STATE ENGINEER DEPARTMENT

BISMARCK, NORTH DAKOTA

THIRTEENTH

BIENNIAL REPORT

OF THE

STATE ENGINEER

TO THE

Governor of North Dakota

1927-1928

ROBT. E. KENNEDY
State Engineer

LETTER OF TRANSMITTAL

The Honorable

WALTER MADDOCK,

Governor of North Dakota.

Sir:

In accordance with the provisions of the statutes I am pleased to submit herewith the report of this Department for the Biennium ending June 30, 1928.

Respectfully,

ROBT. E. KENNEDY,
State Engineer.

Bismarck, North Dakota.
September 30th, 1928.

CONTENTS

PART I

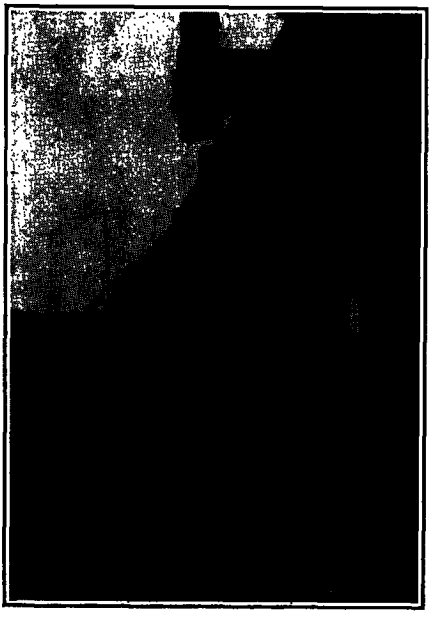
PERSPECTUS OF DEPARTMENTAL ACTIVITIES

Thirteenth Biennial
Report of
State Engineer of
North Dakota

THE MISSOURI RIVER DIVERSION TO DEVILS LAKE

The Missouri River Diversion scheme is an effort primarily to rescue Devils Lake from complete annihilation by the forces of Nature. The most beautiful lake in the state even yet altho it is now only a shadow of its former magnificence.

In 1867 it was 37 feet deep and had an estimated area of 170 square miles. It had an area of 111 square miles when it was meandered by the public land survey in 1883. In May, 1903, it was twenty-three feet deep. The last measurement, August, 1928, gives an area of about twenty square miles and a depth of twelve feet. In the interval of 26 years it has fallen at an average rate of about five inches to the year. A large investment has accumulated around its shores. Not only local people of the city of Devils Lake and the lakes region but state and federal departments are concerned about its welfare.



The water in this arm of Devils Lake was ten feet higher in 1907 when this trestle was built than it is now. This is Mr. Jim Barrett, Secretary of the Civic and Commerce Association, who with Mr. Severt Thompson, President of the Missouri Diversion Association, also of Devils Lake, N. Dak., gave the diversion idea national publicity.

As the problem was studied a number of cities on the James and Sheyenne Rivers in the eastern part of the two Dakotas were found to have problems which may be solved by the proposed diversion. In

general, their problems have not yet become acute enough to force them to commit themselves to any particular solution.

For a source of additional water the Missouri River is the most abundant but not quite so accessible as the Mouse River whose supply is limited and erratic. Devils Lake is located about 100 miles northeasterly from the big bend in the Missouri River near Coleharbor, North Dakota. See Fig. 1. The elevation of the lake is about 260 feet below the water in the Missouri. The Sheyenne and the James Rivers head in the general locality of the lake. The divide to the east of the Missouri at this place is roughly about 40 miles wide of gently rolling glaciated country with an elevation of 300 to 400 feet above the water in the Missouri. It is known as the Coteau.

Suggested Solutions

The problem is how to get the water of the Missouri to Devils Lake and the James and Sheyenne Rivers. The Missouri River has a grade through the state of nine inches to the mile. A ditch out of the river to reach over the divide would have to begin in Montana somewhere. A tunnel has been suggested. But the recently completed topographic maps reveal the fact that the tunnel would have to be 43 miles long to reach through the Coteau to the head of the Sheyenne River from the normal high water in the Missouri River. A report has been prepared by this Department upon the project. Tunnel costs were estimated at $600,000 a mile for a tunnel of 15 to 20 miles in length. If that estimate could be applied to a tunnel twice to three times as long, which is doubtful, that would make the idea entirely visionary for the present from the standpoint of cost alone, if for no other reason. There would be additional heavy construction to get the water into Devils Lake and the headwater of the James River.

THE MISSOURI RIVER DAM

A dam in the Missouri River was suggested first by John F. Stevens of Panama Canal fame, and later by C. L. Ricker, an engineer from Washington, D. C., who was introduced by Senator L. J. Frazier. It is pretty much in the dream stage as yet but it has the advantage of having a practical bearing upon the national program of flood control and navigation on the main tributaries of the Mississippi River.

While not built primarily for power still large quantities of power would be available as more or less of a by-product and at rates 25 to 30 percent less than the present lignite power rates. Pumping would be feasible. Water could then be pumped to these dry rivers and lakes where human habitation depends upon them for existence.

The dam would be of gigantic proportions and calls for much more investigation than has yet been made. A revival of navigation on the Missouri opens up a large field of investigation relative to the economic

possibilities of this landlocked Northwest, the relief of freight congestion, the retention of industries now leaving for the seaboard. This Department has not gone into these problems.

From an engineering point of view it is evident that the water is there in abundance but not at the right time. No amount of revetment and channel improvement will make June's water flow in October when our wheat is ready for market. Only a dam and reservoir will do that. A report made by this Department upon the Missouri River Dam in October, 1927, places the cost of the dam at 47½ millions of dollars.

A report by Army Engineers in 1908 upon the cost of reveting and improving the channel for navigation to Sioux City, Iowa, placed that cost at 42½ millions with over a million dollars annual maintenance.* These figures would probably be raised 100% with unit costs as they are now, making 85 million dollars, first cost.

Some maintenance and patrol work upon the river would still be necessary but the dam and reservoir would take the teeth out of the river and make it a docile and useful servant to mankind.

The Army Engineers have taken over the problem again under the recent Act of Congress authorizing an investigation of the streams tributary to the Mississippi River. They are giving it their specific and immediate attention.

This Department is planning on bringing out a report on the meteorological phases of the problem similar to that published for the Mouse River. Measurement of the river at Bismarck will be continued by this Department.

THE LOWER YELLOWSTONE PROJECT

By H. A. Parker, Superintendent

The Lower Yellowstone Federal Reclamation project comprising an irrigable area of about 59,000 acres is an interstate proposition. Approximately two-thirds of the area is in Montana and one-third in North Dakota. The project is being operated by the Government and will be until the end of 1931 when the management of the system will be turned over to the water-users. Since 1926 no appropriations have been made by Congress for operation and maintenance, the entire amount required being advanced by the water users.

A large program of drainage construction was being carried on during 1927 and 1928. To June 30, 1928, there had been built 17 miles of deep drains involving 375,000 cubic yards of excavation and fifty-five miscellaneous structures. It is expected that this work will be about completed by the end of 1929.

*Report of D. W. Lockwood, Colonel, Corp. of Engineers, House Document No. 1120, 60th Congress, 2nd Session.

Irrigation vs. Dry Farming

During 1926 about 23,330 acres were irrigated on which the average crop value was $32.22 per acre. During the same year about 9,500 acres that could have been irrigated were dry farmed with a return of $10.53 per acre.

During 1927 the irrigated area dropped to 15,629 acres with an average crop value of $26.97 per acre. The decrease in acreage was due to the fact that about 12 inches of precipitation fell during the growing season. About 18,300 acres were dry farmed with a return of $14.77 per acre.

The per acre cost of water was as follows:

Year	Construction Repayment	Operation and Maintenance	Total
1926	$0.35 (average)	$1.25	$1.60
1927	0.75 (average)	1.15	1.90

The beet sugar factory at Sidney has operated each year since 1925. Beets are one of the most profitable crops grown and due to the intensive cultivation required put the land in excellent condition for following crops. The by-products consisting of tops and pulp furnish a large amount of excellent forage, and stimulates the fattening of livestock. During 1926 about 17,000 sheep and 2,300 cattle in addition to the usual project livestock were fattened. In 1927 about the same amount of sheep but somewhat less cattle were fed.

