perry Goodall Project	7,000	Pumping from Missouri River onto bottom lands.
29.	McKenzie	Cartwright	Birdhead Bottom Project	7,000	Pumping from Missouri River onto bottom lands.
30.	McKenzie	Banks	Sand Creek Bottoms Project	4,000	Pumping from Missouri River onto bottom lands.
31.	McKenzie	Williston	Lewis & Clark Bridge Bottoms Project	5,000	Pumping from Missouri River onto bottom lands.
32.	Burleigh & Emmons	Menoken	Glencoe Project	6,000	Pumping from Missouri River onto bottom lands.
33.	Emmons	Moffit	Stout Project	2,400	Pumping from Missouri River onto bottom lands.
			TOTAL	196,000	

PROBABLE EXTENT OF LANDS WHICH MAY BE DEVELOPED BY IRRIGATION ADJOINING STREAMS OTHER THAN THE MISSOURI RIVER

County	Stream Basin	Lands Irrigable
Williams	Little Muddy	18,000 acres
Mountrail	White Earth River	5,000 "
Mountrail	Little Knife	1,000 "
Mountrail	Shell Creek	2,000 "
Mountrail	Gibbs Ranch Project on Tributary of Little Knife	1,000 "
McLean	Douglas Creek Project	500 "
McLean	Turtle Creek	1,000 "
McLean	Painted Woods Creek	2 000 "
Burleigh	Apple Creek	6,000 "
Emmons	Beaver Creek	1,000 "
Oliver	Square Butte Creek	3,000 "
Ward-McHenry	Mouse River	21,000 "
Foster-Stutsman	Pipestem River	1,000 "
Stutsman-LaMoure	James River	1,000 "
Barnes-Foster and Eddy	Sheyenne River	10,000 "
Bowman-Slope and Billings	Little Missouri	3,000 "
Slope	Beaver Creek	4,000 "
Mercer-Dunn	Knife River	30,000 "
Grant-Morton	Heart River	22,000 "
Sioux-Grant and Hettinger	Cannonball River	15,000 "
Bowman	Grand River	8,000 "
McKenzie	Yellowstone River	10,000 "
Ward	DesLacs River	5,500 "
	TOTAL	170,000 acres

CONSTRUCTION OF SMALL DAMS FOR FARM AND COMMUNITY USE

SPILLWAY DESIGN

The importance of designing an adequate spillway cannot be overstated because more dams fail due to inadequate spillway capacity than from any other single cause. The probable maximum run-off from the watershed area tributary to the dam should be carefully estimated and an adequate spillway provided, taking into consideration the importance of the project and the damage which would result in case the dam were overtopped.

The maximum flood discharges recorded from small watershed areas have varied from less than 10 cubic feet per second per square mile to more than 2,000 cubic feet per second per square mile. The highest rates of run-off are likely to occur only after very intense precipitation when the ground is either frozen, covered with snow, or saturated from previous rains. Frequently it is not feasible to design a spillway for the maximum possible flood. To do so might involve such a large and expensive spillway that the project would not be practicable. Therefore the problem usually consists of selecting the run-off coefficient justifiable for the project.

Since most small dams must be built in locations where no stream measurements have been made it is necessary to estimate the probable amount of water available in order to design spillway of sufficient capacity.

The standard practice applicable to North Dakota streams is to assume that the average annual run-off as recorded at a gaging station over a long period of time tends to be a uniform contribution from each section of land on the watershed. This, is, of course, only a rough approximation depending on a similarity of rainfall, topography, soil texture, soil porosity and other factors too numerous to mention. It is a short-cut method at best and justified as much by its convenience as by its accuracy.

The average annual acre feet of run-off per square mile of watershed for the principle stream basins in North Dakota are as follows:

Knife—55.2; Heart—50.3; Cannonball—34.1; Mouse—11.8;
Pembina—40.5; Red—70.8.

RATES OF STORAGE CAPACITY TO WATERSHED

The size of the reservoir feasible for a given watershed depends entirely upon the purpose for which the water is to be used. If the dam is to create a stockwater pond or merely to store whatever is available regardless of amount the limiting consideration is its cost per acre-foot. The C.C.C. dams built under the President's Emergency Conservation Work cannot exceed $150.00 an acre-foot.

On the other hand if the dam is to create a recreational pool where swimming and fishing are desired as permanent attractions a fairly stable water surface elevation is necessary. Otherwise bath houses and summer cottages built at the water's edge during wet years, for instance, will be unsightly and inconvenient distance away when the dry hot years return. Also fish planted in deep water will die when the pool becomes shallow.

A recreational reservoir must be so small in relation to the mean annual run-off at that point that even small summer flows during dry years will be enough to keep the water surface up to near the crest of the dam and occasionally to flush out the pool.

As a general rule applicable to ponds not spring fed a fairly permanent water surface elevation is assured only when the storage capacity below the crest of the dam does not exceed one-half of one percent of the mean annual run-off.

This is based upon the experience with the pools at New England and Crosby, North Dakota, which are located on the Cannonball and Mouse River watersheds respectively. These pools have not maintained themselves absolutely 100% of the time. During these dry years they have become unsuitable for use at times. But in the main they are considered by local people as sufficiently satisfactory to amply justify the effort made to create them. They illustrate what is probably the minimum ratio between storage capacity and watershed.

The New England pool constructed in 1929 has given somewhat better results. It contains about 55 acre-feet and has a drainage area of 300 square miles. The run-off from the Cannonball River averages 34 acre-feet per section. This amounts to 10,200 acre-feet per annum for the New England site. Then ½ of 1% is 51 acre-feet, which is close enough in view of the other approximations used.

The Crosby pool built in 1931 drains a watershed of 470 square miles. The Mouse River run-off is only 12 acre-feet per square mile. This amounts to 5,640 acre-feet of average annual run-off at the dam. One-half of 1% is 28 acre-feet. The pool contains about 50 acre-feet.

The depth of the pools should not be less than 7 feet in the deepest part, if fish life is to be maintained.

CAUSES OF FAILURE OF EARTH DAM

(1) Over Topping

By far the largest cause of failure of earth dams is an insufficient spillway to bypass the floods which therefore must go over the top of the dam.

The design of a spillway is decidedly an engineering problem but it can be side-stepped to a considerable extent by a proper selection of the site. (See Spillways.)

(2) Too Narrow a Bottom Width

Another cause of failure frequently observed is too narrow a bottom width thru the dam. Most people are more familiar with road embankments than with dams. But highways carry loads that press downward, whereas dams carry loads which push in a horizontal direction against a dam with the heaviest push at the bottom. The bottom width of a road embankment is about three times its height plus the top width. An earth dam should be at least five times its height plus the top width. Another criterion to observe is that the bottom width should be at least six times the depth of water to be stored behind the dam. This is to prevent excessive seepage.

All earth dams are porous. It is not to be expected that they stop absolutely all the water. They merely slow down the velocity of that small amount that does get thru to such an extent that it cannot dislodge and carry away the small particles of the soil of which the dam is made. The longer the base width the slower the velocity.

An indication of excess seepage is for it to show up on the downstream edge of the dam. If this occurs after the dam is built, erosion is apt to develop at this point which will eventually destroy the dam. To prevent this erosion to a large extent in event excessive seepage does develop it is desirable to place gravel and boulders in the toe of the slope as shown on the drawing, Fig. 1.

(3) Sod Under the Dam

Excessive seepage under an earth dam is frequently caused by failure to break up sod before building. This sod becomes a thin layer of fibrous material along which water will travel with comparative ease. The site should be plowed not as a field is plowed but rather by single plow furrows four or five feet apart along the long axis of the dam and at right angles to the direction of flow of the water. This will open up and allow fresh earth to come in contact with the new earth placed in the dam, and thereby in a sense key the dam to the foundation.

(4) Not Sufficient Packing and Tamping During Construction

Most small earth dams are built altogether too loosely. They are built too much like highway embankments, the earth merely hauled in and the top leveled off. Because earth dams are so porous at best anything done to make them more dense is a clear gain for permanence. They should be built up a layer at a time, only six inches or so thick, the earth spread and leveled out so that it can be packed and tamped by teams continually tramping over it. Much better if a heavy tractor with side wheels could be driven back and forth across the dam as it is built up.

(5) Wave Action

Dams are sometimes destroyed by the action of the waves cutting away the top. This can be avoided by facing the dam with boulders carefully laid together. Willows are frequently used. They produce a fibrous root which discourages burrowing animals and offers some protection during brief overflow. They make it difficult to get to a break and make an emergency repair; which on the other hand, of course, is less likely to occur.

DESIGN OF EARTH DAMS

Only earth dams having an average height of 12 feet or less are considered in these instructions. An allowance of approximately 15% must be made for the settlement of earth dams; for instance a dam 10 feet high should be constructed 11½ feet high.

The section which should be used for dams below, 12 feet in height is shown in Figure 1. The top width of a dam should be approximately one-third of the height unless the top of the dam is to be used as a roadway requiring a top width of 8 to 12 feet. A minimum width of 12 feet should be used. The upstream slope shall not be less than 3 horizontal to one vertical, and the downstream slope shall not be less than 2 horizontal to 1 vertical.

PROTECTION FOR EARTH DAM

If the reservoir covers more than approximately one acre of ground the earth dam shall be protected against wave action. Riprap shall be placed on the upstream and downstream faces of the dam as shown in Figure 1. If no large stones are available and there is an adequate supply of coarse gravel, good protection can be obtained by placing 12 to 24 inch layer of this material on the slopes of the dam.

The type of protection necessary for the downstream face and toe of the dam depends upon the foundation height of dam and height and duration of backwater. A triangular ridge of rock having a height of 3 to 4 feet should be constructed. This rock

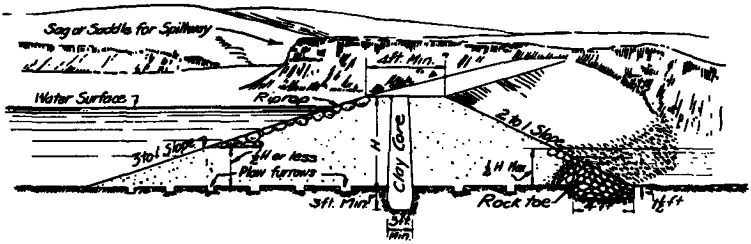


FIG. 1. CROSS SECTION OF EARTH DAM
12 FEET HIGH OR LESS

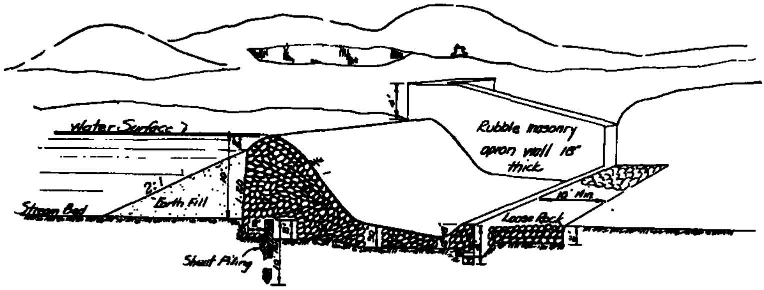


FIG. 2. CROSS SECTION OF RUBBLE MASONRY
OVERFLOW DAM

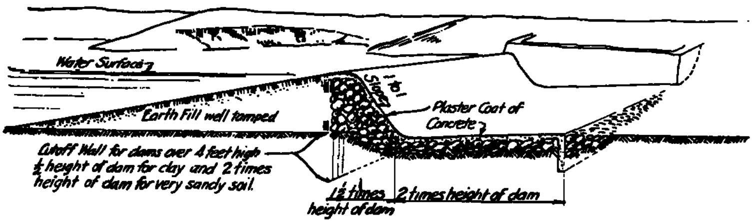


FIG 3. CROSS SECTION OF CONCRETE COVERED
ROCK FILL DAM.

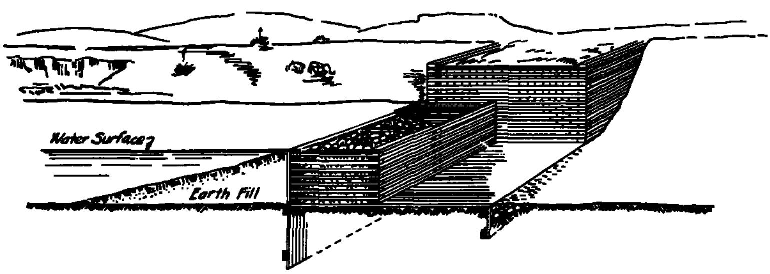


FIG. 4. CROSS-SECTION OF ROCK FILLED TIMBER CRIB DAM.

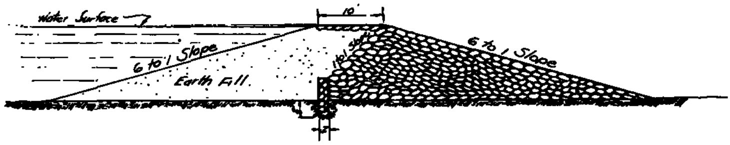


FIG. 5 CROSS SECTION ROCK. FILLED DAM

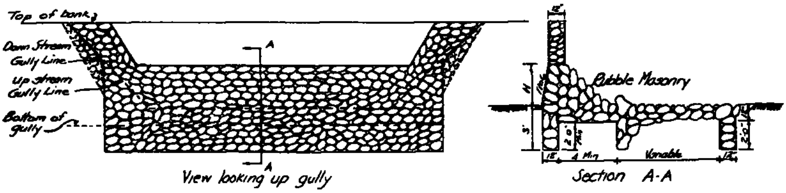


FIG. 6. RUBBLE MASONRY CHECK DAM FOR GULLY CONTROL.
MAXIMUM HEIGHT 5 FEET.

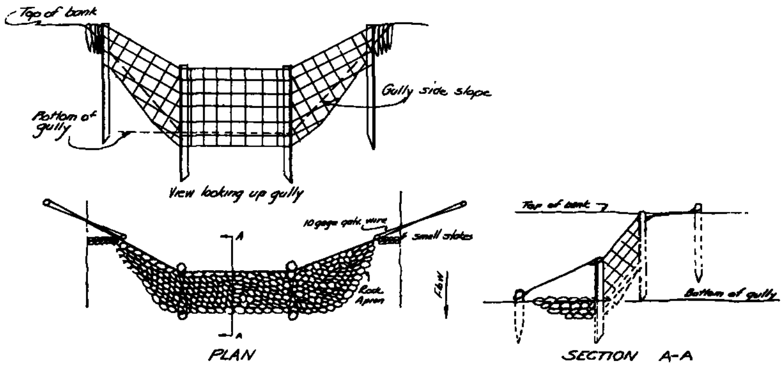


FIG. 7. WOVEN WIRE FENCE CHECK DAM FOR GULLY CONTROL

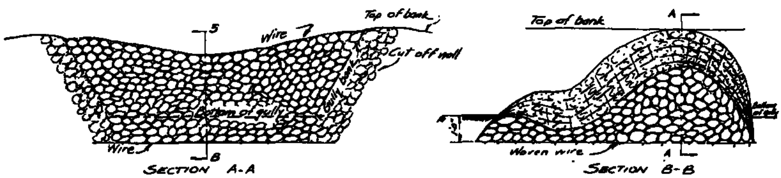


FIG. 8. LOOSE ROCK CHECK DAM COVERED WITH WOVEN WIRE.

protects the downstream toe from sloughing off. This protection is especially desirable where the stream will be diverted through the spillway into the channel below the dam and cause backwater eddies against the downstream toe of the dam.

Riprap should be placed on the downstream slope at least to the elevation which will be reached by normal spring flow. It is estimated that by placing riprap to an elevation of 4 to 5 feet an ample factor of safety is secured.

All dams should be fenced in, in order to keep livestock from causing damage to the structure.