The Government assisted by the Great Northern and Northern Pacific Railways and the Holly Sugar Corporation has carried on quite an extensive campaign to obtain more farmers. This work has been fairly successful considering the weak trend of movement to the farms.

THE MOUSE RIVER FLOOD CONTROL PROJECT

The city of Minot, North Dakota, is displaying unusual foresight in preparing to spend over a million dollars for the control of a flood which has not yet occurred. The reason is that the biennial threatenings which the Mouse River has made are not only an irritating nuisance and a continual drain upon the city treasury but also an intimation of what great damage the river might do when a real flood occurred.

To convince the city that such a great flood is an actual and imminent danger has been the problem of this Department. It is the subject of a technical report included in this volume.

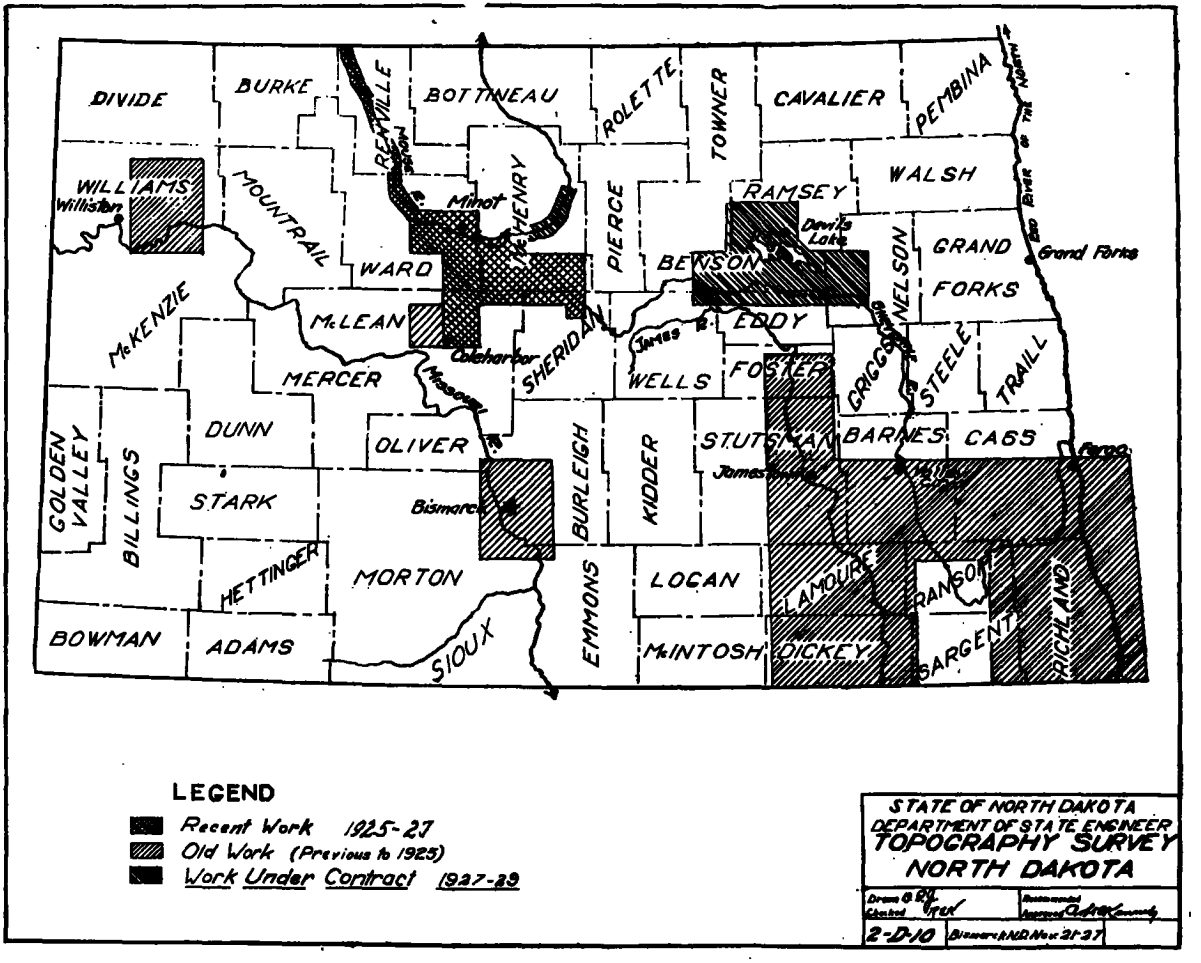

DIVIDE
BURKE
BOTTINEAU
ROLETTE
TOWNER
CAVALIER
PEMBINA
WILLIAMS
Williston
MOUNTRAIL
WARD
Minot
MCHENRY
PIERCE
RAMSEY
Devils Lake
WALSH
GRAND FORKS
Grand Forks
BENSON
NELSON
McKENZIE
McLEAN
SHERIDAN
EDDY
FOSTER
GRIGGS
STEELE
TRAILL
MERCER
WELLS
DUNN
OLIVER
STUTSMAN
BARNES
CASS
GOLDEN VALLEY
BILLINGS
STARK
Bismarck
BURLEIGH
KIDDER
METTINGER
MORTON
LOGAN
LAMOURE
RANSOM
RICHLAND
BOWMAN
ADAMS
SIOUX
EMMONS
McINTOSH
DICKEY
SARGENT
LEGEND
Recent Work 1925-27
Old Work (Previous to 1925)
Work Under Contract 1927-29
STATE OF NORTH DAKOTA
DEPARTMENT OF STATE ENGINEER
TOPOGRAPHY SURVEY
NORTH DAKOTA
2-D-10
Bismarck N.D. Mar 31-27

Fig 1

MISCELLANEOUS ACTIVITIES OF THE DEPARTMENT

Topographic Mapping

Large areas of the state have been mapped in the last two bienniums under a contract with the United States Geological Survey whereby the state bore half the cost. The extent of the area now under topographic survey is shown in Figure 1.

This work was done under the immediate supervision of Captain C. L. Saddler, U. S. G. S., Washington, D. C., to whose careful and conscientious work we are indebted for its excellent accuracy and reliability. The work was authorized primarily for the flood control project at Minot and the Missouri River Diversion to Devils Lake.

In addition it should be noted that these maps are a permanent addition to the information about our state. No other kind of map has so much information packed into a square inch. Roads, buildings, hills, valleys, rivers, lakes, ponds, swamps, reservoir possibilities, dam sites, and drainage areas are all displayed. Moreover the survey leaves bench marks of permanent sea level elevations throughout the territory they have mapped which are a great value to many other lines of engineering endeavors. These maps are now ready for distribution.

Flood Irrigation

A suggestion made by Mr. J. B. Eaton, Denbigh, North Dakota, whereby irrigation of hay meadows might be done at a reasonable expense was incorporated in an act of the last session of the legislature and an appropriation of $5,000 made for the investigation. A map was prepared by Captain Saddler of the U. S. Geological Survey of that portion of the Mouse River valley in which Mr. Eaton is interested.

In general Mr. Eaton's idea is to construct a dam in the river which will more or less automatically divert the annual spring flows out over the meadows when they are not large enough to overflow the banks otherwise.

The idea has been growing for some time throughout the western part of the state. Where the cost of the dam is nominal the scheme has worked admirably. Mr. Levi Dodge, Reeder, N. Dak., has a dam in a small creek which is practically dry much of the time. There is no gate in the dam. It is simply built so high that the water flows out over his alfalfa field whenever it rains enough upon the watershed above him to cause a flow in the creek. He has about 75 square miles of drainage above him.

Applying the idea on such a large scale as Mr. Eaton proposes raises a problem in which the increased crop values must be balanced against the cost and maintenance of the dam and the probable behavior of the Mouse River. A casual inspection of the proposed dam site indicates that the problem can hardly be answered off-hand. It is a

problem in which the studies of the Mouse River for the flood control problem at Minot will have a pertinent bearing.

If feasible here it will be applicable to many other places on the Mouse and Des Lacs. There is about $3,200.00 left in the fund. This Department is glad to proceed with a detailed study.

The New England Dam

The city of New England, North Dakota, was desirous of creating a municipal pond and bathing beach in a stream that skirts the city. By making it suitable for the propagation of fish they obtained a substantial contribution from the State Game and Fish Commission. Then by a remarkable demonstration of civic co-operation they constructed a dam and paved the beach with sand almost entirely with donated labor. The dam is a wooden crib structure filled with rock nine feet wide, seven feet deep, and 120 feet long. It would have cost about $3,000 had it been let by contract. Plans and supervision were furnished by this Department.

Personnel

Robert E. Kennedy ..... State Engineer
Maurice Diehl ..... Hydrographer
Bayert P. Jacobson ..... Draftsman, Costkeeper, etc.

The Department usually enlarges its organization temporarily during the summer season by the addition of a field party or two.

FINANCIAL STATEMENT

As of July 1st, 1928

Item	Appropriation	Previous Payments	Balance
Salary	$ 6,000.00	$ 3,000.00	$ 3,000.00
Clerkhire	7,440.00	5,472.08	1,967.92
Postage	300.00	.....	300.00
Office Supplies	300.00	112.66	187.34
Furniture & Fixtures	300.00	.....	300.00
Printing	500.00	20.69	479.31
Miscellaneous	200.00	199.99	.01
Travel Expense	2,000.00	1,628.46	371.54
Field Assistants	2,000.00	769.75	1,230.25
Hydrographic Survey	2,000.00	1,078.98	921.02
U. S. Geological Survey (Missouri River Diversion)	25,000.00	10,093.44	14,906.56
Prior	128.32	94.47	33.85
Flood Irrigation	5,000.00	1,679.93	3,320.07
Contingent	500.00	241.97	258.03
Totals	$51,668.32	$24,392.42	$27,275.90

Distribution of Expenditures

	For year ending June 30, 1927	For year ending June 30,1928	Total
Examination & Surveys (small miscellaneous activities)	$415.08	$259.23	$674.31
Irrigation (surveys for local projects)	1,190.24	199.26	1,389.50
Hydrometry (stream measurement and gage observers' salaries)	1,956.05	2,626.91	4,582.96
Flood Control (Minot and vicinity)	2,076.39	5,536.06	7,612.45
Water resources (Missouri River Diversion)	2,032.05	5,476.97	7,509.02
Topographic Mapping U. S. Geo. Survey	26,700.00	10,293.99	36,993.99
Transfer to Highway Fund (Interdept. accts.)	445.56	.....	445.56
Totals	$34,815.37	$24,392.42	$59,207.99

N. B. Each day's work of each employee is accounted for.

PART II

THE MOUSE RIVER FLOOD CONTROL PROJECT

Second Report:

METEOROLOGICAL AND HYDRAULIC STUDIES

Thirteenth Biennial Report
of
State Engineer of
North Dakota

CONTENTS

ACKNOWLEDGMENTS

The work of this report was made possible by the previous endeavor and co-operation of many people to whom the writer feels indebted and only a few of whom can be mentioned.

The most important factor in these investigations has been the gaging record of the U. S. Geological Survey at Minot under the supervision of Dean E. F. Chandler of the University of North Dakota. Topographic maps prepared by Captain C. L. Saddler of the U. S. Geological Survey were of great value. Unstinting co-operation was accorded by the Canadian authorities in furnishing stream and weather records. The office of the City Engineer, W. W. Peterson, and the County Engineer, E. J. Thomas, at Minot gave freely of time, data, and men whenever asked.

The Bureau of Reclamation contributed a valuable report on the irrigation and flood control possibilities of the Mouse River by Mr. Geo. E. Stratton and also loaned the services of Mr. I. B. Hosig for ten days, which were greatly appreciated.

R. E. Kennedy.

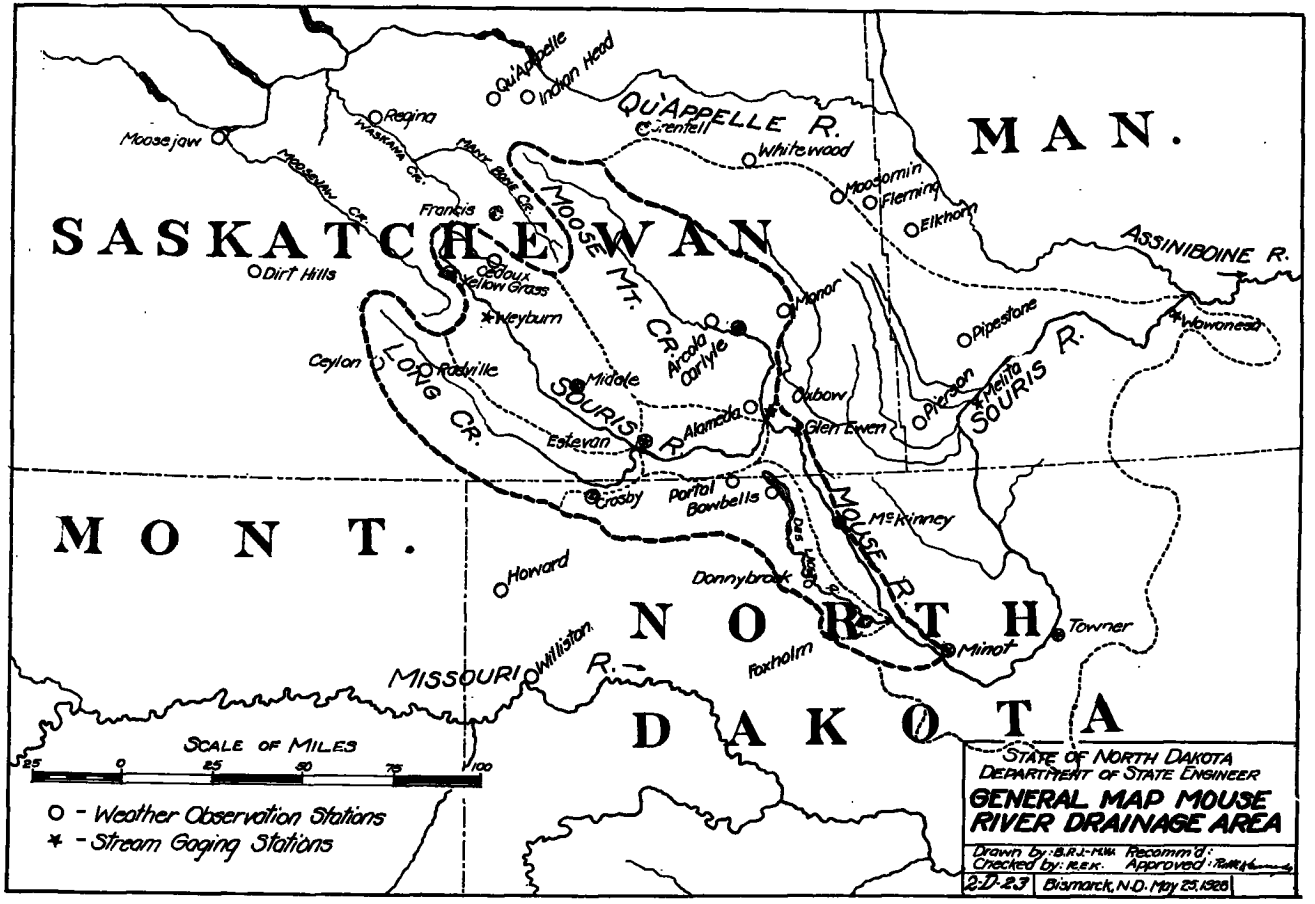
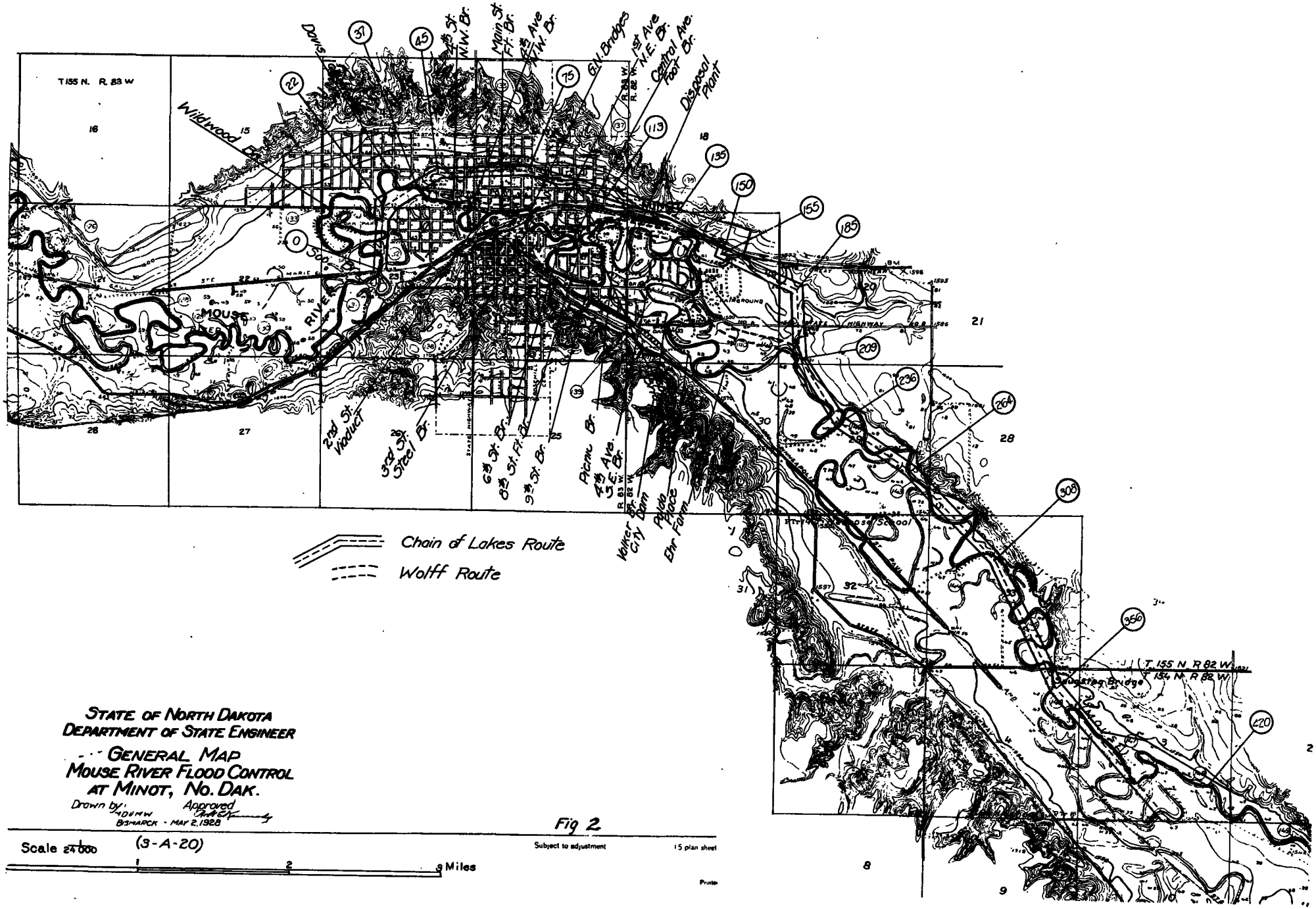