CORE WALL AND SHEET PILING

Sheet piling may be required for earth dams less than 12 feet in height for protection against burrowing animals. As a rule for dams of 12 feet in height or less a tamped clay core should be constructed. To construct this clay core an impervious clay shall be selected, placed in position in thin layers, sprinkled with water, and carefully tamped in place by hand.

Where wood sheet piling is used a double row of sheet piling extending up to the elevation of high water should be driven. Planks 2 inches thick should be used if they can be driven; otherwise 3 inch planks should be used. The planks should be staggered and securely bolted together. If the foundation contains so many rocks and boulders that sheet piling cannot be driven, it will be necessary to excavate a deep trench in which to set the piling, or some other type of core wall must be used.

Other types of core walls are rubble masonry, concrete, or clay puddle core, or steel sheet piling. If properly constructed these types reduce seepage satisfactorily, are structurally safe, and all except the puddled clay type are effective against burrowing animals. The choice of type of core wall depends on its cost, and on the location of the dam, materials available and the damage that would result in case of failure.

FOUNDATION AND CONSTRUCTION

The most suitable material on which to place an earth dam is clay containing a small amount of silt or sand. In preparing the foundation the greatest precautions should be taken to insure a safe structure. All sod, brush, trees, roots, and other perishable matter shall be removed from the entire area to be occupied by the dam and such material shall not be used in the dam. Soft, mucky soil should be removed from the foundation. The entire surface should be plowed or scarified to insure a firm bond between the dam and the foundation.

If sheet piling is to be used, it may be driven along the center line of the dam without constructing a trench. It should be driven to a depth of at least half the height of the dam, or should be driven through any pervious strata of gravel or sand. If deep strata of sand and gravel are encountered the site should be abandoned and a new site located. When a core of puddled earth is used instead of sheet piling, a trench should be excavated having a minimum depth of 3 feet and a minimum width of 3 feet. This trench should be deep enough to cut off any strata of gravel and sand found beneath the site and should extend a minimum of 2 feet into impervious strata.

The core trench should be backfilled with clay and it is permissible to have a slight amount of sand mixed with the clay. If an abundant water supply is available, the clay core shall be puddled and should extend to the top of the dam. If water is scarce, the material selected for the clay core must be sprinkled and tamped firmly in place.

The stream banks which will be covered by the dam should be sloped and then scarified. The amount of slope depends on the soil. This sloping will reduce the tendency to form shrinkage cracks along well defined planes and produce more equal settlement.

The dam should be constructed to the dimensions shown in Figures 1 and 2 from carefully selected materials. Slope stakes should be set for the proper width of fill. Impervious sandy or gravelly clay which is firm when wet is considered the best material for dam construction. If there is not sufficient material to construct the whole of the dam of watertight material, that which is most watertight should be placed in the upstream and center sections of the dam. The coarser materials should be placed in the downstream section of the dam.

The fills should be constructed in layers not over 12 inches thick. The layers should be placed to the full width at all levels. At the completion of each week's work a slight ridge should be constructed around the edge of the fill in order to collect any rain that may fill and help to settle the earth.

The travel of teams and wagons or scrapers over the embankment should be distributed to secure as thorough and uniform compacting as practicable. If this does not produce a firm, well compacted embankment at all points the fill should be sprinkled with water if possible and rolled with a horse drawn roller. A good roller can be constructed from a 50-gallon oil drum filled with concrete with a 2-inch pipe through the center. Such rollers have been satisfactory in construction work.

The rock protection for the downstream toe should be carefully constructed, as shown in Figure 1. Large boulders and rocks encountered during construction should be placed in the downstream toe.

All earth fills should be completed approximately one month before freezing weather is likely to occur. In order to insure safety, it is imperative that the earth fill be permitted to settle for at least this long a time before freezing takes place in the fall.

RUBBLE MASONRY OVERFLOW DAMS

The term 'rubble Masonry' is here used to refer to masonry made up of cheap durable stone not suitable for cutting which is embedded in or bonded together with portland cement mortar.

The mortar for these dams should be of the best quality. The term 'mortar' usually refers to a mixture of cement and sand, but for this rubble masonry we recommend a mixture of cement, sand and gravel or crushed rock, which is commonly known as concrete. A plastic and workable mixture containing no more than six gallons of water per sack of cement with the proportions by dry compact volume of 1-2-3 (one volume cement, two volumes fine aggregate or sand, and three volumes of coarse aggregate, gravel or crushed stone) is recommended as a strong mortar for these rubble masonry structures.

Masonry dams having an average height of 10 feet or less measured from the bed of the stream to the spillway lip are suitable to North Dakota conditions and will be considered in this report. Higher dams than 10 feet are not planned because of difficulties encountered in constructing a masonry dam on earth foundation.

Although it is desirable to construct a masonry overflow dam on solid rock, this type of foundation will probably not be found in North Dakota Projects. In designing a masonry dam for construction on an earth or poor rock foundation, the uplift pressure must be considered. Buoyancy from tail water also enters into the design and must be considered.

The type of masonry dam recommended for use in North Dakota is shown in Figure 2. The apron of the dam shown is drained at the downstream toe and must be heavy enough to resist uplift pressure. The apron thickness (T) varies with the height of dam as follows:

TABLE TO DETERMINE T

	H	T
Under	5	12″
	5&6	18″
	7&8	24″
	9&10	30″

This type of dam should be used for earth foundations where topography, soil and stream flow are such that it is not likely the soil beneath the downstream apron can be drained during the winter months. In locations where the stream bed will drain during winter months drains should be provided beneath the downstream apron to dry out the foundation during the winter and thus prevent the apron heaving from frost action. A trench should be extended downstream for a sufficient distance to drain the riprap during the winter months. It is very important to secure a free outlet during the winter so that the apron will drain and will not be in danger of heaving from frost action. The lip of the spillway has been sloped in front and designed with a large section to resist ice pressure. The spillway should be slightly curved at the crest and at the base to conform approximately with the natural curve of the water. It is not considered practicable, due to construction difficulties, to round the spillway to conform to the shape of the nappe.

Unless the spillway conforms to the shape of the nappe, water may jump clear of the downstream face, causing a partial vacuum and adding to the overturning forces acting on the dam. Vent pipes should be provided in the wing walls to minimize the effect of such forces. The vents should be of terra cotta sewer pipe or black iron pipe.

The arrangement of the wing and apron walls depends on the topography of the stream bed and the length of the weir. These walls should have ample dimensions and should be carefully constructed so that water cannot seep around the ends of the dam. Such connections with stream banks are frequently inadequate and washing occurs around the ends. Wing walls should be so designed that the length of the path of percolation along any line beneath or around the wing wall is not less than the path beneath the dam.

The apron walls should have a minimum thickness of 18 inches. An apron wall 18″ thick will ordinarily be adequate in North Dakota and only in exceptional cases will a thicker wall be necessary. The wing walls should have a minimum thickness of

30". The height of the apron wall above the downstream apron should be at least 1¼ times the height of the wing wall above the spillway lip. The apron wing wall should be back filled with porous material and drained. The downstream end of the backfill should be riprapped with large rocks.

Expansion joints are not considered necessary and need not be used in rubble masonry dams covered by these instructions. The wing walls and apron walls should be high enough to confine the maximum flow within the banks of the stream. A freeboard of at least 18 inches should be allowed between the elevation of the top of the wing walls and the maximum estimated reservoir stage.

CONCRETE COVERED ROCK FILL DAM

If concrete materials are available quite a permanent structure can be made of a rock fill dam by covering it over the outside with a plaster coat of concrete. (See Fig. 3.) The shape can also be modified to save the labor of hauling so many boulders.

The concrete should be mixed with only enough water to make it plaster well so it can be troweled in around the outer layer of boulders which are first stacked up carefully by hand to the shape and cross section shown.

If this type is to be placed in a stream channel the water must first be dammed off just upstream with a temporary earth dam, in order to give the concrete time to set. This earth dam may then be extended downstream and become a part of the permanent dam.

This type of dam was built at New England, North Dakota. It is seven feet high and 105 feet long. In dams of that height a reinforcing steel mesh and a good quality concrete at least six inches thick is necessary.

ROCK FILLED TIMBER CRIB DAM

A cheaper but also more temporary type of dam may be constructed by building wooden cribs of 2x6 boards laid flatwise in log cabin fashion with long rods through the corners. (See Fig. 4.) These 2x6 are usually spaced about six inches apart. The crib is about 16 feet long, 8 feet wide and four or five feet high tied thru the middle to make two compartments eight feet square. It is built upon a platform with ten feet of the platform extending downstream for an apron. The crib is placed next to the cut-off wall as shown on Fig. 4, and boarded up tightly on the upstream side. Abutments may be made in the same manner and sheeted up on the inside with two inch lumber. The abutments should also be sheeted to the top on the upstream face. These cribs should be covered to save fish from getting caught in the boulders in the crib in high water and dying. This is not a very permanent type of construction because the lumber is subject to alternate wetting and drying and hence rots quickly. Creosoted timber makes the cost approach that of the concrete covered type.

ROCK FILL DAMS

Where an abundance of field stones and boulders is available a rock fill dam has the advantage over an earth dam in that it can be overtopped and in that sense be its own spillway. In many places they are much less likely to wash out than an earth dam. They are suitable where a small dam is desired in a creek or small river where some water is flowing. They can be constructed in the water and built up, while the water flows thru the spaces between the boulders. The earth fill must be placed against the upstream face of the dam so as to tighten up the small cracks between the loose rock. The earth, then well compacted will make the dam water tight and lengthen the path of percolation and seepage under the dam. (See Figure 5.)

A rock filled dam needs careful attention in three places, where the water goes under the dam, over the dam, and to prevent it going around the ends.

There is usually more or less sand in a creek bed. It often happens that when the water begins to rise a few feet behind the dam little boils develop in the creek bottom below the dam and the water will be seen throwing up little turbulent cones of sand. That water is coming thru from above the dam and traveling along a sort of pipe which it has formed thru the sand under the dam. The sand is coming from under the dam itself. It will be only a question of a few hours before those "pipes" will develop into a large hole and the dam is destroyed. The remedy is to fill in upstream with dirt until those little cones cease boiling, or muddy water ceases coming from under the dam. This earth fill upstream lengthens the distance the water must travel. The farther it has to go the slower is the velocity because of the greater amount of friction en route. Where foundation is poor a concrete or rubble masonry core wall must be provided as shown in Figure 5.

The effect of high water over a rock fill dam is to roll off the top layer of boulders and move them downstream. There is no infallible remedy for this so long as the boulders are loosely laid together. The best thing to do is to make the dam very wide and flat and not very high as shown in the sketch, Figure 2. Four feet in height is about the maximum. With the additional expense of a little concrete a plaster coat around the boulders of the top layer will hold them together and make the dam more permanent.

The water in passing a dam sets up turbulences at each end along the creek bank, which erode away the earth and unless special protection is provided the entire stream will soon be going around one end or the other.

A U-shaped abutment similar to that used for the approach to a bridge is the most satisfactory. The bottom of the abutments should be even with the bottom of the dam. The wings should extend into the bank a distance of at least three times the height of the dam. They should be at least one-half again as high as the dam and should be as wide as the dam is up and downstream.

A good way is to excavate a wide trench into the bank for the two wings and fill it with boulders to the natural surface. The part facing the dam should then be laid by hand on the same slope as that of the river bank.

RUBBLE MASONRY CHECK DAM

Where rock is available a rubble masonry check dam (Figure 6) is a very desirable check dam. The rock should be very carefully laid and ordinarily for heights of 2 or 3 feet, concrete work will be required only in the outer shell or layer of rock including the spillway. Soft rock should not be used. For higher dams, the high water pressure makes it advisable to lay all the rock in cement. This type of dam is particularly adopted for use in gullies that have comparatively large drainage areas with correspondingly large run-off and for the design shown in the Figure, is not recommended for a height of over 5 feet.

WOVEN WIRE FENCE CHECK DAM

The woven wire check dam shown in Figure 7 consists essentially of a low fence across a gully. The common method of building these dams consists of setting a row of wooden or steel fence posts across a gully about 4 feet apart. The posts should be set at least 4 feet deep and should be anchored by wire to posts, as shown in the Figure. A trench about 6 inches deep should be dug along the upper side of the posts and the lower 6 inches of the wire buried in the ground. This type of dam is suitable for use in shallow gullies with small drainage areas and should not exceed 2½ feet in height at center. In order to promote rapid filling, straw should be packed in above the dam to the height of the crest. Rock, if available, is usually placed below the dam to prevent erosion. If the dams are placed close together so that a fill is backed up to the next dam above, an apron may not be necessary.

LOOSE ROCK CHECK DAM COVERED WITH WOVEN WIRE

In Figure 8 is shown a loose rock check dam held in place by an envelope of woven wire completely inclosing the rock. It is difficult to build satisfactory loose rock dams without some means of holding the rock in place unless a large amount of rock is used and unless there is sufficient large rock for use on the surface to cover all small rock that could be easily moved by the current of water. Small rock can be quite effectively used in the construction of check dams, when held in place with woven wire. The woven wire is laid on the bottom and sides of the gully, a piece being selected large enough to fold over the surface of the dam and short pieces of wire spaced about one foot apart in both directions are attached to this bottom layer of woven wire. The rock is then placed to form the dam, as shown in the Figure, permitting the short wires to extend through the rock. The woven wire is than folded over the surface of the entire dam including apron and side wall protection, and the short pieces of wire are drawn tight and fastened to the woven wire covering the entire surface of the dam. Careful workmanship is required to obtain a smooth looking job. This type of dam is recommended for a height not exceeding 5 to 6 feet.

MONTHLY DISCHARGE OF NORTH DAKOTA RIVERS

1931-1932-1933-1934-1935

The following tabulation is furnished by the U. S. Geological Survey of which Nathan C. Grover is Chief Hydraulic Engineer. The Missouri River drainage stations are under the supervision of W. A. Lamb, District Engineer, Helena, Montana; and H. C. Beckman, District Engineer, Rolla, Missouri. The Hudson Bay drainage stations are under the supervision of Chas. L. Batchelder, District Engineer, 808 New Post Office Building, St. Paul, Minnesota.

A record of daily discharge for rivers in North Dakota for the above years may be obtained from the U. S. Geological Survey offices mentioned above or from the State Engineers Office in Bismarck, North Dakota.

CONTENTS

MISSOURI RIVER DRAINAGE

HUDSON BAY DRAINAGE

MISSOURI RIVER DRAINAGE

Missouri River at Williston, N. Dak.

LOCATION.—In sec. 31, T. 154 N., R. 101 W., 7 miles west of Williston, N. Dak., 50 feet downstream from Lewis & Clark Highway Bridge on U. S. Highway No. 85.

DRAINAGE AREA.—167,530 square miles.

RECORDS AVAILABLE.—March 1905-May 1907. October 1928-September 1935.

GAGE.—Au gage installed October 22, 1928 in wooden shelter over well connected with river by 3" pipe. Located on left bank 50 feet below bridge. Inside staff gage with enameled gage faces 0-13.4 feet and outside wire gage on downstream side of bridge. Inspected by Mr. Andrew Bjorlo, Williston, N. Dak.

DISCHARGE MEASUREMENTS.—Open water section. Downstream side of highway bridge, 20 feet intervals. Stations are marked in red paint on concrete guard rail. Special reel is stored in gage house.

CHANNEL & CONTROL.—Control is entire river channel below gage. Bed of sand and silt. Shifting. Ice gorging frequent.

EXTREMES OF DISCHARGE.—1928-1935: Maximum stage 10.8 feet, June 8, 1929, discharge 109,000 second-feet; minimum stage 0.17 feet on August 24, 1934, discharge 3,320 second-feet.

ICE.—Severe ice conditions during winter. Occasional gorges during period when ice breaks up.

DIVERSIONS.—Flow is affected somewhat by numerous irrigation diversions and power developments in Montana.