MAN.
SASKATCHEWAN
MONT.
NORTH DAKOTA
QU'APPELLE R.
Qu'Appelle
Indian Head
Regina
Moosejaw
Moosejaw Cr.
Wascana Cr.
Maple Bank Cr.
Francis
Dirt Hills
Gouldtown
Yellow Grass
Weyburn
MOOSE MT. CR.
Grenfell
Whitewood
Moosomin
Fleming
Elkhorn
ASSINIBOINE R.
Manor
Arcola
Carlyle
Pipestone
Wawanesa
Ceylon
LONG CR.
Redvill
Middale
SOURIS R.
Estevan
Alameda
Oxbow
Glen Ewen
Pierson
Melita
SOURIS R.
Crosby
Portal
Bowbells
MOUSE R.
McKinney
Howard
Donnybrook
Kenaston
Towner
Minot
Foxholm
MISSOURI R.
Williston
SCALE OF MILES
25 0 25 50 75 100
O - Weather Observation Stations
* - Stream Gaging Stations
STATE OF NORTH DAKOTA
DEPARTMENT OF STATE ENGINEER
GENERAL MAP MOUSE RIVER DRAINAGE AREA
Drawn by: B.R.I-HWA Recomm'd:
Checked by: R.E.K. Approved:
2-D-23
Bismarck, N.D. May 23, 1926

FIG. 1



STATE OF NORTH DAKOTA
DEPARTMENT OF STATE ENGINEER

GENERAL MAP
MOUSE RIVER FLOOD CONTROL
AT MINOT, NO. DAK.

Drawn by: ADSHW
Approved
BISMARCK - MAY 2, 1928

Scale 1/24000 (3-A-20)

1 2 3 Miles

Fig 2

Subject to adjustment

15 plan sheet

Printed

THE MOUSE RIVER FLOOD CONTROL PROJECT

METEOROLOGICAL AND HYDRAULIC STUDIES

By Robt. E. Kennedy
State Engineer

Introduction

The Mouse River is a small sluggish Canadian stream which loops thru the northwestern part of North Dakota for about 200 miles by valley as shown on Fig. 1. The city of Minot, North Dakota, a prosperous and progressive city of perhaps 15,000 people, has built a beautiful residence section and an important business district across the rivers flood plain about a mile in width.

In so doing it has trespassed upon sacred ground. Repeatedly the river has risen to reclaim its own. The last three floods have occurred biennially since 1923. This contest with the river over this valuable territory has been a continual and irritating drain upon the city treasury. The 1927 flood cost $35,000 in cash outlay and probably an equal amount in donated labor by the citizens under quite exciting circumstances.

A preliminary report by this Department, dated October 20, 1927, recommended a flood control channel thru the city because of the absence of suitable dam sites. The cost estimate was $1,200,000. On July 19, 1928, after the river had staged another small flood that spring, Mr. L. P. Wolff, Consulting Engineer of St. Paul, Minn., with the co-operation of this Department, submitted cost estimates upon six alternate routes thru the city. The one selected by the city is estimated to cost $1,179,000. It is labeled as the Wolff Route on Figure 2. Mr. Wolff is now proceeding with plans and specifications.

Purpose of this Report

The motive of this paper is to put into report form the meteorological and hydraulic data referred to in the above mentioned preliminary report and show why a flood about fifty percent larger than the present known maximum flood of 1904 is a reasonable possibility.

Summary of Conclusions

(1) **The Snowfall—Stream Flow Relation:** Since we have 25 years of stream flow record at Minot and about 34 years of weather records on the watershed of the Mouse River the first problem is to find, if possible, a reliable relationship between the weather data and the stream flow data so the latter may be extended back to cover the 34 year period. This was done by the aid of the principles enunciated by Mr. Meyer.* The readily ascertainable factors assumed to primarily

*"Elements of Hydrology" Meyer, 2nd Ed. John Wiley & Sons, Chapter XI.

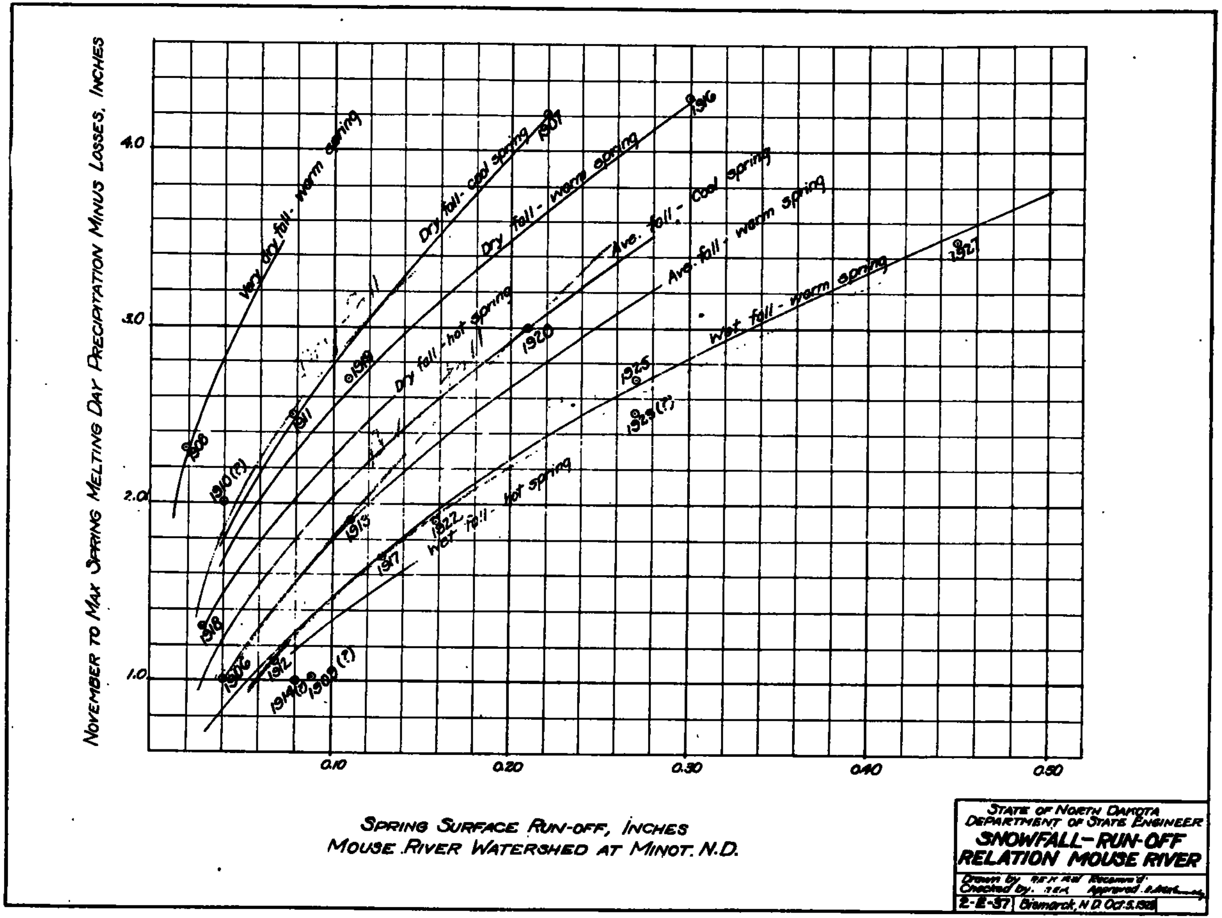

November to Max Spring Melting Day Precipitation Minus Losses, Inches
4.0
3.0
2.0
1.0
0.10
0.20
0.30
0.40
0.50
Very dry fall - warm spring
Dry fall - cool spring
Dry fall - warm spring
Dry fall - hot spring
Ave. fall - cool spring
Ave. fall - warm spring
Wet fall - warm spring
Wet fall - hot spring
1908
1910 (?)
1918
1906
1912
1914
1909 (?)
1911
1919
1913
1917
1922
1920
1925
1923 (?)
1916
1907
1927
Spring Surface Run-off, Inches
Mouse River Watershed at Minot. N.D.
State of North Dakota
Department of State Engineer
Snowfall-Run-off
Relation Mouse River
2-E-37
Bismarck, N.D. Oct. 5. 1938

Fig. 3

affect the occurrence of spring floods are (a) precipitation available in the spring, (b) degree of winter soil saturation, and (c) type of spring, whether cool or warm.

The curves resulting from these computations, see Figure 3, provide the means of determining roughly this desired snowfall-run-off relation. The stream flow record was thus lengthened about 40%. The curves will be of technical interest in showing how closely they will predict future flows.

(See pages 21 to 35.)

(2) **Probability of Maximum Flood:** When these floods are arranged in descending order of magnitude and plotted on logarithmic paper a curve becomes apparent which may be extended into the upper reaches of great size and rare frequency. The upper limit of the curve is determined by the following considerations.

(See pages 35 and 36.)

(a) **Geographical Limitation:** An inspection of the maps of mean annual rainfall, of the maximum recorded storms, and of the maximum recorded floods over the eastern half of the United States emphasizes the obvious conclusion that a Florida flood will not occur in North Dakota under the present geological status. There is a rough limit to Nature's ability to collect moisture upon the Mouse River watershed.

(See page 37.)

(b) **Frequency of Maximum Flood:** Two of the primary factors causing floods, namely, soil and spring conditions, are propitious for a flood about once in every three years if the moisture is available. The maximum amount of moisture is estimated to be ten inches and to occur about once in not less than 100 years. The chance of these three factors occurring the same year is therefor about once in 300 years. Using that frequency as the upper limit on the curve the corresponding run-off is 1.5 cubic feet per second per square mile of drainage area, or about 18,000 cubic feet per second.

(See page 37.)

(c) **Comparison with neighboring River Systems:** Of the five river systems surrounding the Mouse River watershed the Red River of the North has the largest rainfall and the longest record,—nearly fifty years. A fifty percent increase of its maximum recorded flood used as a basis of comparison produces a roughly computed maximum flood that exceeds by much more than fifty percent the known and recorded maximum flood at practically all of the twenty-four stations on these five watersheds.

(See pages 39 to 40.)

(d) **Rainfall cycles:** The present data have been taken from what may prove to be a dry section of the rainfall cycle which is known to go in great irregular oscillations of, say, fifty to seventy-five years between peaks with smaller erratic cycles within them. Mr. John R. Freeman after making a study of the fluctuations of the levels of the Great Lakes in 1925 predicted a rise due to a return of greater annual rainfall which seems to be working out as he predicted. A longer

record which included a wet section of the rainfall cycle would probably show the frequency of the maximum flood to be much less than once in 300 years. In any event, we have no way of telling when Nature began counting her time. Its occurrence is inevitable. Procrastination is dangerous.

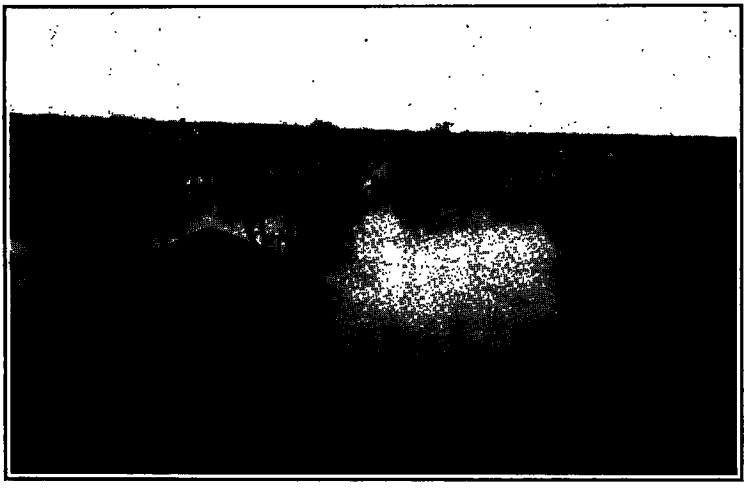
(See page 41.)

(3) **Hydraulic Computations at Minot:** Computations based upon values of Kutter's "n" as determined from the 1927 flood indicate that the city in reclaiming the river bottoms has contributed to the flood hazard by encroaching upon the river's right of way. The top width of the channel is 30% less and the depth 1.5 feet more thru the city than thru the country section below. A repetition of the 1904 flood would reach a foot higher than it did in 1904 and an 18,000 second-foot flood would rise four feet higher than the 1927 stage.

(See pages 40 to 46.)

(4) **Flood Damages:** If Minot had been a city of its present size in 1882 and experienced the ten subsequent floods they probably would have cost on an average of about $25,000 a year. This is a continual outlay with no respite in sight. Temporary diking is not a solution. There is no protection worthy of the name that does not include the maximum probable flood.

(See pages 46 to 47.)



Looking up the Mouse River from the Second Street Viaduct, Minot, N. Dak., April 27th, 1927.