REGULATION.—None.

ACCURACY.—Records fair. Weakness is in shifting control, frequent measurements necessary.

MONTHLY DISCHARGE OF MISSOURI RIVER AT WILLISTON, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	17,500	10,400	13,400	824,000
November	13,000	8,560	11,400	678,000
December	14,200	5,920	10,300	633,000
January	10,700	4,600	7,260	446,000
February	14,200	11,100	12,900	716,000
March	20,200	8,380	12,500	769,000
April	25,600	10,400	12,700	756,000
May	40,000	8,560	17,800	1,090,000
June	50,600	20,900	37,100	2,210,000
July	19,300	3,930	10,000	615,000
August	15,500	4,640	8,400	516,000
September	11,100	4,340	6,120	364,000
The period	50,600	3,930	13,300	9,617,000

1930-1931 Maximum Stage 1:00 A.M., June 13, 1931 Discharge 52,000 sec. ft.
Minimum Stage 1:00 P.M., July 30, 1931 Discharge 3,930 sec. ft.
Ice period November 27 to April 2, 1931

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	11,100	7,890	9,040	556,000
November	9,170	3,800	6,990	416,000
December	7,710	3,340	5,020	309,000
January	9,170	4,640	6,540	402,000
February	8,980	4,340	5,630	324,000
March	18,800	7,890	10,600	652,000
April	45,100	12,700	24,800	1,240,000
May	67,700	22,100	37,800	2,320,000
June	95,600	37,600	69,100	4,110,000
July	83,000	14,300	35,600	2,190,000
August	17,300	10,700	13,100	806,000
September	13,900	9,550	11,000	655,000
The period	95,600	3,340	19,300	13,980,000

1931-1932 Maximum Stage 8:00 P.M., June 29, 1932 Discharge 99,200 sec. ft.
Minimum Stage ----- December 3, 1931 Discharge 3,340 sec. ft.
Ice period November 21 to April 2, 1932

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	13,500	9,930	11,000	676,000
November	......	......	9,140	544,000
December	......	......	6,690	411,000
January	......	......	7,660	471,000
February	......	......	7,100	394,000
March	44,600	......	24,800	1,520,000
April	19,800	15,500	17,300	1,030,000
May	58,100	20,900	34,000	2,090,000
June	88,100	43,500	71,400	4,250,000
July	39,600	9,910	22,100	1,360,000
August	30,500	7,230	10,400	640,000
September	31,500	9,320	13,600	809,000
The period	88,100	......	19,600	14,195,000

1932-1933 Maximum Stage 8:00 P.M., March 16, 1933, Ice.
Maximum Stage 9:30 A.M., June 21, 1933 Discharge 92,400 sec. ft.
Minimum Stage—During ice period.

MONTHLY DISCHARGE OF MISSOURI RIVER AT WILLISTON, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	10,500	8,940	9,620	591,500
November	17,100	8,760	11,620	691,400
December	12,200	6,290	8,521	523,900
January	13,500	6,600	10,510	646,300
February	20,400	12,600	17,720	984,000
March	47,700	9,520	17,500	1,076,000
April	27,200	14,800	19,250	1,146,000
May	32,900	21,100	27,460	1,689,000
June	37,700	17,200	26,020	1,548,000
July	17,200	5,870	9,314	572,700
August	11,500	3,320	5,397	331,900
September	6,800	3,700	4,655	277,000
The period	47,700	3,320	13,920	10,077,700

1933-1934 Maximum Stage 5:30 A.M., Mar. 16, 1934 Discharge 58,900 sec. ft.
Minimum Stage 9:30 A.M., Aug. 24, 1934 Discharge 3,320 sec. ft.
Ice Period December 10 to March 19, 1934.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	9,290	7,720	8,199	504,100
November	9,450	7,260	8,539	508,100
December	8,420	4,200	6,379	392,300
January	8,250	3,520	5,336	328,000
February	9,850	5,320	8,717	484,100
March	18,100	8,420	12,080	742,700
April	19,000	12,100	15,510	922,700
May	33,900	13,100	18,200	1,119,000
June	83,800	33,800	54,340	3,234,000
July	66,000	20,000	33,560	2,063,000
August	18,500	7,750	10,540	648,000
September	8,420	6,490	7,377	439,000
The period	83,800	3,520	15,730	11,385,100

1934-1935 Maximum Stage 11:30 P.M., Mar. 27, 1935, Ice.
Maximum Stage 12:00 M., June 19, 1935 Discharge 84,100 sec. ft.
Minimum Stage (ice present) January 2, 1935, Discharge 3,520 sec. ft.
Ice Period December 1 to April 13, 1935.

MISSOURI RIVER DRAINAGE

Missouri River at Sanish, N. Dak.

LOCATION.—In W.½ Sec. 14, T. 152 N., R. 93 W., one-half mile west of Sanish, N. Dak. At highway bridge between Sanish and Watford City, state highway No. 23 on M. St. P. & St. M. Ry. one mile below mouth of Little Knife River.

RECORDS AVAILABLE.—October 1928-September 1932.

GAGE.—Stevens wire gage on left span highway bridge. Read to hundredths once daily by H. J. Houser, Sanish, N. Dak.

DISCHARGE MEASUREMENTS.—Open water section. Downstream side of highway bridge. Use special reel which is stored in observer's garage. Ice section is 200 feet below bridge section.

CHANNEL AND CONTROL.—Channel control has no fixed section. Shifting. Liable to ice gorging at bridge.

EXTREMES OF DISCHARGE.—1928-1932: Maximum stage 9.7 feet, June 9, 1929, discharge 90,000 second-feet; minimum stage 37 feet at 10:00 A.M., November 22, 1931, discharge 3,250 second-feet.

DIVERSIONS.—Numerous large and small diversions for irrigation in Montana.

REGULATION.—None.

ACCURACY.—Good records may be obtained if sufficient discharge measurements are made to determine effects of shifting control.

REMARKS.—This gaging station was discontinued September 30, 1932.

MONTHLY DISCHARGE OF MISSOURI RIVER AT SANISH, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	21,400	11,500	14,900	916,000
November	15,900	7,100	11,400	678,000
December	12,900	7,100	9,780	601,000
January	9,880	4,900	6,920	425,000
February	12,900	10,500	11,700	650,000
March	15,900	9,560	12,200	750,000
April	41,200	10,500	12,900	768,000
May	34,000	9,560	17,600	1,080,000
June	47,400	19,200	36,800	2,190,000
July	22,600	5,120	11,000	676,000
August	16,000	5,120	8,420	518,000
September	9,640	4,700	5,650	336,000
The period	47,400	4,700	13,300	9,590,000

1930-1931 Maximum Stage 7.13 feet at 10:00 A.M. June 12, 1931, Discharge 47,400 second-feet.
Minimum Stage .03 feet, September 20-23, 1931, Discharge 4,700 second-feet.
Ice period November 14, 21 and 30, 1930 to March 30, 1931.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	10,400	8,000	8,940	550,000
November	8,930	3,250	7,020	418,000
December	7,400	3,400	5,040	310,000
January	9,270	5,000	6,640	408,000
February	8,000	4,400	5,660	326,000
March	18,600	8,600	11,600	713,000
April	50,700	15,000	24,000	1,430,000
May	68,400	19,800	36,300	2,230,000
June	100,000	42,300	70,400	4,190,000
July	84,800	15,500	37,500	2,310,000
August	18,600	10,800	13,500	830,000
September	16,500	9,270	11,300	672,000
The period	100,000	3,250	19,800	14,387,000

1931-1932 Maximum Stage June 12-13, 1932 Discharge 100,000 sec. ft.
Minimum Stage November 22, 1931 Discharge 3,250 sec. ft.

MISSOURI RIVER DRAINAGE

Missouri River at Bismarck, N. Dak.

LOCATION.—In Sec. 31, T. 139 N., R. 80 W., at city water plant, 1900 feet above Memorial Highway Bridge, 2100 feet below Northern Pacific Railway Bridge, and one mile west of Bismarck, Burleigh County.

DRAINAGE AREA.—186,400 square miles.

RECORDS AVAILABLE.—October, 1904 to April 1906. October 1927 to October, 1935.

GAGE.—Stevens water-stage recorder type A-30 installed October 17, 1928 in wooded shelter over old well at city water plant. Recorder is referred to Kennison float gage, which is kept reading same as vertical staff gage in well. Outside gage is an inclined 3" galvanized pipe, with graduations cut into it at intervals of 0.1 feet fastened to concrete piers along river bank at recorder site. Inclined gage read daily and recorder inspected weekly by W. B. Hartley, engineer at the water plant.

DISCHARGE MEASUREMENTS.—Made from downstream side of Memorial highway bridge. Initial point for soundings at left pier. Bed clean and sandy. Shifting sand bars may divide channel at low stages. Channel straight for one mile above and below gage. Water swift at high stages. Left bank high. Right bank gradually sloping and is overflowed only during extreme high water.

CHANNEL AND CONTROL.—No well defined control. Bed composed of rapidly shifting sands. Extreme ice conditions during cold weather.

EXTREMES OF DISCHARGE.—1930-1935: Maximum stage 8.33 feet at 8:00 P.M., June 13, 1932, discharge 118,000 second-feet. Minimum Stage 2.90 feet on September 4, 1934, discharge 3,300 second-feet.

DIVERSIONS.—None from the main stream in North Dakota.

REGULATION.—None on main stream in North Dakota.

ICE.—Severe ice conditions during winter. Occasional gorges during period when ice breaks up.

ACCURACY.—Good.

MONTHLY DISCHARGE OF MISSOURI RIVER AT BISMARCK, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	19,500	11,400	13,300	818,000
November	15,400	6,970	12,500	744,000
December	11,800	6,190	8,790	540,000
January	7,690	5,840	6,690	411,000
February	12,600	7,690	10,100	561,000
March	23,300	10,400	13,400	824,000
April	26,900	11,000	13,100	780,000
May	31,500	10,400	16,300	1,000,000
June	45,700	15,400	34,500	2,050,000
July	23,900	6,410	12,600	775,000
August	15,300	6,200	9,050	556,000
September	8,930	5,460	6,120	364,000
The period	45,700	5,460	13,000	9,423,000

1930-1931 Maximum Stage 5.31 feet at 4:00 A.M. June 10, 1931, Discharge 47,200 second-feet.
Minimum Stage 1.93 feet at 10:00 P.M. Sept. 15, 1931, Discharge 5,460 second-feet.
Ice November 19 to March 24 and March 27, 31, 1931.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	10,600	8,360	9,400	578,000
November	8,930	3,820	7,270	433,000
December	6,630	3,690	5,170	318,000
January	8,640	4,530	6,510	400,000
February	9,560	4,380	5,560	320,000
March	25,100	10,600	12,500	769,000
April	79,900	15,300	27,900	1,660,000
May	79,900	18,500	36,500	2,240,000
June	116,000	33,300	69,200	4,120,000
July	101,000	19,000	43,400	2,670,000
August	18,000	11,000	13,800	848,000
September	16,600	9,880	11,900	708,000
The period	116,000	3,690	20,700	15,164,000

1931-1932 Maximum Stage 8.33 feet at 8:00 P.M. on June 13, 1932, Discharge 118,000 sec.-feet.
Minimum Stage, ice, December 10, 1931, Discharge 3,690 second-feet.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	14,500	10,600	11,600	713,000
November	14,500	7,340	9,270	552,000
December	13,600	3,820	7,770	478,000
January	9,240	6,630	8,180	503,000
February	8,640	5,810	7,550	419,000
March	87,500	7,840	28,400	1,750,000
April	57,000	15,100	19,900	1,180,000
May	79,200	18,000	39,200	2,410,000
June	88,800	46,200	70,800	4,210,000
July	52,100	12,000	25,100	1,540,000
August	12,000	7,810	9,070	558,000
September	38,600	9,710	16,000	952,000
The period	88,800	3,820	21,100	15,265,000

1932-1933 Maximum Stage 9.53 feet at 4:00 P.M., March 21, 1933, (Ice Effect), Discharge 88,800 second-feet, (June 21, 1933).
Minimum Stage, December 28, 1932, Discharge 3,820 second-feet.
Ice period November 9 to March 30, 1933.

MONTHLY DISCHARGE OF MISSOURI RIVER AT BISMARCK, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	10,300	8,590	9,343	574,500
November	26,600	5,500	12,050	717,000
December	12,000	3,300	5,974	367,300
January	13,500	4,200	8,877	545,900
February	20,200	12,400	15,370	853,500
March	48,500	13,100	19,030	1,170,000
April	24,100	15,600	19,260	1,146,000
May	31,700	20,800	26,040	1,601,000
June	47,400	19,000	28,450	1,693,000
July	20,200	6,150	11,000	676,100
August	10,000	4,040	6,249	384,200
September	5,290	3,980	4,561	271,400
The period	48,500	3,300	13,810	9,999,900

1933-1934 Maximum Stage 7.41 feet at 6:30 P.M., March 20, 1934, Discharge 79,200 second-feet.
Minimum Stage -2.90 feet, September 4, 1934, Discharge 3,300 second-feet.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	8,200	5,620	7,521	462,400
November	8,900	8,240	8,658	515,200
December	7,500	3,400	5,481	337,000
January	6,500	4,000	5,029	309,200
February	9,900	5,800	8,236	457,400
March	14,900	8,500	10,380	638,500
April	29,000	10,900	17,450	1,038,000
May	34,100	13,600	16,800	1,033,000
June	82,600	32,200	53,800	3,202,000
July	104,000	21,000	39,200	2,411,000
August	23,000	8,340	11,990	737,000
September	9,250	7,140	7,876	468,700
The period	104,000	3,400	16,030	11,609,400

1934-1935 Maximum Stage 13.15 feet at 3:00 A.M., July 13, 1935, Discharge 116,000 second-feet.
Minimum Stage 1.95 feet at 12:30 A.M., October 1, 1934, Discharge about 3,400 sec.-ft.

MISSOURI RIVER DRAINAGE

Little Missouri River at Medora, N. Dak.

LOCATION.—In NE¼ Sec. 27, T. 140 N., R. 102 W., at bridge on U. S. Highway No. 10 about 150 feet downstream from railway bridge one-third mile west of Northern Pacific Railway depot at Medora in Billings County.

DRAINAGE AREA.—6,190 square miles.

RECORDS AVAILABLE.—May 1903—October 1908. October 1921 —April 1926. September 1928—September 1932.

GAGE.—Wire gage on upstream side of bridge. Read daily to even hundredths by Richard Hellickson, Medora, N. Dak.

DISCHARGE MEASUREMENTS.—Measured from highway bridge or by wading about 500 feet above bridge. Bed of stream largely of gravel and quicksand; clean, shifting. One channel at all stages except when an occasional shifting sand bar may temporarily divide channel. Water swift at ordinary stages. Channel straight for 150 feet above and 300 feet below gage.

CHANNEL AND CONTROL.—Shifting bars of clay, sand and gravel across a width of about 500 feet cause lack of any stable control.

EXTREMES OF DISCHARGE.—1903-1908; 1921-1926; 1928-1932; Maximum stage 17.2 feet June 7, 1929, discharge 33,700 second-feet; minimum discharge 2 second-feet, September 28, 1905.

DIVERSION.—None.

REGULATION.—None.

ACCURACY.—Because of shifting control frequent discharge measurements are necessary to insure accurate results.

REMARKS.—This station was discontinued September 30, 1932.

MONTHLY DISCHARGE OF LITTLE MISSOURI RIVER AT MEDORA, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	58	23	35.7	2,200
November	31	16	21.4	1,270
December	33	16	20.7	1,270
January	..	..	....	.....
February	..	..	....	.....
March	..	..	....	.....
April	391	24	88.8	5,280
May	48	17	23.6	1,450
June	1,660	50	315	18,700
July	814	..	296	18,200
August	1,130	70	395	24,300
September	416	..	121	7,200

1930-1931 Maximum Stage 4.52 feet at 10:30 A.M., June 22, 1931, Discharge 1,660 second-feet. Minimum Stage on November 22-23-28-29-30, 1930, Discharge 16 second-feet. Ice, December 17 to March 31. Gage weight on sand bar July 17 to 31; August 29 to September 19, 1931.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	268	44	91.8	5,640
November	152	..	57.5	3,420
December	...	..	....	.....
January	...	..	....	.....
February	...	..	....	.....
March	2,250	1,300	1,690	20,000
April	12,200	120	1,790	107,000
May	3,950	188	776	47,700
June	3,740	197	1,400	83,300
July	3,290	56	524	32,200
August	456	33	97.0	5,960
September	404	11	57.7	3,430

1931-1932 Maximum Stage 9.66 feet at 8:00 and 9:20 A.M., April 28, 1932, Discharge 12,500 second-feet.
Minimum Stage 1.64 feet at various times, September 25-30, 1932, Discharge 11 second-feet.
Ice, November 21 to March 25.
November 20-30 computed.
Readings for March include six days only.

MISSOURI RIVER DRAINAGE

Knife River at Hazen, N. Dak.

LOCATION.—On the east section line near the northeast corner of Sec. 19, T. 144 N., R. 86 W., on state highway No. 25, 0.7 mile south of railway depot at Hazen, Mercer County, a station on the Killdeer branch of the Northern Pacific Railway.

RECORDS AVAILABLE.—October 1928—September 1932.

GAGE.—Wire gage on downstream handrail of highway bridge. Read daily to even hundredths by Mrs. Fred Haas, Box 117, Hazen.

DISCHARGE MEASUREMENTS.—Made from bridge or by wading near control. Water sluggish at gage, but swift at control. Both banks wooded. Channel straight for 800 feet above and 500 feet below gage. Good measurements should be obtained.

CHANNEL AND CONTROL.—The low water control is a riffle about 500 feet downstream from gage, composed of sand and gravel, probably shifting at high stages.

EXTREME OF DISCHARGE.—1928-1932: Maximum stage 11.80 feet, June 14, 1932, Discharge 1,450 second-feet; minimum stage 1.68 feet, November 24, 1931, Discharge 1.6 second-feet.

DIVERSIONS.—None.

REGULATIONS.—Small dam at Beulah 10 miles upstream regulated for park purposes may cause some fluctuations.

ACCURACY.—Good.

REMARKS.—This station was discontinued September 30, 1932.

MONTHLY DISCHARGE OF KNIFE RIVER AT HAZEN, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	125	8.8	61.8	3,800
November	22	8.4	15.5	553
December	..	...	....	.....
January	..	...	....	.....
February	..	...	....	.....
March	81	44	68.2	2,160
April	69	18	40	2,380
May	19	15	17	1,050
June	496	11	58.3	3,470
July	194	6.2	39.9	2,450
August	170	15	44.7	2,750
September	986	3.8	137	8,150

1930-1931 Maximum Stage 11.28 feet, September 22, 1931, Discharge 1,190 second-feet.
Minimum Stage 1.36 feet, September 9-10, 1931, Discharge 3.8 second-feet.
Ice, October 16-17, and November 19 to March 15.
Reading for November, 18 days only.
Reading for March, 16 days only.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	114	12	24.5	1,510
November	13	1.6	7.73	460
December	13	2.3	6.95	427
January	..	....	....	...
February	.	....	....	.....
March	1,080	73	291	17,900
April	696	38	139	8,270
May	274	19	63.3	3,890
June	1,250	24	244	14,500
July	52	8.6	18.6	1,140
August	8.6	7.4	8.17	502
September	38	....	128	762

1931-1932 Maximum Stage 11.80 feet, June 14, 1932, Discharge 1,450 second-feet.
Minimum Stage 1.68 feet (ice), November 24, 1931, Discharge 1.6 second-feet.
Ice, November 17 to December 31, and March 1-27.
No water under gage September 16 to September 30, 1932.
Discharge estimated.
No records January 1 to March 4, 1932.

MISSOURI RIVER DRAINAGE

Heart River at Sunny, N. Dak.

LOCATION.—In NE¼ Sec. 25, T. 139 N., R. 82 W., at highway bridge about 300 feet below Northern Pacific Railway bridge, nine-tenths mile west of Sunny, Morton County, five miles west of Mandan and about 10 miles above the mouth of the river.

DRAINAGE AREA.—3,320 square miles.

RECORDS AVAILABLE.—April 1924—September 1932.

GAGE.—Chain gage on downstream side of bridge. Read once or twice daily to even hundredths by Roy Morrell, Mandan.

DISCHARGE MEASUREMENTS.—Made from bridge or by wading.

CHANNEL AND CONTROL.—The sandy stream bed is liable to shift. Ice gorging causes changing stage-discharge relation when ice goes out. Ice jams in Missouri at mouth of Heart River may have some backwater effect.

EXTREMES OF DISCHARGE.—1924-1932: Maximum stage 11.55 feet (ice effect), February 28, 1932, discharge 3,400 second-feet; minimum stage 3.88 feet, August 20, 1929, discharge 0.00 second-feet.

ICE.—Stage-discharge affected by ice.

DIVERSIONS.—None.

ACCURACY.—Good.

REMARKS.—This station was discontinued September 30, 1932.

MONTHLY DISCHARGE OF HEART RIVER AT SUNNY, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	28	10	18.3	1,130
November	22	16	17.7	1,050
December	..	..	12.3	756
January	..	..	19.7	1,210
February	..	..	119	6,610
March	198	..	95.8	5,890
April	177	22	78.7	4,680
May	39	12	20.5	1,260
June	209	12	40.3	2,400
July	167	9.5	53.8	3,310
August	56	9.5	30.6	1,880
September	120	1.3	25.3	1,510
The Period	209	1.3	43.7	31,686

1930-1931 Maximum Stage 5.70 feet at 9:00 A.M., June 30, 1931, Discharge 2.09 second-feet.
Minimum Stage 3.98 feet at 2:00 P.M., September 18, 1931, Discharge 1.3 second feet.
Ice November 21 to March 23, 1931.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	157	20	45.7	2,810
November	20	..	18.7	1,110
December	20	11	15.9	978
January	..	..	....	.....
February	..	..	....	.....
March	2,250	164	549	33,800
April	618	62	154	9,160
May	98	7.8	59.4	3,650
June	1,240	43	377	22,400
July	76	9.0	39.3	2,420
August	8.4	0	3.65	224
September	2.8	..	1.43	85

1931-1932 Maximum Stage 11.55 feet at 3:45 P.M., February 28, 1932, Discharge 3,400 second-ft.
Minimum Stage 4.00 feet at 1:00 P.M., August 24, 1932, Discharge 0.
Ice November 26 to December 31 and March 1-31, 1932. Discharge estimated.

MISSOURI RIVER DRAINAGE

Cannonball River at Timmer, N. Dak.

LOCATION.—In NW¼ Sec. 21, T. 133 N., R. 82 W., F. S. Bengenheimer ranch, 3½ mi. South of Timmer, N. Dak.

DRAINAGE AREA.—3,650 square miles.

RECORDS AVAILABLE.—June 1903—November 1908—August 1911—September 1919—October 1921—December 1934.

GAGE.—Cantilever gage on left bank with regulation weight and wire chain one-fourth mile upstream from observer's house.

DISCHARGE MEASUREMENTS.—Made at high stage from cable car about 150 mi. upstream from gage, how stage measurements made by wading one-fourth mile downstream from gage at riffle.

CHANNEL AND CONTROL.—One channel at all stages. High left bank and medium high right bank looking downstream. Right bank covered with brush.

EXTREMES OF DISCHARGE.—1921—1934: Maximum stage 11.1 feet, March 18, 1929, discharge 6,250 second-feet; minimum stage, zero discharge at various times in August 1930—September 1931—July 1933—September 1933—, at various times in 1934 and from October 1 to 15 in 1935.

ICE.—Stage-discharge, relation affected by ice. Observations discontinued during winter.

REGULATIONS.—No dams or diversions.

ACCURACY.—Fairly accurate records obtainable.

REMARKS.—This gaging station was discontinued on November 30, 1934, and replaced by a station at Breien which is more accessible during wet weather.

MONTHLY DISCHARGE OF CANNONBALL RIVER AT TIMMER, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	66	0.7	11.9	732
November	6.8	4.1	5.33	317
December	....	....	5.0	307
January	....	....	11.8	726
February	....	....	40.4	2,240
March	....	....	36.6	2,250
April	...	21	52.4	3,120
May	40	4.8	11.5	707
June	1,080	2.6	63.1	3,750
July	345	1.7	43.3	2,660
August	136	2.6	16.8	1,030
September	52	0	6.49	386
The Period	1,080	0	25.2	18,225

1930-1931 Maximum Stage 6.08 feet at 3:00 P.M., June 22. 1931, Discharge 1,150 second-feet.
Minimum Stage, no flow—September 14-18, 1931.
Stage discharge relation affected by Ice November 18—April 3.
Discharge estimated.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	6.5	0.9	2.20	135
November	5.4	1.7	4.35	181
December	....	....	.....	.....
January	....	....	.....	.....
February	....	....	.....	.....
March	....	....	75.3	4,630
April	530	39	139	8,270
May	193	31	78.0	4,800
June	6,390	54	757	45,000
July	530	8.1	88.2	5,420
August	8.1	0.9	2.35	144
September	6.8	0.3	1.23	73

1931-1932 No recordings made during December—January and February.
November readings are for 21 days only.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	19	0.2	5.24	322
November	14	0	8.34	198
December	....	....	.....	.....
January	....	....	.....	.....
February	160	12	85.5	1,020
March	1,350	75	706	43,400
April	424	62	166	9,880
May	720	28	110	6,760
June	110	3.8	38.6	2,300
July	22	0	6.94	427
August	0	0	0	0
September	3.8	0	0.7	42

1932-1933 Maximum Stage 11.82 feet at 10:45 A.M., March 20 (Ice), Discharge unknown.
Maximum Stage March 18 - 21.
Minimum Stage July 19-23-29—September 2-7 and 17-30 inclusive. No flow.
Ice Period November 9 to March 24. Records Incomplete.

MONTHLY DISCHARGE OF CANNONBALL RIVER AT TIMMER, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	0	0	0	0
November	8.2	0	1.52	90
December	8.2	0	.85	52
January	0	0	0	0
February	6.0	0	.32	18
March	....	..	9.32	573
April	40	5	16.1	958
May	3.9	0	1.46	90
June	72	0	11.1	660
July	45	0	5.26	324
August	0	0	0	0
September	0	0	0	0
The Period	72	0	3.82	2,765

1933-1934 Maximum Stage 3.92 feet at 8:30 A.M., March 22 (ice) Discharge 76 sec.-ft. on June 8. Minimum discharge 0 on many days. Record good except for period of Ice effect (Dec. 3 to April 4) which are poor.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	160	0	9.06	557
November	1.6	.9	1.24	74

Station Discontinued—November 30, 1934.

MONTHLY DISCHARGE OF CANNONBALL RIVER AT BREIEN, N. DAK.

Month	Discharge of second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	178	0.1	9.88	608
November	1.1	.6	.86	51
December	.9	.1	.38	23
January	.1	0	.03	2
February	0	0	0	0
March	868	0	104	6,410
April	97	5	26.2	1,560
May	614	22	91.5	5,630
June	1,060	2.5	155	9,220
July	2,050	9	320	19,670
August	817	.5	41.5	2,550
September	12	.4	1.04	62
The Period	2,050	0	63.2	45,786

1934-1935 Maximum Stage 6.80 feet at 3:45 A.M., July 12, 1935, Discharge 2,920 second-feet. Minimum Stage 0.11 feet at 6:10 P.M., October 5. No flow January 11 to Mar. 1, 1935.

HUDSON BAY DRAINAGE

James River at Jamestown, N. Dak.

LOCATION.—At about the middle of the east boundary of SE¼ Sec. 36, T. 140 N., R. 64 W. at the Asylum bridge at Jamestown, Stutsman Co., and about 1½ miles downstream from mouth of Pipestone Creek.

RECORDS AVAILABLE.—June 28—September 1932.

GAGE.—High water gage is vertical staff reading from 10.0 to 19.5 ft. bolted to steel channel piling on downstream side near right bank, low water vertical staff with third section enamel face is set in stream bed near right bank. Read to hundredths daily by S. C. Calvalage, who is Chief Engineer for State Insane Hospital which is about 1 mile S. W. of gage.

DISCHARGE MEASUREMENTS.—Measured from bridge at high stages. A good wading section at ordinary stages at about 150 ft. below gage. Stream bed is gravel and silt with some vegetation and is possibly shifting. One channel at all stages, water sluggish at gage with varying angle of current. Channel curved above and below gage. Both banks high, leaving brush and occasional small trees, and not subject to overflow. Rubbish dumped from bridge may affect low water control.

CHANNEL AND CONTROL.—Gravel and silt bed of stream with no well defined riffle, but an island about 75 feet below gage is drowned out at a stage of about 10 feet. Below this island the channel narrows to a section of 40 feet wide with fairly steep banks.

EXTREMES OF DISCHARGE.—1931-1932. Maximum stage 12.38 ft. at 6:30 P. M. on February 28, 1932. Discharge 722 second-feet, Minimum stage 614 ft. at various times during November 12-16. Discharge 0.2 second-feet.

REGULATIONS.—A small dam ¼ mile upstream is occasionally regulated for park purposes.

ACCURACY.—Records at this station should be fair or good depending on frequency and range of discharge measurements.

REMARKS.—This station was discontinued September 30, 1932.

MONTHLY DISCHARGE OF JAMES RIVER AT JAMESTOWN, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	1.2	0.4	0.66	41
November	1.6	0.6	.97	58
December	.8	.6	.72	44
January	3.4	.8	.99	61
February	15	1.0	4.79	266
March	40	2.2	12.9	793
April	91	2.6	31.2	1,860
May	3.2	1.2	2.24	138
June	1.8	.6	1.27	76
July	1.4	.6	.99	61
August	2.4	.6	1.12	69
September	4.2	1.0	1.73	103
The Period	91	.4	4.93	3,570

1930-1931 Maximum Stage 7.44 feet on April 6, 1931, Discharge 91 second-feet.
Minimum Stage 6.06 feet on October 16-26, Discharge 0.4 second-feet.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	6.9	.4	1.32	81
November	1.0	.2	.64	38
December	1.8	.8	1.14	70
January	1.4	1.2	1.23	76
February	626	1.2	65.2	3,750
March	388	14	79.2	4,870
April	50	24	38.7	2,300
May	37	3.8	12.3	756
June	37	5.5	13.6	809
July	8.7	1.2	2.97	183
August	1.4	.8	1.06	65
September	11	1.8	3.95	235
The Period	626	0.2	18.2	13,233

1931-1932 Maximum Stage 12.38 feet at 6:30 P.M., February 28, 1932, Discharge 722 sec.-feet.
Minimum Stage 6.14 feet November 12-16, 1931, Discharge 0.2 second-feet.

MISSOURI RIVER DRAINAGE

Little Muddy River Near Williston

LOCATION.—At Carlson Farm in Sec. 31, T. 155, R. 100, ½ mile upstream from bridge on U. S. Highway No. 2; 4½ miles Northeast of Williston.

DRAINAGE AREA.—1100 square miles.

RECORDS AVAILABLE.—June 1932—July 1933.

GAGE.—Wire gage on right bank about 150 feet downstream from barn. Length—13.92; read daily by Arthur A. Carlson, farmer. Distance 200 ft.

DISCHARGE MEASUREMENTS.—Measured by wading about 75 ft. below gage. Highwater can be measured at bridge on U. S. Highway No. 2. Bed of sand, gravel and silt; probably shifting and subject to clogging by tumble weeds. Good measurements may be made when able to wade stream.