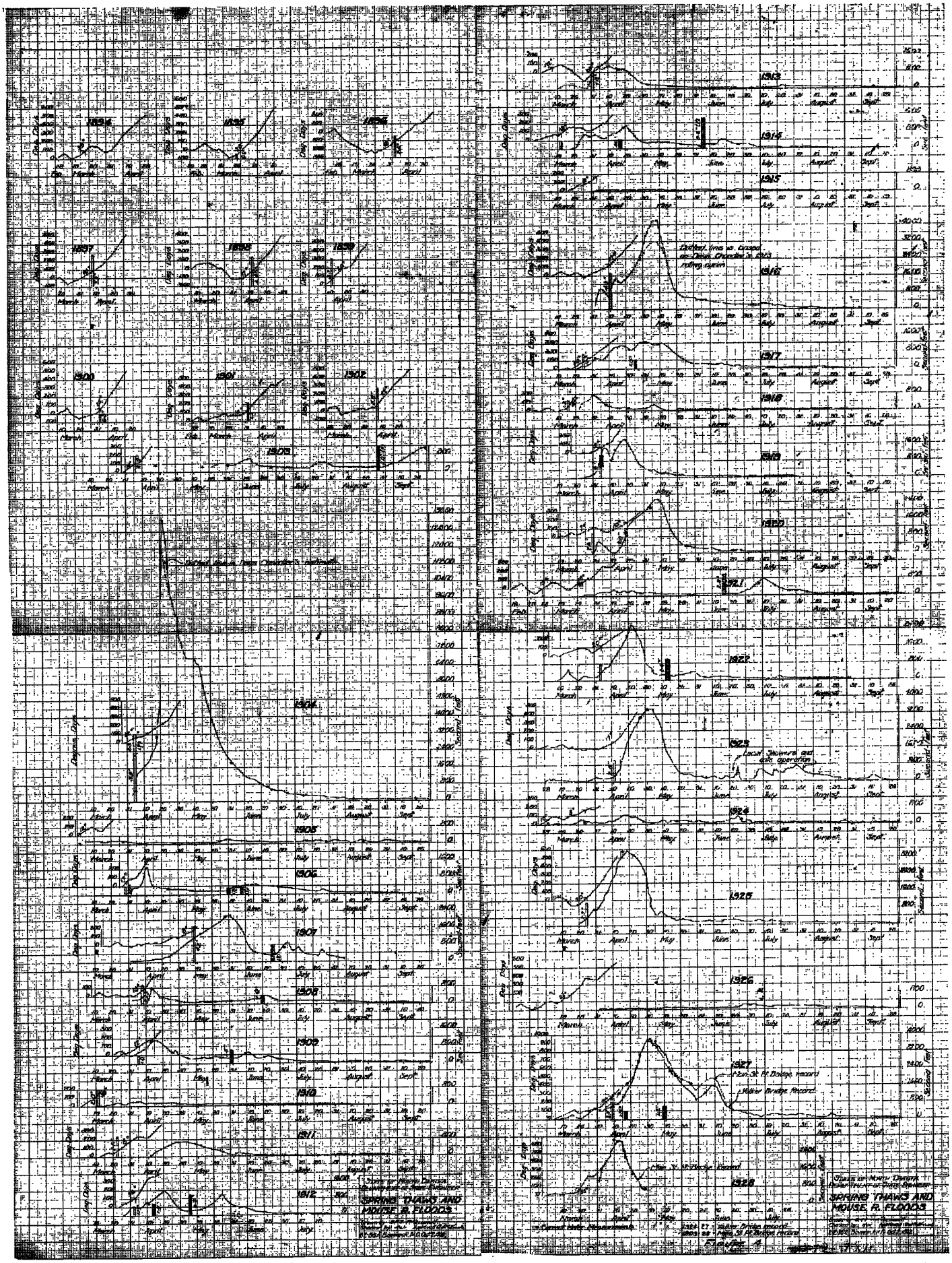
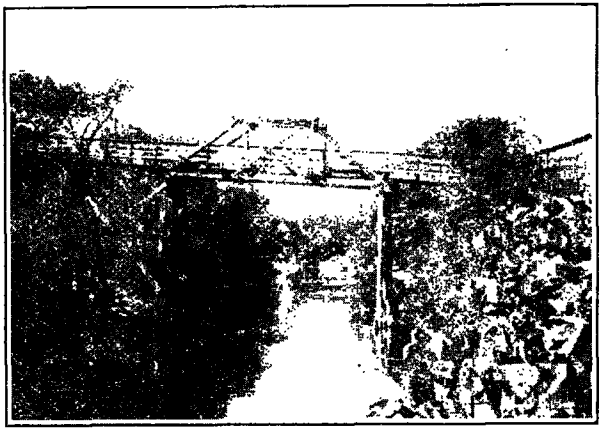


Fig. 4. Mouse River Hydrographs, Spring Temperature Curves, and Precipitation.

(5) **Miscellaneous Problems:** Opportunity is afforded to discuss three mooted questions, (a) the effect of the Park Board Dam upon flood stages through the city, (b) the effect of land drainage in Canada upon flood stages here, both of which are shown to be negligable, and (c) the extent to which flood prediction is feasible, which is shown to be limited to general quantities as to amount and about three weeks as to time.

(See pages 47 to 51.)



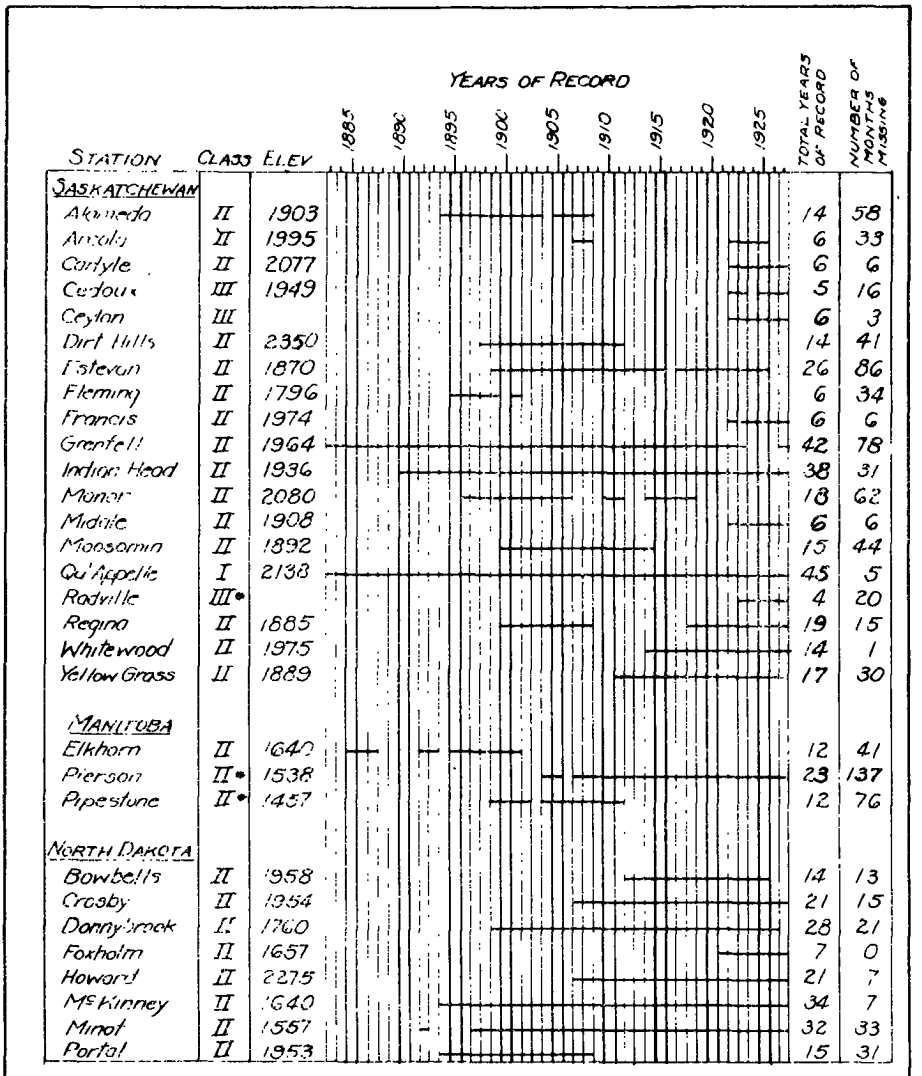
The Mouse River at low stage. The Main Street Foot Bridge Gaging Station, August 1927.

METEOROLOGICAL AND HYDRAULIC STUDIES

The Snowfall—Stream Flow Relation

We can merely hope to isolate some of the more readily determinate factors which cause floods on the Mouse River, trusting that the many indeterminate and unknown factors will in the main counterbalance each other. The results indicate that they usually do, altho sometimes, instead, they combine together against us and overbalance the factors upon which we depend.

We may state with assurance, however, from an inspection of the hydrographs given in Figure 4 that all floods of any size in the 25 years of record have come invariably from the melting of winter snows. Summer floods are rare and of nominal amount. Judging from the probability curve of rainstorm floods, Figure 7, the maximum rain water crest will never exceed 1800 to 2000 second-feet which is the bank full capacity of the stream at Minot. The topography is exceedingly flat. Evaporation and transpiration consume practically all the summer precipitation. The annual run-off averages only 1.3% of the precipitation, see Table 3.