CHANNEL AND CONTROL.—Gravel and stone riffle about 500 ft. below gage; probably shifting and drowned out during highwater.

EXTREMES OF DISCHARGE.—1932-1933: Maximum stage 11.54 ft., March 8-9-10-11, 1933. Discharge 798 second-feet. Minimum discharge 0.1 second-feet various times during February 1933.

WINTER FLOW.—Very small flow during winter but always enough for stock water. Spring floods usually due to ice gorging.

DIVERSIONS.—None.

REGULATION.—None.

ACCURACY.—Records fair. Weakness is in shifting control.

REMARKS.—Station discontinued July 1, 1933.

MONTHLY DISCHARGE OF LITTLE MUDDY NEAR WILLISTON, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	...	..	....	.....
November	...	..	....	.....
December	..	.	....	.....
January	...	..	....	.....
February	...	..	....	.....
March	...	..	....	.....
April	...	..	....	.....
May	...	..	....	.....
June	206	16	57.6	1,830
July	61	5	14.1	867
August	7	4	5.3	326
September	8	6	6.3	375
The Period	206	4	....	3,398

1931-1932 Maximum Stage 7.30 feet at 10:00 P.M., on June 16, 1932, Discharge 426 second-feet.
Minimum Stage 2.26 feet—August 2-9, 1932, Discharge 4 second-feet.
Records for June are for 16 days only.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	14	5.4	8.27	508
November	11	8	8.50	506
December	...	....	2.38	146
January	...	....	.20	12.3
February	546	0.1	40.2	2,230
March	798	207	414	25,500
April	139	22	48	2,860
May	95	15.9	27.8	1,710
June	23	7.2	9.88	608
July	..	....	.....	.....
August	..	....	.....	.....
September	..	....	.....	.....

HUDSON BAY DRAINAGE

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

LOCATION.—Above dam half mile above highway bridge connecting Front Street, Fargo, Cass County, N. Dak., with Moorhead, Minn., 10 miles above mouth of Sheyenne River.

DRAINAGE AREA.—6,420 square miles.

RECORDS AVAILABLE.—June 1901—September 1935.

GAGE.—Vertical staff attached to tree on left bank 6 rods above dam looking downstream; vertical staff for convenient comparison attached to upper end of fishway, left end of dam. Gage read by City Engineer.

DISCHARGE MEASUREMENTS.—Made from footbridge a few feet upstream from gage.

CHANNEL AND CONTROL.—Bed composed of clay and silt; nearly permanent. Control is timber and steel crib dam, rock filled, below gage; has settled a few inches since construction. At extreme low stage the fall over the dam is about 5 feet.

EXTREMES OF DISCHARGE.—1901-1935: Maximum open-water stage recorded, 17.34 ft., July 11, 1916, discharge, 7,740 second-feet; Minimum stage 6.63 ft. at 8:00 A. M. August 23, 1932, zero discharge, 5.89 ft. at 8:00 A. M. February 25, 1933, zero discharge, 4.82 ft. at 8:00 A. M. June 15, 1934, zero discharge.

ICE.—Stage discharge relation effected by ice.

DIVERSION.—None.

REGULATION.—No power plants or storage above the station nearer than 60 mi., and storage not great enough ordinarily to effect discharge at station.

ACCURACY.—Stage-discharge relation changed slightly due to settling of dam; slightly affected by ice during year. Rating curve fairly well defined between 80 and 4,400 second-feet. Gage read by City Engineer to hundredths once daily except during winter, when it was read once or twice a week. Daily discharge obtained by applying daily gage height to rating table. Open-water records fair, winter records poor.

MONTHLY DISCHARGE OF RED RIVER OF THE NORTH AT FARGO, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	48	13	30.5	1,880
November	61	26	37.7	2,240
December	32	16	24.6	1,510
January	30	13	21.1	1,300
February	102	28	39.3	2,180
March	207	90	128	7,870
April	365	118	190	11,300
May	295	101	168	10,300
June	275	33	132	7,860
July	130	21	64.8	3,980
August	33	7	20.8	1,280
September	141	2.1	15.6	928
The Period	365	2.1	72.7	52,628

1930-1931 Maximum Stage 8.55 feet at 8:00 A.M., April 3, 1931, Discharge 365 second-feet. Minimum Stage 7.30 feet various times, September 18-19-20, Discharge 1.4 second-feet. Discharge estimated February 24 and July 25 due to opening and closing fishway.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	98	10	26.6	1,640
November	51	15	28	1,670
December	33	17	21.6	1,330
January	45	25	36.1	2,220
February	177	31	47.3	2,720
March	340	31	135	8,300
April	868	49	232	13,800
May	92	25	55.6	3,420
June	63	9.2	33.2	1,980
July	16	0	7.73	475
August	0	0	0	0
September	13	2.8	8.78	522
The Period	868	0	52.4	38,077

1931-1932 Maximum Stage 9.45 feet at 9:00 A.M., April 11, 1932, Discharge 875 second-feet. Minimum Stage 6.63 feet at 8:00 A.M., August 23, 1932, Discharge 0 second-feet. No flow July 25—August 31.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	21	11	14.1	867
November	17	0	6.74	401
December	10	0	1.93	119
January	0	0	0	0
February	4.0	0	0.18	9.9
March	255	8.0	129	7,930
April	605	41	207	12,300
May	152	48	73.6	4,530
June	139	12	51.1	3,040
July	42	0.2	15.3	941
August	5.7	0	1.59	98
September	2.2	0	0.08	4.6
The Period	605	0	41.7	30,240.5

1932-1933 Maximum Stage 9.04 feet at 8:00 A.M., April 5, 1933, Discharge 605 second-feet. Minimum Stage 5.89 feet at 8:00 A.M., February 25, 1933, Discharge 0 second-feet. Discharge estimated February 27 to March 3 and April 27 due to opening and closing of fishway. Zero flow December 11—February 26, August 13, August 25, September 1—25.

MONTHLY DISCHARGE OF RED RIVER OF THE NORTH AT FARGO, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	11	0	4.72	290
November	10	0	2.49	148
December	30	1.3	13.3	819
January	19	9.0	14.0	859
February	36	13	20.5	1,140
March	62	18	43.0	2,640
April	323	22	102	6,070
May	35	0	8.12	499
June	27	0	3.31	197
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
The Period	323	0	17.5	12,662

1933-1934 Maximum Stage 8.55 feet at 8:00 A.M., April 10, 1934. Discharge 323 second-feet. Minimum Stage 4.82 feet at 8:00 A.M., June 15, 1934, Discharge 0 second-feet. No flow June 30—October 4th.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	0	0	0	0
November	9.9	0	.59	35
December	8.9	0	.57	35
January	0	0	0	0
February	34	0	11.7	651
March	930	22	386	23,750
April	347	65	152	9,020
May	231	25	113	6,930
June	30.9	6.8	86.7	5,160
July	366	65	184	11,290
August	103	6.8	32.5	2,000
September	25	.2	8.45	503
The Period	930	0	82.0	59,374

1934-1935 Maximum Stage 9.70 feet at 8:00 A.M., on March 19-20-21-22, 1935, Discharge 930 second-feet.

HUDSON BAY DRAINAGE

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

LOCATION.—At Northern Pacific Railway bridge between Grand Forks, Grand Forks County, N. Dak. and East Grand Forks, Minnesota, half a mile below mouth of Red Lake River.

DRAINAGE AREA.—25,500 square miles.

RECORDS AVAILABLE. — June 1901 — September 1935. Gage-height records at same point kept by United States Engineer Corps from 1882 to 1901 and a few discharge measurements made by them in early years.

GAGE.—Vertical staff attached to ice-breaker below center pier of bridge. Gages maintained by the United States Engineer Corps and the United States Weather Bureau at the same bridge have a datum 5.00 feet higher than the gage datum of the Geological Survey and are more convenient for use. The Weather Bureau gage is used with correction applied. Observers were Alex Slattery, Harold Bowes, A. S. Gray, Eddie Roning, Marloe Axtell.

DISCHARGE MEASUREMENTS.—Made from the Great Northern Railway bridge a quarter of a mile above gage.

CHANNEL AND CONTROL.—Clay and silt; changes very slowly.

EXTREMES OF DISCHARGE.—1882-1935; Maximum stage recorded 50.2 feet April 10, 1897, discharge 43,000 second-feet; Minimum state 1.18 feet at 6:00 P. M. on October 19, 1932, discharge 13 second-feet. (Stage-discharge relations affected by ice.

ICE.—Stage-discharge relation seriously affected by ice.

DIVERSIONS.—None.

REGULATION.—No power plants above with sufficient storage to cause noticeable variations in flow.

ACCURACY.—Stage-discharge relation permanent except as affected by ice. Rating curve well defined between 400 and 15,000 second-feet and fairly well defined to 30,000 second-feet. Gage read to quarter-tenths twice daily except during winter period when it was read twice a week. Daily discharge ascertained by applying mean daily gage height to rating table except for periods indicated in foot note to table of daily discharge. Open water records good, winter records fair.

MONTHLY DISCHARGE OF RED RIVER OF THE NORTH AT GRAND FORKS, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	240	131	197	12,100
November	365	170	251	14,900
December	275	178	194	11;900
January	178	156	161	9,900
February	471	200	273	15,200
March	885	341	477	29,300
April	1,580	796	1,090	64,900
May	796	534	612	37,600
June	830	228	492	29,300
July	504	136	277	17,000
August	170	110	136	8,360
September	113	20	59.5	3,540
The Period	1,580	20	351	254,000

1930-1931 Maximum Stage 6.48 feet at 12:00 Noon on April 10, 1931, Discharge 1,630 second-ft.
Minimum Stage 1.18 feet at 7:00 P.M., on September 25, 1931, Discharge 20 second-ft.
Ice—November 26 to April 8.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	208	39	111	6,820
November	249	152	199	11,800
December	179	101	133	8,180
January	208	136	160	9,840
February	1,090	67	207	11,900
March	2,810	534	1,170	71,900
April	10,200	1,180	3,930	234,000
May	1,260	559	919	56,500
June	529	278	401	23,900
July	361	81	178	10,900
August	78	50	58.6	3,600
September	56	26	43.4	2,580
The Period	10,200	26	623	451,920

1931-1932 Maximum Stage 22.07 feet at 6:30 P.M., April 10, 1932, Discharge 10,400 second-ft.
Minimum Stage 1.30 feet at 5:00 P.M., October 1, 1931, Discharge 26 second-feet.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	100	13	36.0	2,210
November	114	64	82.7	4,920
December	81	33	57.4	3,530
January	48	31	38.6	2,370
February	76	...	33.6	1,870
March	1,780	77	927	57,000
April	4,380	789	2,250	134,000
May	1,050	529	768	47,200
June	754	128	428	25,500
July	175	68	116	7,130
August	76	19	41.5	2,550
September	44	21	31.3	1,860
The Period	4,380	13	401	290,140

1932-1933 Maximum Stage 15.18 feet at 6:30 P.M., on April 3, 1933, Discharge 4,380 second-feet.
Minimum Stage 1.18 feet at 6:00 P.M., on October 19, 1932, Discharge 13 second-feet.

MONTHLY DISCHARGE OF RED RIVER OF THE NORTH AT GRAND FORKS, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	60	21	31.7	1,950
November	135	50	79	4,700
December	61	42	52.5	3,230
January	56	18	39.2	2,410
February	70	29	54.3	3,010
March	720	80	419	25,780
April	3,150	590	1,540	91,650
May	622	142	373	22,950
June	234	78	151	8,980
July	336	39	153	9,420
August	37	24	30.6	1,880
September	28	16	20.7	1,230
The Period	3,150	16	245	177,190

1933-1934 Maximum Stage 10.02 feet at 8:00 P.M., on April 12, 1934, Discharge 3,210 second-ft. Minimum Stage 1.16 feet at 3:00 P.M., October 25, 1933, Discharge on September 16—15 second-feet.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	80	16	40.6	2,500
November	102	60	73.0	4,340
December	81	27	40.7	2,500
January	34	24	277	1,700
February	51	22	31.8	1,770
March	2,750	52	898	55,220
April	2,300	974	1,521	90,490
May	1,050	428	856	52,640
June	860	300	503	29,930
July	878	456	666	40,960
August	590	223	404	24,870
September	312	100	184	10,930
The Period	2,750	16	439	317,850

1934-1935 Maximum Stage 13.07 feet at 11:00 A.M., March 29, 1935, Discharge 2.920 second-ft. Minimum Stage 1.32 feet at 2:00 A.M., February 11, 1935, (ice effect), Discharge 16 second-feet October 4—10.
Ice November 29 to April 8.

HUDSON BAY DRAINAGE

Sheyenne River at Sheyenne, North Dakota

LOCATION.—About one mile north of Sheyenne on highway No. 4. It is located on the steel truss bridge with wooden floor. The city of Sheyenne is located on the Leeds branch of the Northern Pacific Railway from Carrington, N. Dak. Railroad connections are inconvenient.

RECORDS AVAILABLE.—April 1929—September 1933.

GAGE.—Ten-foot horizontal enameled face staff fastened to upper guard on the edge of the wooden floor of the bridge. Wire cable with 5 lb. window weight runs over pulley fastened at the foot of the staff and has one marker wired in place. Observer is Edwin F. Hallsten, Sheyenne, N. Dak. Observer is mail carrier who passes over the bridge and takes a reading at 8 o'clock in the morning.

DISCHARGE MEASUREMENTS. — Measurements taken from bridge. Two foot permanent station markers painted on hand rail.

CHANNEL AND CONTROL.—Banks composed of alluvial loam heavily sodded with marsh and aquatic grasses.
Both banks low and subject to overflow.
Channel straight above and below station. Velocity slow.
One channel at all stages.

EXTREMES OF DISCHARGE.—1929-1933; Maximum stage 8.79 feet, February 27, 1930, discharge 990 second-feet; Minimum, zero flow during summer months.

DIVERSIONS.—None.

REGULATIONS.—None.

ACCURACY.—Accuracy should be good. Difficulty is experience in obtaining discharge measurements at the proper stages to provide data for rating curve.

REMARKS.—This gaging station was discontinued September 30, 1933.

MONTHLY DISCHARGE OF SHEYENNE RIVER AT SHEYENNE, N. DAK.

Month	Discharge in second-feet			Run-off in acre-feet
	Maximum	Minimum	Mean	
1930-1931				
October	....	....	.....	.....
November	....	....	.....	.....
December	....	....	.....	.....
January	....	....	.....	.....
February	....	....	.....	.....
March	....	....	5	89
April	58	2.6	26.7	1,590
May	3.4	.7	2.19	135
June	1.1	0	.35	21
July	1.3	0	.34	21
August	0	0	0	0
September	0	0	0	0

1930-1931 Maximum discharge April 9 and 10, discharge 58 second-feet.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	....	....	.....	.....
November	....	....	.....	.....
December	....	....	.....	.....
January	....	....	.....	.....
February	....	....	.....	.....
March	....	....	29.2	1,800
April	73	4.9	31.3	1,860
May	30	2.5	9.81	603
June	19	1.9	8.77	522
July	2.3	.6	1.25	37
August	....	....	.....	.....
September	....	....	.....	.....

1931-1932 Maximum Stage 5.62 feet at 1:30 P.M., March 1.
Minimum Stage 2.04 feet July 5, Discharge .6 second-feet.
Gage removed July 15. Recordings for July are for 15 days only.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	....	....	.....	.....
November	....	....	.....	.....
December	....	....	.....	.....
January	....	....	.....	.....
February	161	0	8.76	487
March	296	38	112	6,890
April	214	23	84.4	5,020
May	18	.9	7.57	465
June	1.4	0	.35	21
July	....	....	.....	.....
August	....	....	.....	.....
September	....	....	.....	.....

1932-1933 Run-off recorded during period 12,883.
Maximum Stage 6.08 feet at 4:00 P.M., March 2, Discharge 296 second-feet.
Minimum Stage June 15 - 21, Discharge 0 second-feet.
Station discontinued June 30th.

HUDSON BAY DRAINAGE

Sheyenne River at West Fargo, N. Dak.

LOCATION.—At West Fargo, N. Dak., formerly called Haggart in Sec. 6, T. 139 N., R. 40 W., at the steel truss bridge with concrete floor on U. S. Highway No. 10 North of the Northern Pacific Railway station about one-half mile. Station is about one-fourth mile down-stream from the original station, maintained for the years 1902-1907 and 1919. No tributaries enter the river between the two sites.

RECORDS AVAILABLE.—1902-1907, 1919, 1929-1934.

GAGE.—Ten-foot horizontal enameled face staff is placed in the truss even with the edge of the floor. Wire cable holding 5 lb. window weight runs over pulley in end of staff and has two markers soldered to cable ten feet apart. Observer is R. E. Alford, West Fargo.

DISCHARGE MEASUREMENTS.—Measurements are taken from the bridge; two-foot permanent station marks for sounding are painted on the hand rail.

CHANNEL AND CONTROL.—Banks composed of alluvial loam apparently quite stable. Left bank looking upstream is low bench while right bank is steep and rises directly up to the bridge abutment. One channel at all stages. Channel straight for about 100 feet above station but curved above that point. Velocity slow. Formation of ice impeded by discharge of warm sewerage from Armour Packing Plant about ⅝-mile above the station.

EXTREMES OF DISCHARGE.—1902-1907, 1919, 1929-1934; Maximum discharge April 28, 1919, 2,220 second-feet; minimum discharge August 5, 1934—stage 2.13 feet, discharge 4.6 second feet.

DIVERSIONS.—None.

REGULATION.—The Northern Pacific dam is located about a quarter of a mile upstream.

ACCURACY.—Accuracy should be good.

REMARKS.—This station was discontinued September 30, 1934.

MONTHLY DISCHARGE OF SHEYENNE RIVER AT WEST FARGO, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	28	17	23.0	1,410
November	61	21	32.8	1,950
December	44	12	22.9	1,410
January	30	6	12.8	787
February	159	6	51.2	2,840
March	342	...	122	7,500
April	390	132	228	13,600
May	129	64	84.6	5,200
June	320	54	117	6,960
July	56	15	31.2	1,920
August	42	15	21.7	1,330
September	20	17	18.3	1,090
The Period	390	6	636	45,997

1930-1931 Maximum Stage 7.84 feet on April 7th, Discharge 390 second-feet. Ice November 23 to March 22nd.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	33	16	20.7	1,270
November	47	31	39.6	2,360
December	51	20	34.5	2,120
January	37	19	25.5	1,570
February	35	13	20.8	1,200
March	412	35	224	13,800
April	1,040	179	551	32,800
May	301	87	144	8,850
June	312	102	128	7,620
July	97	31	59.5	3,660
August	36	25	30.4	1,870
September	32	17	21.1	1,260
The Period	1,040	13	108	78,380

1931-1932 Maximum Stage 11.84 feet at 4:00 P.M., on April 13, 1932, Discharge 1,110 second-ft. Minimum Discharge on February 15, 1932, 13 second-feet.

MONTHLY DISCHARGE OF SHEYENNE RIVER AT WEST FARGO, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	31	15	21.2	1,300
November	43	31	34.5	2,050
December	30	14	21.0	1,290
January	...	...	16.0	984
February	32	...	15.7	872
March	680	41	416	25,600
April	616	206	402	23,900
May	268	113	177	10,900
June	113	34	68.2	4,060
July	77	23	39.4	2,420
August	37	12	17.7	1,090
September	20	7.2	12.0	714
The Period	680	7.2	104	75,180

1932-1933 Maximum Stage 11.82 feet at 5:00 P.M., March 11, Discharge 680 second-feet.
Minimum Stage 2.24 feet at 1:00 A.M., September 30, Discharge 6.8 second-feet.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	18	8.0	11.9	735
November	27	13	17.2	1,020
December	20	10	13.4	825
January	10	10	10.0	615
February	17	11	13.6	754
March	221	19	65.1	4,000
April	312	92	201	11,940
May	95	24	56.2	3,460
June	34	20	25.2	1,500
July	31	6.8	14.7	902
August	27	4.6	9.64	593
September	14	4.8	8.95	532
The Period	312	4.6	37.1	26,876

1933-1934 Maximum Stage 7.22 feet at 8:00 A.M., on April 13, Discharge 336 second-feet.
Minimum Stage 2.11 feet at 1:00 A.M., on August 27, Discharge 4.2 second-feet.

HUDSON BAY DRAINAGE

Pembina River at Neche, N. Dak.

LOCATION.—At Great Northern Railway bridge two-thirds mile north of Neche, Pembina County, N. Dak.

DRAINAGE AREA.—2,960 square miles.

RECORDS AVAILABLE.—May 1903—September 1915, April 1919—September 1935.

GAGE.—Vertical staff bolted to concrete abutment at north end of railway bridge; read to tenths once daily by P. J. Horgan.

DISCHARGE MEASUREMENTS.—Made from highway bridge 20 rods below railway bridge by wading below Great Northern dam.

CHANNEL AND CONTROL.—Bed composed of clay and silt. Control is loose-rock dam about 3 feet high, a third of a mile below gage, constructed to give sufficient depth of water for the intake of Great Northern Railway water tank; shifts slightly.

EXTREMES OF DISCHARGE.—1903-1915; 1919-1935; Maximum open water stage recorded, 20.9 feet May 2, 1904, discharge 3,870 second-feet; minimum stage recorded, No flow—February 1-25, 1932; No flow—January 11, 1933; No flow—September 22, 1934; No flow during parts of several months in 1935.

ICE.—Stage-discharge relation seriously affected by ice.

REGULATION.—None.

ACCURACY.—Stage-discharge relation not permanent; affected by ice and by shift of control. Both rating curves fairly well defined. Records fair.

MONTHLY DISCHARGE OF PEMBINA RIVER AT NECHE, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	28	21	25.8	1,590
November	22	3.0	11.2	666
December	...	....	2.75	169
January	...	....	7.17	441
February	...	....	6.56	364
March	291	6	45.2	2,780
April	1,490	112	463	27,600
May	145	46	103	6,330
June	46	8.0	22.3	1,330
July	21	5	10.8	664
August	20	.5	2.07	127
September	.5	.2	0.39	23
The Period	1,490	.2	58.0	42,084

1930-1931 Maximum Discharge 1,490 second-feet on April 9 –(effected by ice).
Minimum Stage 0.2 second-feet on September 9 - 19.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	3.0	.2	.64	39
November	8.0	2.6	4.92	293
December	2.5	.2	1.04	64
January	....	....	.13	8
February	....	0	3.4	196
March	....	....	14.1	867
April	1,170	57	423	25,200
May	262	114	186	11,400
June	114	36	71.2	4,240
July	32	8.4	21.1	1,300
August	14	1.6	6.10	375
September	7.8	.3	1.84	109
The Period	1,170	0	60.7	44,091

1931-1932 Maximum Stage 13.6 feet on April 9, Discharge 1,240 second-feet.
Minimum Stage (est.) February 1 - 25, Discharge 0 second-feet.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	29	.1	7.53	463
November	15	2.8	8.02	477
December	...	....	2.71	167
January	0	0	0	0
February	0	0	0	0
March	496	0	17.9	1,100
April	1,100	516	721	42,900
May	1,420	385	573	35,200
June	686	138	320	19,000
July	140	41	74.5	4,580
August	38	19	27.2	1,670
September	41	18	28.9	1,720
The Period	1,420	0	148	107,277

1932-1933 Maximum Discharge 12:30 P.M., May 26, 1933—1420 second-feet.
Minimum Discharge January 11, 1933— 0 second-feet.

MONTHLY DISCHARGE OF PEMBINA RIVER AT NECHE, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	55	34	47.2	2,810
November	38	17	24.1	1,440
December	15	5.3	9.6	590
January	5.1	4.6	4.74	292
February	5.4	4.4	4.81	267
March	188	4.6	75.2	4,630
April	780	74	343	20,430
May	224	91	154	9,440
June	88	41	67.7	4,030
July	40	4.6	19.9	1,220
August	3.5	.4	1.37	84
September	.6	0	.10	6.0
The Period	780	0	62.6	45,239

1933-1934 Maximum Stage 9.76 feet (ice effect) 7:00 P.M., April 9, 1934, Discharge 780 sec.-ft.
Minimum Stage 2.15 feet at 1:15 P.M., September 22, 1934, Discharge 0 second-feet.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	16	0	1.68	103
November	20	.7	1.07	63
December	.7	0	.08	5.2
January	....	....	0	.....
February	....	....	0	.....
March	130	0	12.6	776
April	342	63	144	8,580
May	78	44	64.2	3,950
June	364	53	108	6,440
July	116	22	62.4	3,840
August	51	7.4	23.5	1,450
September	24	9.0	14.9	884
The Period	364	0	36.0	26,091.2

1934-1935 Maximum Discharge June 18, 1935—364 second-feet.
Minimum Discharge during parts of several months 0 second-feet.

HUDSON BAY DRAINAGE

Mouse (Souris) River at Minot, N. Dak.

LOCATION.—In Minot, N. Dak. at the foot-bridge across the Mouse River 100 feet from the Great Northern Railway roundhouse until the construction of a dam in 1923 in the river 4⅔ miles downstream from the gage. The crest of this dam was in an elevation of 9.07 feet on the gage and introduced considerable disturbance of the stage-discharge relation because of the operation of the gate. A staff was installed on the Valker bridge just above the dam in 1924. The record from this point included the operation of the gate but it was not entirely satisfactory.

In 1927 a staff was placed on the Saugstad bridge five miles below Minot. Parallel records and partial records were kept at the three stations at various intervals.

RECORDS AVAILABLE.—1903-1928; 1929-1935.

GAGE.—Vertical staff gage attached to piling of the bridges in Minot; wire gage used at the Saugstad bridge. Records are now taken at Minot by F. H. Peters.

DISCHARGE MEASUREMENTS.—Made from the Main Street footbridge and other bridges and by wading.

CHANNEL AND CONTROL.—Channel in clay and silt, nearly permanent, but changed somewhat in recent years by encroachment of the channel through the city.

EXTREMES OF DISCHARGE.—1903-1930; Maximum stage 21.9 feet, April 20, 1904, discharge 12,000 second-feet; Minimum—no flow during much of 1934-1935.

ICE.—Stage-discharge relation only slightly affected by ice.

DIVERSIONS.—None.

REGULATIONS.—None.

ACCURACY.—Stage-discharge relation fairly permanent during year, except for slight ice effect and for backwater from City Park dam. It was built to raise the low water stage. Its operation disturbs the gage rating, especially when gate is only partly open. Otherwise rating curve fairly well defined between 3 and 3,500 second-feet. Gage read to tenths once daily. Daily discharge ascertained by applying daily gage height to rating table. Records fair.

MONTHLY DISCHARGE OF MOUSE (SOURIS) RIVER AT MINOT, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	.6	.1	.25	15
November	1.0	.2	.44	26
December	1.0	.2	.45	28
January	.6	.2	.28	17
February	1.0	.2	.50	28
March	3.3	1.0	2.26	139
April	7.5	3.3	5.44	324
May	8.0	.9	4.01	247
June	1.0	.3	.71	42
July	....	....	(est.) .50	31
August	....	....	(est.) .40	25
September	....	....	(est.) .30	18
The Period	8.0	0.1	1.30	940

1930-1931 Ice period November 26 to March 13.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	....	....	(est.) .30	18
November	....	....	(est.) .20	12
December	....	....	(est.) .20	12
January	....	....	(est.) .10	6.1
February	....	....	(est.) .10	5.8
March	2.0	0.1	.85	52
April	230	2.0	60.5	3,600
May	28	3.0	14.2	873
June	202	1.0	14.6	869
July	6.0	.5	1.9	117
August	.5	.3	.35	22
September	....	....	(est.) .30	18
The Period	230	....	7.72	5,604.9

1931-1932 Maximum Stage 7.20 feet Midnight June 8, 1932, Discharge 260 second-feet.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	...	..	0.40	25
November	...	..	0.6	36
December	...	..	0.6	37
January	...	..	.5	31
February	50	..	3.18	177
March	759	26	193	11,900
April	1,040	90	398	23,700
May	109	31	53.5	3,290
June	857	27	336	20,000
July	...	..	39.2	2,410
August	...	..	3.0	184
September	...	..	1.0	60
The Period	1,040	..	85.4	61,850

1932-1933 Maximum Stage 10.00 feet at 12 N. April 6th, Discharge 1,040 second-feet.

MONTHLY DISCHARGE OF MOUSE (SOURIS) RIVER AT MINOT, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	.2	.1	.17	10
November	.4	.2	.26	15
December	.4	.3	.36	22
January	.3	.3	.30	18
February	40	.2	3.50	194
March	328	20	184	11,340
April	190	37	124	7,380
May	34	1	9.65	593
June	.3	.2	.23	14
July	1.5	.3	.87	54
August	1.5	1.5	1.50	92
September	1.5	1.5	1.50	89
The Period	328	.1	27.4	19,821

1933-1934 Maximum Stage 7.25 feet at 4:45 P.M., March 23, 1934, Discharge 328 second-feet.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	.....	....	0	0
November	.....	....	0	0
December	.....	....	0	0
January	.....	....	0	0
February	.....	....	0	0
March	100	0	8.26	508
April	50	0	9.43	561
May	428	1.5	65.1	4,000
June	3.2	0	.31	18
July	43	0	17.3	1,060
August	16	0	4.29	264
September	0	0	0	0
The Period	428	0	8.86	6,411

1934-1935 Maximum Stage 6.67 feet at 6:30 A.M., May 5, 1935, Discharge 612 second-feet.

HUDSON BAY DRAINAGE

Mouse (Souris) River near Westhope, N. Dak.

LOCATION.—In T. 163 N., R. 79 W., on county highway bridge about two and one-half miles east of Westhope on the road to Landa. Six miles south of international boundary.

RECORDS AVAILABLE.—July 1929-September 1935.

GAGE.—Chain gage located on upstream side of highway bridge. Read to hundredths once a day by A. C. Anderson, Landa, N. Dak.

DISCHARGE MEASUREMENTS.—Measurements made from a highway bridge at the gage or by wading a short distance below the bridge. Bed of stream is black mud. Banks are low and subject to overflow. A few willows grow along the edge of the dredged channel but except for them the banks are covered with wild hay.

CHANNEL AND CONTROL.—Control is indefinite. The channel of the stream has been dredged for many miles above and below the station. The dredged banks are subject to overflow at a stage of about five feet.

EXTREMES OF DISCHARGE.—1929-1935; Maximum stage 7.25 feet at 6:00 P.M. April 19, 1933, discharge 1130 second feet; Minimum stage, no flow for several months during summer.

DIVERSIONS.—None.

REGULATIONS.—None.

ACCURACY.—Good records should be obtained at this station.