CLASSIFICATION

I = Government Weather Bureau Station
II = Cooperative Weather Bureau Station
III = Precipitation Station
* Record for Summer months only

STATE OF NORTH DAKOTA
DEPARTMENT OF STATE ENGINEER

CHART OF WEATHER STATIONS MOUSE R. FLOOD STUDIES

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2-D-2 Bismarck, N.D. May 24, 1928

TABLE I

TABLE 2-AVERAGE PRECIPITATION MOUSE RIVER BASIN FROM SELECTED STATIONS

	JAN		FEB		MARCH		APRIL		MAY		JUNE		JULY		AUG		SEPT		OCT		NOV		DEC		TOTAL
	AVE	DEP	AVE	DEP	AVE	DEP	AVE	DEP	AVE	DEP	AVE	DEP	AVE	DEP	AVE	DEP	AVE	DEP	AVE	DEP	AVE	DEP	AVE	DEP	
1894	.67	+0.03	.37	-0.20	.81	-0.13	2.03	+0.86	1.22	-0.83	3.08	-0.31	.46	-1.88	1.20	-0.75	1.67	0.00	1.32	+0.32	.56	-0.26	.33	-0.26	13.72
1895	.57	-0.07	.34	-0.23	.06	-0.88	.99	-0.18	2.28	+0.23	3.11	-0.28	4.19	+1.85	1.86	-0.59	1.19	-0.48	.31	-0.69	.86	+0.04	.43	-0.16	15.69
1896	1.10	+0.46	.22	-0.35	.99	+0.05	2.12	+0.95	4.01	+1.96	4.10	+0.71	1.83	-0.51	1.05	-0.90	.99	-0.68	.25	-0.75	1.67	+0.85	.36	-0.23	18.69
1897	.31	-0.33	1.01	+0.44	.93	[illegible]	.88	-0.29	.38	-1.67	3.93	+0.54	1.76	-0.58	.72	-1.23	.27	-1.40	.43	-0.57	.86	+0.04	.58	-0.01	12.06
1898	.20	-0.44	.64	+0.07	1.88	+0.94	.86	-0.31	.51	-1.54	3.49	+0.10	2.28	-0.06	2.11	+0.16	2.25	+0.58	2.06	+1.06	.59	-0.23	.13	-0.46	17.00
1899	.67	+0.03	.10	-0.47	1.67	+0.73	.47	-0.70	2.72	+0.67	3.42	+0.03	1.61	-0.73	1.50	-0.45	.65	-1.02	2.07	+1.07	.24	-0.58	.47	-0.1?	15.59
1900	.21	-0.43	.92	+0.35	.75	-0.19	.36	-0.81	1.42	-0.63	.78	-2.61	2.43	+0.09	3.54	+1.59	3.34	+1.67	1.27	+0.27	1.11	+0.29	.33	-0.26	16.46
1901	1.27	+0.63	.72	+0.15	.54	-0.40	1.70	+0.53	.52	-1.53	5.50	+2.11	4.31	+1.97	1.36	-0.59	3.54	+1.87	.44	-0.50	.16	-0.66	.72	+0.13	20.78
1902	.32	-0.32	1.92	+1.35	2.13	+1.19	.76	-0.41	3.80	+1.75	4.77	+1.38	1.80	-0.44	1.88	-0.07	.35	-1.32	.47	-0.53	.72	-0.10	.91	+0.32	19.93
1903	.49	-0.15	.41	0.16	.63	-0.31	.83	-0.34	4.08	+2.03	2.20	-1.19	2.94	+0.60	5.60	+3.65	1.42	-0.25	.42	0.52	.63	-0.19	.82	+0.23	20.47
1904	.72	+0.08	1.46	+0.89	3.04	+2.10	.52	-0.65	1.40	-0.65	2.72	-0.67	2.24	-0.10	1.44	-0.51	2.07	+0.40	.71	-0.29	.28	-0.54	.67	+0.08	17.27
1905	.36	-0.28	.44	-0.13	.40	-0.54	.45	-0.72	2.95	+0.90	3.54	+0.15	3.40	+1.06	2.39	+0.44	2.98	+1.31	.53	-0.47	1.02	+0.20	.43	-0.16	18.89
1906	.95	+0.31	.20	-0.37	.19	-0.75	1.62	+0.45	2.87	+0.82	5.78	+2.39	.94	-1.40	1.24	-0.71	.73	+0.06	0.47	+0.53	2.05	+1.23	1.73	+1.14	21.06
1907	.95	+0.31	.25	-0.32	1.16	+0.22	.86	-0.29	.65	-1.40	3.25	-0.14	2.22	-0.12	2.88	+0.93	.82	-0.85	.13	-0.87	.16	-0.66	.76	+0.17	14.11
1908	.20	-0.44	1.03	+0.46	1.49	+0.55	1.54	+0.37	1.83	-0.22	4.38	+0.99	1.35	-0.99	2.31	+0.36	1.32	-0.35	1.54	+0.54	.93	+0.11	.46	-0.13	18.38
1909	.65	+0.01	.47	-0.10	.48	-0.46	1.57	+0.40	3.74	+1.69	1.38	-2.01	5.04	+2.70	1.77	-0.18	1.16	-0.51	.57	-0.43	.92	+0.10	1.29	+0.70	19.04
1910	.25	-0.39	.50	0.07	2.31	+1.37	1.09	-0.08	2.61	+0.56	3.40	+0.01	1.52	-0.82	1.89	-0.06	.64	-1.03	.38	-0.62	1.34	+0.52	.82	+0.23	[illegible]
1911	.97	+0.33	.54	-0.03	.28	-0.66	.40	-0.77	2.82	+0.77	2.49	-0.90	2.56	+0.22	2.94	+0.99	2.27	+0.60	1.64	+0.64	.77	-0.05	[illegible]	[illegible]	[illegible]
1912	.30	-0.34	.13	-0.44	.42	-0.52	1.55	+0.38	4.61	+2.56	1.07	-2.32	3.10	[illegible]	[illegible]	+0.24	2.58	+0.91	.74	-0.26	[illegible]	[illegible]	.55	-0.26	17.62
1913	.77	+0.13	.48	-0.09	.85	0.03	.45	-0.72	1.72	-0.33	3.88	+0.49	2.18	-0.16	3.02	+1.07	1.32	-0.35	1.08	+0.08	.57	[illegible]	.92	0.57	[illegible]
1914	1.09	+0.45	.23	-0.34	.76	-0.18	1.11	-0.06	1.98	-0.07	4.30	+0.91	2.74	+0.40	1.91	-0.04	.74	-0.93	.82	-0.18	.67	0.15	.26	[illegible]	[illegible]
1915	.31	-0.33	.23	-0.29	.16	-0.78	.45	-0.72	2.12	+0.07	2.96	-0.43	3.45	+1.11	.74	-1.21	2.23	+0.56	.31	-0.69	1.64	+0.82	.71	+0.12	15.69
1916	1.49	+0.85	.52	0.01	1.49	+0.55	1.28	+0.11	1.74	-0.31	3.60	+0.21	1.22	-1.12	2.09	+0.14	2.55	+0.88	1.49	+0.49	.54	-0.28	.61	-0.02	15.76
1917	.85	+0.21	.75	+0.18	.61	-0.33	1.88	+0.71	.20	-1.85	1.97	-1.42	1.48	-0.86	1.39	-0.56	.91	-0.76	[illegible]	+0.40	.12	-0.70	.94	+0.35	12.50
1918	.54	[illegible]	.30	-0.27	.62	-0.32	1.96	+0.79	1.36	-0.69	1.08	2.31	1.63	-0.71	3.08	+1.13	.51	-1.16	.61	-0.39	.70	-0.12	.83	+0.24	13.22
1919	.30	0.34	.76	+0.19	.62	-0.32	1.74	+0.57	1.87	-0.18	2.53	-0.86	2.06	-0.28	.90	-1.05	1.12	-0.55	1.49	+0.49	.88	+0.06	.47	-0.12	14.74
1920	[illegible]	+0.51	.31	-0.26	1.10	+0.16	.75	-0.42	1.68	-0.37	3.40	+0.10	2.34	0.00	1.47	-0.48	1.76	+0.09	1.14	+0.14	.34	-0.48	.26	-0.33	15.79
1921	.23	-0.41	.49	-0.08	.84	-0.10	1.83	+0.66	2.40	+0.35	5.32	+1.93	[illegible]	[illegible]	[illegible]	[illegible]	3.16	+1.49	.75	-0.25	1.27	+0.45	.21	-0.38	21.18
1922	.41	-0.23	.68	+0.11	.90	-0.04	1.43	+0.26	3.43	+1.38	3.50	+0.11	2.30	-0.04	2.01	+0.06	1.55	-0.2	.87	[illegible]	[illegible]	[illegible]	[illegible]	+0.12	[illegible]
1923	.77	+0.13	.79	+0.22	.75	-0.19	1.84	+0.67	1.19	-0.86	5.66	+2.27	3.81	+1.47	1.36	-0.59	1.57	-0.10	.82	-0.18	1.02	+0.20	.38	-0.21	19.96
1924	.53	-0.11	.46	-0.11	.55	-0.39	1.65	+0.48	.41	-1.64	3.86	+0.47	1.49	-0.85	2.25	+0.30	1.00	-0.67	2.68	+1.68	.85	+0.03	1.02	+0.43	16.75
1925	1.04	+0.40	.45	-0.12	1.16	+0.22	1.03	-0.14	.86	-1.19	4.09	+0.70	1.57	-0.77	.77	-1.12	3.03	+1.36	1.01	+0.01	.43	-0.39	.21	-0.38	15.65
1926	.47	-0.17	.68	+0.11	.43	-0.51	.57	-0.60	2.34	+0.29	3.38	-0.01	1.71	-0.63	2.20	+0.25	2.34	+0.67	1.49	+0.49	1.37	+0.55	.44	-0.15	17.42
1927	.42	-0.22	.69	+0.12	1.39	+0.45	.96	-0.21	3.07	+1.02	1.59	-1.80													
MEAN	0.64		0.57		0.94		1.17		2.05		3.39		2.34		1.95		1.67		1.00		0.82		0.59		17.11