MONTHLY DISCHARGE OF MOUSE (SOURIS) RIVER NEAR WESTHOPE, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	43	1.8	11.1	682
November	...	....	20.3	602
December	...	...	....	.....
January	...	...	....	.....
February	...	....	....	.....
March	...	....	....	.....
April	118	25	58.4	3,480
May	44	9.6	22.5	1,380
June	13	0.4	4.81	286
July	14	0	2.24	138
August	0	0	0	0
September	0	0	0	0

1930-1931 Maximum Discharge 118 second-feet April 6 and 7, effected by ice.
No record November 16 to March 31.
No flow July 20 to September 30.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	...	....	5.27	324
November	14	4.9	9.85	352
December	...	....	....	.....
January	...	....	....	.....
February	...	....	....	.....
March	24	9	18	286
April	134	27	73.8	4,390
May	169	22	63.3	3,890
June	63	6.9	26.3	1,560
July	31	3.3	12.6	775
August	14	0	2.07	127
September	0	0	0	0
The Period	169	0	.....	11,704

1931-1932 Maximum Stage 3.98 feet May 4, 1932, Discharge 169 second-feet.
Zero Discharge at various times during the year.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	0	0	0	0
November	22	.....	10.7	446
December	...	.....	.....	.....
January	...	.....	.....	.....
February	...	.....	.....	.....
March	765	45	369	6,590
April	1,130	494	875	52,100
May	446	159	219	13,500
June	272	141	183	10,900
July	272	123	209	12,900
August	123	19	55.1	3,390
September	24	4.9	10.3	613

1932-1933 Maximum Stage 7.25 feet at 6:00 P.M., on April 19, Discharge 1,130 second-feet.

MONTHLY DISCHARGE OF MOUSE (SOURIS) RIVER NEAR WESTHOPE, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	26	2.0	6.16	379
November	31	5.0	14.0	835
December	...	....	.....	.....
January	...	.....	.....	.....
February	...	.....	.....	.....
March	279	94	180	3,920
April	524	121	294	17,520
May	121	12	56.2	3,460
June	10	1.1	4.62	275
July	2.5	0	.77	48
August	.....	.....	......	.....
September	.....	.....	......	.....

1933-1934 Maximum Stage 6.02 feet at 5:00 P.M., April 7, Discharge 524 second-feet.
Minimum Stage no flow July 28—September 30, Discharge 0 second-feet.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	...	....	......	.....
November	...	....	......	.....
December	...	....	......	.....
January	...	....	......	.....
February	...	....	......	.....
March	...	....	......	.....
April	74	30	55.5	3,300
May	139	26	75.0	4,610
June	63	4.5	17.9	1,070
July	279	22	163	10,010
August	130	20	68.6	4,220
September	23	.4	7.85	467

1934-1935 Maximum Stage 7.06 feet at 8:00 A.M., July 9, Discharge 279 second-feet.
No flow for most of period October 1 to March 31.

HUDSON BAY DRAINAGE

Mouse River at Sherwood, North Dakota

LOCATION.—In NE¼ of Sec. 33, T. 164 N., R. 87 W., about 16 miles NW of Sherwood, N. Dak. and ¾ mile south of International boundary; can be reached by driving west on county road that passes on the north side of Sherwood until the Souris River is crossed on Stafford bridge, then turn north and follow up the river road about 1½ miles to William Harkness farm.

RECORDS AVAILABLE.—March 1930-September 1935.

GAGE.—Vertical staff gage in five sections on the right bank of River about 100 ft. north of the William Harkness farmhouse. First section of gage, from 0 to 6.6 ft is attached to concrete pier at edge of river. Gage is read to hundredths, twice daily by William Harkness.

DISCHARGE MEASUREMENTS.—Made from cable ⅛ mile east of gage which point is approximately 1 mile downstream to a long bend in river, stream bed is of clean gravel and probably permanent. One channel at all stages. Flow smooth and rather sluggish. Channel is straight for several hundred feet above and below station. Both banks are wooded and not liable to overflow. Low water measurements made by wading about ¼ mile below cable.

CHANNEL AND CONTROL.—Indefinite and probably is not the same for low and high stages.

EXTREMES OF DISCHARGE.—1930-1935; Maximum Stage 13.10 feet at 7:00 P. M. on March 31, 1933, discharge 1370 second-feet; Minimum noflow various periods during summer months.

ICE.—Stage discharge relation affected by ice November to March or April.

DIVERSION.—None.

REGULATION.—None.

ACCURACY.—Good records should be obtained at this station.

MONTHLY DISCHARGE OF MOUSE RIVER AT SHERWOOD, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	2.1	.0	1.48	91
November	1.4	.6	1.15	50
December	....	....	.....	.....
January	....	....	.....	.....
February	....	....	.....	.....
March	....	....	.....	.....
April	18	3.6	12.4	713
May	16	3.8	8.71	536
June	3.5	0	1.06	63
July	.3	0	.06	3.7
August	0	0	0	0
September	0	0	0	0

1930-1931 Maximum Stage 1.17 feet at 7:00 P.M., on April 14, Discharge 19 second-feet.
Minimum Stage -.,51 feet on July 31, September 15-21, Discharge 0 second-feet.
No record November 23 to April 1.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	....	....	.....	.....
November	....	....	.....	.....
December	....	....	.....	.....
January	....	....	.....	.....
February	....	....	.....	.....
March	14	.2	4.09	154
April	90	13	50.6	3,010
May	55	3.9	16.1	990
June	58	2.0	16.1	958
July	62	.2	9.74	599
August	6.2	0	1.25	77
September	0	0	0	0

1931-1932 Maximum Stage 3.17 feet at 7:00 P.M., on April 9, Discharge 102 second-feet.
Minimum Stage -.72 feet on September 30, Discharge 0 second-feet.
No record October 1 to November 16 and November 18 to March 2.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	.....	....	....	.....
November	.....	....	....	.....
December	.....	....	....	.....
January	.....	....	....	.....
February	23	3	15.7	93
March	1,350	6	247	15,200
April	1,140	58	224	13,300
May	563	23	75.8	4,660
June	1,000	49	34.1	20,300
July	49	3.6	20	1,230
August	17	0.7	5.4	332
September	1.0	0.6	.75	45
The Period	1,140	0.6	128.08	55,160

1932-1933 Maximum Stage 13.10 feet at 7:00 P.M., on March 31, Discharge 1,370 second-feet.
Minimum Stage -.21 feet at 9 A.M., on November 21, Discharge 0.5 second-feet.
Little or no flow October 1 to February 25.

MONTHLY DISCHARGE OF MOUSE RIVER AT SHERWOOD, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	2.6	.8	1.53	94
November	2.0	1.0	1.71	75
December	.....	....	.....	.....
January	.....	....	......	.....
February	128	9.8	46.9	1,390
March	344	81	195	12,000
April	155	32	89.3	5,310
May	32	6.0	14.9	918
June	5.8	2.2	3.61	215
July	2.2	.2	1.36	84
August	0	0	0	0
September	0	0	0	0

1933-1934 Maximum Stage 7.74 feet at 8:50 A.M., and 6:10 P.M., March 16. Discharge 344 second-feet.
Minimum Stage -.77 feet at 8:00 A.M., on August 25 - 26, Discharge 0 second-feet.
No flow August 1 to September 30. No record November 23 to February 13.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0
January	0	0	0	0
February	0	0	0	0
March	37	0	2.55	157
April	165	1.0	48.6	2,890
May	85	15	44.4	2,730
June	20	5.9	14.3	852
July	140	5.3	32.1	1,470
August	4.8	.8	2.72	167
September	.7	0	.26	16
The Period	165	0	12.1	8,782

1934-1935 Maximum Stage 2.78 feet at 6:00 P.M., July 5, Discharge 200 second-feet.
Minimum Stage. No flow much of year. Ice effect March 23 to April 22.

HUDSON BAY DRAINAGE

Mouse River at Towner, North Dakota

LOCATION.—In Section 10, T. 156, R. 76 W., McHenry County, about ¾ mile NW of Towner, N. Dak. on Great Northern Railway bridge. Can be reached from Towner by road west from city water tower to side road branching from highway at right end of highway bridge and south to gage. Railway bridge is about 1,000 feet upstream from highway bridge.

RECORDS AVAILABLE.—November 1932-September 1935.

GAGE.—Staff gage attached to wooden trestle piling of Maxbass branch Great Northern Railway bridge. Lower section standard gage face 0-3.3′ section attached to downstream side of piling near upstream end of center group, 3.4-10.1′ sections attached to piling near right bank and 10.2-13.5′ section on piling higher on right bank.

DISCHARGE MEASUREMENTS.—High stage measurements made may be made from highway bridge 1,000 feet downstream. Low water measurements may be made by wading a short distance below gage.

CHANNEL AND CONTROL.—Low water control consists of timber and rock fill dam at downstream edge of Railway bridge. At low stages there is 2′ or 3′ difference in water levels above and below this dam. High water control probably indefinite.

EXTREMES OF DISCHARGE.—1932-1935; Maximum Stage 9.02 feet at 1:00 P. M. April 10, 1933, discharge 1080 second-feet; Minimum Stage .10 feet at 10:00 A. M., September 24, 1934, discharge 0 second-feet.

ICE.—Ice conditions prevail on this river from November to April but control will probably remain open most of the winter.

DIVERSIONS.—None.

REGULATIONS.—None.

ACCURACY.—A reliable record should be obtained if no changes are made in rock fill dam acting as control.

MONTHLY DISCHARGE OF MOUSE RIVER AT TOWNER, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	...	..	...	......
November	...	..	...	......
December	...	..	...	......
January	...	..	...	......
February	...	..	...	......
March	535	54	298	16,600
April	1,080	166	561	33,400
May	203	88	119	7,320
June	850	80	387	23,000
July	166	32	80.5	4,950
August	32	3.4	12.4	762
September	11	.6	3.01	179

1932-1933 *Maximum Stage 9.02 feet at 1:00 P.M., on April 10, Discharge 1,080 second-feet.* Minimum Stage .86 feet on September 27 and 30, Discharge 0.6 second-feet.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	...	..	...	.....
November	...	..	...	.....
December	...	..	...	.....
January	...	..	...	.....
February	...	..	...	.....
March	355	31	199	9,060
April	385	78	228	13,580
May	72	1.8	18.3	1,130
June	19	0	5.5	327
July	3.0	0	.85	52
August	...	..	...	.....
September	...	..	...	.....

1933-1934 Maximum Stage at 5.02 feet (effected by ice) 11:00 A.M., April 3, Discharge 385 second-feet.
Minimum Stage .10 feet at 10:00 A.M., September 24, Discharge 0 second-feet. No record October 1 to March 28.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	...	..	....	.....
November	...	..	....	.....
December	...	..	....	.....
January	...	..	....	.....
February	...	..	....	.....
March	124	40	76.1	1,360
April	78	17	31.6	1,880
May	230	35	84.5	5,200
June	35	6	17.0	1,010
July	320	4	92.6	5,700
August	68	7.2	20.1	1,240
September	12	2.2	4.89	291

1934-1935 Maximum Discharge at 10:00 P.M., July 26, 334 second-feet.
Minimum Discharge at Noon September 29, 1.9 second-feet.

HUDSON BAY DRAINAGE

Monthly Discharge of Park River at Grafton

LOCATION.—North edge of Grafton, reached by U. S. Highway No. 81 to Grafton, then about 3 blocks downstream from highway bridge. In T. 157 N., R. 53 W.

RECORDS AVAILABLE.—April 1931-September 1935.

GAGE.—Chain gage on upstream side of steel truss bridge. Chain length to low water marker, 23.94 feet, to high water marker 13.94 feet. Jackson, chief of police, is observer, address Grafton, N. Dak. Gage read to hundredths daily. Gage height book may be found at municipal light plant in sales department.

DISCHARGE MEASUREMENTS.—Low water by wading under bridge, downstream or upstream side of bridge for highwater, bed of stream fairly clean, loam banks, channel fairly straight above and below measuring section.

CHANNEL AND CONTROL.—Artificial rock riffle 100 feet below bridge for low water, indefinite channel downstream for high and medium stages.

EXTREMES OF DISCHARGE.—1931-1935; maximum stage 15.18 feet at 10.15 A. M. on April 2, 1933, discharge 2010 second-feet; Minimum—No flow various times during summer months.

ICE.—Stage discharge relation affected by ice.

DIVERSION.—None.

REGULATION.—None.

ACCURACY.—Accuracy should be fair with large number of measurements to define curve.

MONTHLY DISCHARGE OF PARK RIVER AT GRAFTON, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	....	....	....	.....
November	....	....	....	.....
December	....	....	....	.....
January	....	....	....	.....
February	....	....	....	.....
March	....	....	....	.....
April	....	....	20.5	81
May	22	6.5	12.5	769
June	6.9	1.0	3.04	181
July	4.4	.1	.98	60
August	.6	0	.19	12
September	....	....	.....	.....

1930-1931 Maximum Stage 2.02 feet on May 1, Discharge 22 second-feet.
Minimum Stage—Various times during July and August.
Recording for April were for 2 days only.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	...	....	....	.....
November	...	....	....	.....
December	...	....	....	.....
January	...	....	....	.....
February	...	....	....	.....
March	...	....	67.5	268
April	550	9	155	9,220
May	42	7.3	21.7	1,330
June	21	.4	5.58	332
July	1.1	0	.27	17
August	0	0	0	0
September	0	0	0	0
The Period	550	0	30.5	11,167

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	3.9	0.7	1.99	55
November	.....	....	......	.....
December	.....	....	......	.....
January	.....	....	......	.....
February	.....	....	......	.....
March	819	58	369	2,200
April	2,010	42	411	24,500
May	38	13	22.3	1,370
June	34	0.7	12.2	726
July	.....	....	....	.....
August	.....	....	....	.....
September	.....	....	....	.....

1932-1933 Maximum Stage 15.18 feet (ice) 10:15 A.M., April 2, Discharge 2,010 second-feet.
Minimum Stage 1.42 feet on October 18 and June 30, Discharge 0.7 second-feet.

MONTHLY DISCHARGE OF PARK RIVER AT GRAFTON, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	...	....	....	.....
November	...	....	....	.....
December	...	....	....	.....
January	...	....	....	.....
February	...	....	....	.....
March	32	16	21.6	428
April	393	7.1	78	4,640
May	6.5	.3	2.16	133
June	1.0	0	.41	25
July	.1	0	.01	.79
August	0	0	0	0
September	.8	0	.08	4.8

1933-1934 Maximum Stage 6.61 feet (ice) 12:30 P.M., April 9, Discharge 393 second-feet.
Minimum Stage .86 feet several days in September, Discharge 0 second-feet.
No record October 1 to March 21.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	...	....	. .	.....
November	...	....	...	.....
December	...	....	...	.....
January	...	....	...	.....
February	...	....	...	.....
March	443	40	158	4,060
April	196	20	65.9	3,920
May	20	1.2	6.07	373
June	18	.4	3.91	232
July	...	....	...	.....
August	...	....	...	.....
September	...	....	...	.....

1934-1935 Maximum Stage 8.34 feet at 9:40 A.M., March 28, Discharge 443 second-feet.
Minimum Stage 1.28 feet at 3:00 P.M., June 11, Discharge .4 second-feet.

HUDSON BAY DRAINAGE

The Goose River at Hillsboro, North Dakota

LOCATION.—In T. 145 N., R. 51 W. on Highway bridge on U. S. No. 81 at north edge of town of Hillsboro.

RECORDS AVAILABLE.—March 1931-September 1935.

GAGE.—Chain gage on upstream side of truss bridge. Two markers Chain lengths. Observer, Chester Kjesbo, Hillsboro, N. Dak. Reads to Hundredths daily.

DISCHARGE MEASUREMENTS.—Measurements at high stage from bridge. Low stage under bridge or any smooth section above or below bridge by wading.

CHANNEL AND CONTROL.—Indefinite channel at high stage.

EXTREMES OF DISCHARGE.—1931-1935; Maximum stage 15.14 feet at 8:15 A. M. March 3, 1932, discharge 959 second-feet; Minimum stage 1.14 feet September 24, 1931 and August 23, 1932.

DIVERSIONS.—None.

REGULATIONS.—None.

ACCURACY.—Data should be fair; but frequent measurements will be necessary.

MONTHLY DISCHARGE OF GOOSE RIVER AT HILLSBORO, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1930-1931				
October	....	....	....	.....
November	....	....	....	.....
December	....	....	....	.....
January	....	....	....	.....
February	....	....	....	.....
March	15	10	14.3	424
April	94	4.3	26.8	1,590
May	14	.4	3.56	219
June	12	.2	4.24	252
July	9.4	.2	1.27	78
August	2.4	.2	1.33	82
September	.7	.2	.33	20

1930-1931 Maximum Stage 4.04 feet at 8:20 A.M. and 4:15 P.M., on April 8, Discharge 94 sec.-ft. Minimum Stage 1.14 feet at 8:30 A.M, on September 24, Discharge .2 second-feet.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	...	..	...	.....
November	...	..	...	.....
December	...	..	...	.....
January	...	..	...	.....
February	...	..	...	.....
March	911	23	272	16,740
April	537	49	239	14,200
May	65	10	27.4	1,680
June	18	3.0	12.6	748
July	3.2	.3	.98	60
August	.4	.2	.29	18
September	.8	.3	.39	23

1931-1932 Maximum Stage 15.14 feet at 8:15 A.M., on March 3, Discharge 959 second-feet. Minimum Stage 1.16 feet at 4:00 P.M., on August 23, Discharge .2 second-feet. No record October 1 to February 29.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	.8	.4	.53	32
November	.9	.8	.83	16
December	.....	....	.....	.....
January	.....	....	.....	.....
February	.....	....	.....	.....
March	140	36	68.0	2,020
April	261	25	106	6,290
May	26	10	16.5	1,010
June	14	.5	6.01	358
July	.....	....	.....	.....
August	.....	....	.....	.....
September	.....	....	.....	.....

1932-1933 Maximum Stage 8.32 feet at 6:30 P.M., on April 3, Discharge 261 second-feet. Minimum Stage 1.22 feet at 4:00 P.M., on October 4, Discharge .4 second-feet. No record November 11 to March 16, July 1 to September 30.

MONTHLY DISCHARGE OF GOOSE RIVER AT HILLSBORO, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	....	....	....	.....
November	....	....	....	.....
December	....	....	....	.....
January	....	....	....	.....
February	....	....	....	.....
March	41	6.9	23.4	696
April	65	5.6	33.1	1,970
May	5.6	.8	2.05	126
June	8.3	.8	2.75	163
July	2.0	.8	1.24	76
August	1.8	.9	1.45	89
September	3.7	1.5	2.77	165

1933-1934 Maximum Stage 4.95 feet at 5:00 P.M., on April 2, Discharge 107 second-feet.
Minimum Stage 1.30 feet May 29 and 30, Discharge .8 second-feet.
No record October 1 to March 16.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	...	...	...	.....
November	...	...	...	.....
December	...	...	...	.....
January	...	...	...	.....
February	...	...	...	.....
March	201	100	148	3,230
April	100	11	32	1,910
May	90	4.2	19.9	1,220
June	627	7.0	88.4	5,260
July	...	...	...	.....
August	...	...	...	.....
September	...	...	...	.....

1934-1935 Maximum Stage 8.45 feet at 11:15 A.M. and 4:15 P.M., on June 15, Discharge 627 second-feet
Minimum Stage 2.19 feet at 11:40 A.M., on August 13, Discharge .6 second-feet.

HUDSON BAY DRAINAGE

Wild Rice River at Abercrombie, N. Dak.

LOCATION.—On U. S. No. 81, 1½ miles north and 1½ miles west of Abercrombie in SE corner Sec. 25, T. 135, R. 49 W., Richland Co., North Dakota.

RECORDS AVAILABLE.—November 1931-September 1935.

GAGE.—Chain gage on upstream side of bridge, chain lengths 20.00 ft. bottom weight to high water marker: 30.00 ft. bottom weight to low water marker.

DISCHARGE MEASUREMENTS.—High water measurements from bridge, low water by wading.

CHANNEL AND CONTROL.—No definite control, alluvial soil banks.

EXTREMES OF DISCHARGE.—1931-1935; Maximum stage 10.21 feet at 8:30 A. M. and 6:00 P. M. March 16, 1935, discharge 513 second-feet; Minimum—No flow at various times during summer months.

DIVERSIONS.—None.

REGULATIONS.—None.

ACCURACY.—Accurate data should be obtained at this station with sufficient measurements.

MONTHLY DISCHARGE OF WILD RICE RIVER AT ABERCROMBIE, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	..	...	....	...
November	..	...	....	...
December	..	...	....	...
January	..	...	....	...
February	..	...	....	...
March	..	...	....	...
April	28	5.7	13.5	723
May	11	1.6	5.8	357
June	6.2	1.6	3.26	194
July	2.6	0	.71	44
August	0	0	0	0
September	0	0	0	0

1931-1932 Maximum Discharge, 6:50 A.M., April 13, 28 second-feet.

1932-1933				
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0
January	0	0	0	0
February	11	0	.43	24
March	67	5.2	33.2	2,040
April	55	3.4	14.7	875
May	15	4.3	7.48	460
June	4.6	0	1.82	108
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0

1932-1933 Maximum Stage 4.10 feet at 6:00 P.M., March 13, Discharge 75 second-feet.

MONTHLY DISCHARGE OF WILD RICE RIVER AT ABERCROMBIE, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	....	..	....	.....
November	....	..	....	.....
December	....	..	....	.....
January	....	..	....	.....
February	....	..	....	.....
March	1.4	0	.52	16
April	15	0	3.71	221
May	1.2	0	.11	6.7
June	5.3	0	1.35	80
July	....	..	....	.....
August	....	..	....	.....
September	....	..	....	.....

1933-1934 Maximum Stage 2.10 feet at 5:35 P.M., April 7, Discharge 15 second-feet.
Minimum Stage .48 feet at 6:15 A.M.—6:20 A.M.—5:50 P.M., on April 27 and 28, Discharge 0 second-feet.
No record October 1 to March 15 and July 1 to September 30.

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	...	...	.....	.....
November	...	...	.....	.....
December	...	...	.....	.....
January	...	...	.....	.....
February	...	...	.....	.....
March	...	...	260	9,269
April	64	9.8	20.0	1,188
May	23	2.0	127	783
June	220	1.0	42.2	2,513
July	...	...	.....	.....
August	...	...	.....	.....
September	...	...	.....	.....

1934-1935 Maximum Stage 10.21 feet at 8:30 A.M. and 6:00 P.M., March 16, Discharge 513 second-feet.
No flow from October 1 to about March.
No record October 1st to March 13th and July 1st to September 30th.

HUDSON BAY DRAINAGE

Forest River at Minto, North Dakota

LOCATION.—Reached by U. S. No. 81; 1.5 miles south and 1.8 miles west of Minto, North Dakota. The 1.5 mile south is gravel road and the 1.8 mile west is graded dirt road.

RECORDS AVAILABLE.—March 1932-September 1935.

GAGE.—Chain gage on upstream side of bridge. Length of bottom weight to high water marker 10.00 feet, bottom of weight to low water marker 20.00 feet. Gage read to hundredths.

DISCHARGE MEASUREMENTS.—Low water measurements by wading somewhere near bridge. High water measurements from downstream side of bridge or from some other of two bridges between gage and Minto or from highway bridge in Minto. The bridge at gage is at an angle with the transverse to the direction of the current but this will possibly not be too serious.

CHANNEL AND CONTROL.—Dam three miles downstream in Minto may be control at medium stages. High stages no definite control. Low stages possibly a small bar of loam. Channel is cut in black clayey loam with steep sides, liable to shift.

EXTREMES OF DISCHARGE.—1932-1935; Maximum stage 12.95 feet at 8:30 A. M. on April 2, discharge 700 second-feet; Minimum—no flow various times during Summer months.

DIVERSIONS.—None.

REGULATIONS.—None.

ICE.—The river freezes over in winter and possibly reduces to zero flow in same seasons.

ACCURACY.—Data should be accurate except for angle of section.

MONTHLY DISCHARGE OF FOREST RIVER AT MINTO, N. DAK.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1931-1932				
October	.....	....	.....	.....
November	....	....	.....	.....
December	.....	....	.....	.....
January	.....	....	.....	.....
February	.....	....	....	.....
March	.....	...	129	512
April	265	41	91.2	5,430
May	44	16	29.3	1,800
June	15	7.1	11.3	672
July	9.2	1.5	5.06	311
August	1.5	0	0.39	24
September	1.2	0	0.16	10
The Period	265	0	23.9	8,759

Month	Maximum	Minimum	Mean	Run-off in acre-feet
1932-1933				
October	10	0	4.08	251
November	..	....	......	30
December	..	....	......	.....
January	...	....	......	.....
February	...	....	......	.....
March	235	....	51	3,030
April	628	36	154	9,160
May	35	18	24	1,480
June	18	5.4	10.7	637
July	...	....	......	.....
August	...	....	......	.....
September	...	....	......	.....

1932-1933 Maximum Stage 12.95 feet at 8:30 A.M.. on April 2. Discharge 700 second-feet.
Minimum Stage October 1 - 14, No flow.
Ice effect March 2 to April 16.

MONTHLY DISCHARGE OF FOREST RIVER AT MINTO, N. DAK.

Cont'd.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1933-1934				
October	..	.	....	.....
November	..	. .	..	.....
December	. . .	..	...	.....
January	. . .	..	....	.....
February	..	...	....	.....
March	29	17	21.2	420
April	79	16	39.4	2,340
May	16	6.1	10.6	654
June	7.9	2.5	5.02	299
July	2.4	0	.87	53
August	0	0	0	0
September	0	0	0	0

1933-1934 Maximum Stage 4.95 feet at 6:30 A.M., April 9. Discharge 90 second-feet (ice effect). Minimum Stage .06 feet at 1:00 P.M., on July 20.

Month	Discharge in second-feet Maximum	Minimum	Mean	Run-off in acre-feet
1934-1935				
October	...	...	...	.....
November	...	...	.....	.....
December	..	....	....	.....
January	...	...	... .	.....
February	...	....	... .	.....
March	366	35	124	3,680
April	102	23	40.3	2,400
May	20	10	14.4	883
June	15	6.4	8.72	519
July	...	....	.....	.....
August	...	...	.....	.....
September	...	....	.....	.....

1934-1935 Maximum Stage 8.99 feet at 5:30 P.M., March 28. Discharge 442 second-feet. Minimum Stage .49 feet at 12:15 P.M., on August 26. Discharge 139 second-feet. No record for period October 1 to March 16 July 1 to 22 – July 24 to August 25. —August 27 to September 30.

STREAM FLOW RECORDINGS—STATUS

Sec. 14 of the Irrigation code states as follows: The State Engineer shall make hydrographic surveys and investigations of each stream and source of water supply in the state, beginning with those most used for irrigation, obtaining and recording all available data for the determination, development and adjudication of the water supply of the state. He shall be authorized to cooperate with the agencies of the Federal Government engaged in similar surveys and investigations, and in the construction of works for the development and use of water supply of the state, expending for such purposes any money available for the work of his office and may accept and use. in connection with the operation of his department, the results of the work of the agencies of the Government.

The following is a list of the North Dakota rivers and lake gaging stations being operated at the present time by the offices of the United States Geological Survey maintained in cooperation with the state of North Dakota:

1. Missouri River at Williston
2. Missouri River at Bismarck
3. Cannonball River at Breien
4. Bois de Sioux River near Fairmount
5. Wild Rice River near Abercrombie
6. Goose River at Hillsboro
7. Forest River near Minto
8. Park River at Grafton
9. Souris (Mouse) River at Minot
10. Devils Lake

Stations maintained by funds transferred from the United States Department of State.

1. Red River at Fargo
2. Red River at Grand Forks
3. Pembina River at Neche
4. Souris (Mouse) River near Sherwood
5. Souris (Mouse) River near Westhope

Gages installed in November 1932 in cooperation with United States Army Engineers, St. Paul, in connection with their study of the Mouse River.

1. Souris (Mouse) River at Logan near Minot
2. Souris (Mouse) River at Saugstad's bridge near Minot
3. Souris (Mouse) River at Towner

The gaging stations operated in cooperation with the United States Geological Survey are operated on an arrangement whereby the United States Government will match such funds as are provided by the state. For the Biennium 1932-33 a total of $3,000 was available for this work. For the 1934-1935, 1936-1937 Bienniums no appropriations were made for this work. However, a sum of $200 was set aside each Biennium from the meager funds appropriated for the office of State Engineer to assist in this work thereby maintained a few of the stations in operation. This very limited fund made it possible to make observations during the spring run-off and prevent the loss of record at many stations.

Due to the drastic reduction of funds for stream gaging the work had to be necessarily curtailed and many stations discontinued.

The following stations were discontinued as a result of curtailment of funds:

1. Missouri River at Sanish—1933
2. Little Missouri River at Medora—1933
3. Little Muddy River near Williston—1933
4. Knife River at Hazen—1933
5. Heart River at Sunny—1933
6. James River at Jamestown—1933
7. Sheyenne River at Sheyenne—1933
8. Sheyenne River at West Fargo—1934
9. Lake Upsilon
10. Lake Metigoshe

Stream measurements are very necessary and should constitute one of the major activities of the office of the State Engineer. Stream flow records are vital to the intelligent use of our water resources. The value of a record of stream flow increases with the length of the record as the longer the record the more accurately can the future flow be estimated. Some of these gaging stations such as the Souris River at Minot, Red River at Fargo and Grand Forks, and the Pembina River at Neche have been operated for many years; most of the other stations have been operated for only relatively few years, mostly during the drought period. Now that we are probably approaching years of heavier precipitation and increased run-off, it becomes most important that these stream flow records be continued if possible.

Efforts should be made to not only continue stations now operating but also to re-establish those stations which were discontinued for lack of funds.

Attention is called to the matter of obtaining cooperative arrangements with the United States Geological Survey whereby federal funds can be made available upon 50 per cent of the cost of stream measurements being taken care of by the State. The acts appropriating funds for use by the Geological Survey provide for cooperation with States and municipalities in the measurement of stream flow, the investigation of underground waters and studies relating to the quality of water on the basis that the State or municipality shall bear at least half of the expense incident thereto. At the present time, the Geological Survey is cooperating on this basis with more than 40 States and many municipalities and their participation in the work aggregates over $600,000 annually, which is matched essentially by an equal amount of Federal funds. North Dakota can thus enter into such a cooperative program with the Geological Survey on the study of its water resources if it so desires. It is recommended that State funds be made available for this purpose.

FINANCIAL STATEMENT

Status of Budget at the end of the Biennium, June 30, 1935

	Present Budget	Total Expenditures	Balance
Salary, State Engineer	$3,840.00	$3,618.06	$ 221.94
Clerkhire, Stenographic	500.00	361.36	138.64
Postage	100.00	53.75	46.25
Office Supplies	200.00	198.51	1.49
Furniture and Fixtures	100.00	93.52	6.48
Printing	200.00	71.04	128.96
Miscellaneous	400.00	370.58	29.42
Travel Expense	1,500.00	999.62	500.38
Lake Conservation	22.55	22.55	......
Flood Irrigation	107.92	107.92	......
Fire Contingent Fund	48.90	48.90	......
Total	$7,019.37	$5,945.81	$1,073.56
Present Prior	1,317.38	1,077.96	239.42

Status of Budget on June 30, 1936

	Present Budget	Total Expenditures	Balance
Salary, State Engineer	$3,840.00	$1,578.40	$2,261.60
Clerkhire, Stenographer	500.00	....	500.00
Postage	100.00	....	100.00
Office Supplies	400.00	25.94	374.06
Furniture and Fixtures	100.00	16.52	83.48
Printing	300.00	26.86	273.14
Miscellaneous	400.00	193.41	206.59
Total Expense	2,000.00	914.53	1,085.47
Field Assistants	1,200.00	848.30	351.70
Missouri River Diversion	5,000.00	3,249.76	1,750.24
General Prior	1,073.56	1,073.56	....
Total	$14,913.56	$7,927.28	$6,986.28