The three readily ascertainable factors which are taken to be the primary causes of floods on the Mouse River are:

(1) Precipitation available on the watershed after deducting the principal winter losses.

(2) Degree of winter soil saturation as judged by fall conditions just prior to winter freeze up.

(3) Type of spring weather, whether cool and hence slow, or warm and hence fast in melting the snow.

Precipitation Available: The monthly precipitation for the watershed was obtained from the monthly record of the most pertinent stations, see Table 1 and Fig. 1. Table 2 gives the result with departure from the normal. Temperature records, Table 4, were taken from the North Dakota weather stations along the border because of their accessibility in the U. S. Weather Bureau at Bismarck, N. Dak. Comparison with selected stations over the watershed, Table 5, indicates that the spring melting temperatures are practically the same. Figure 5 shows graphically the data in Tables 2 and 4.

The major winter loss is evaporation. It was obtained by entering the curve given by Meyer* entitled "Evaporation from Water, Ice and Snow" with the monthly temperature from Table 4 and deducting the corresponding evaporation from the monthly precipitation in Table 2 beginning with November and ending with the probable maximum melting day in the spring. Snow on the ground during months of no precipitation sustained the same losses. The net sum at the end of the winter was the precipitation available for spring run-off.

Degree of Soil Saturation: Snow water must first go down to fill the soil if it is not already filled before the remainder can run-off. November rains are rare, but were considered. October rains primarily determine winter soil condition, September and August to a much more remote degree. Five general degrees of soil saturation were arbitrarily assumed and only generally followed. They are labeled with words rather than inches and are given at the bottom of Table 6. The results are found in column 2 of the table. The type of fall was usually quite apparent. The four erratic years in Figure 3 could not be reconciled with any reasonable digression from the assumptions.

Type of Spring Weather: The size of flood is materially influenced by the character of spring weather. It will be noticed that the 1928 flood was due almost entirely to the four unusually hot melting days of March 19-22. The amount of water actually contained in the total flow was about 10% less than that of the remarkably cool spring of 1907 but the peak flood was about 40% greater.

*Ibid, Page 235.

TABLE 3—RUN-OFF IN INCHES OVER WATERSHED OF MOUSE RIVER AT MINOT, N. D.

	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Jan.	.....	0.002	0.004	0.003	0.002	0.001	0.001	.....	.....	.....	.....	.....	.....
Feb.	.....	0.002	0.003	0.002	0.001	0.001	0.001	.....	.....	.....	.....	.....	.....
Mar.	.....	0.002	0.009	0.003	0.002	0.001	0.016	0.013	0.004	0.005	0.006	0.019	.....
Apr.	.....	0.483	0.006	0.045	0.018	0.031	0.072	0.017	0.034	0.069	0.079	0.064	0.002
May	0.026	0.496	0.007	0.016	0.154	0.014	0.030	0.011	0.046	0.052	0.015	0.023	0.002
June	0.032	0.080	0.010	0.040	0.081	0.024	0.032	0.005	0.014	0.024	0.005	0.026	0.002
July	0.028	0.028	0.008	0.022	0.048	0.013	0.008	0.002	0.004	0.007	0.008	0.005	0.002
Aug.	0.019	0.013	0.007	0.006	0.011	0.010	0.004	.....	0.002	0.001	0.009	.....	0.001
Sept.	0.069	0.008	0.003	0.003	0.004	0.006	0.001	.....	.....	0.003	0.002	.....	0.001
Oct.	0.030	0.007	0.002	0.002	0.002	0.002	.....	.....	.....	0.005	.....	.....	.....
Nov.	0.016	0.005	0.003	0.002	0.002	0.003	.....	.....	0.001	0.004	0.002	.....	.....
Dec.	0.008	0.004	0.002	0.002	0.001	0.002	.....	.....	.....	0.001	0.002	.....	.....
Total Run-off	0.227	1.130	0.064	0.146	0.326	0.108	0.165	0.048	0.105	0.171	0.128	0.137	0.010
Total Precipn	.....	17.2	18.9	.....	15.1	18.4	19.0	16.8	18.0	17.8	16.4	16.6	15.7

	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	Means
Jan.	.....	0.001	.....	0.001	.....	.....	0.001	.....	0.001	0.002	0.002	.....	0.001
Feb.	.....	.....	.....	.....	.....	.....	0.001	.....	.....	0.001	.....	.....	.....
Mar.	.....	0.008	0.027	0.002	0.001	0.003	0.017	0.009	0.011	0.012	0.002	0.018	0.007
Apr.	0.143	0.090	0.025	0.119	0.086	0.018	0.141	0.140	0.026	0.238	0.006	0.154	0.088
May	0.205	0.082	0.011	0.020	0.125	0.006	0.032	0.138	0.016	0.032	0.007	0.223	0.071
June	0.033	0.019	0.002	0.003	0.013	0.005	0.013	0.023	0.014	0.013	0.009	0.080	0.024
July	0.021	0.007	.....	0.001	0.004	0.039	0.005	0.050	0.008	0.006	0.015	0.020	0.014
Aug.	0.006	0.001	.....	.....	0.001	0.005	0.002	0.026	0.003	0.001	0.008	0.012	0.006
Sept.	0.003	.....	0.001	.....	0.001	0.002	0.001	0.007	0.001	0.004	0.005	0.011	0.005
Oct.	0.003	.....	0.002	.....	0.001	0.001	.....	0.002	0.001	0.003	0.004	0.004	0.003
Nov.	0.003	0.003	0.002	.....	0.001	0.001	.....	0.001	0.003	0.003	0.002	0.002	0.002
Dec.	0.002	0.002	0.002	.....	0.001	0.001	.....	0.001	0.002	0.007	0.002	0.002	0.002
Total Run-off	0.419	0.213	0.072	0.146	0.234	0.081	0.213	0.397	0.089	0.325	0.062	0.526	0.223
Total Precipn.	18.8	12.5	13.2	14.7	15.8	21.2	19.3	20.0	16.8	15.6	17.4	.....	17.1

TABLE 4 - MONTHLY MEAN TEMPERATURES
PORTAL AND CROSBY

	JAN		FEB		MARCH		APRIL		MAY		JUNE		JULY		AUG.		SEPT.		OCT.		NOV.		DEC.	
	Mean	Dep	Mean	Dep	Mean	Dep	Mean	Dep	Mean	Dep	Mean	Dep	Mean	Dep	Mean	Dep	Mean	Dep	Mean	Dep.	Mean	Dep.	Mean	Dep.
1894	-0.5	-5.3	25.3	+17.6	4.3	+1.0	45.9	+5.4	55.3	+7.0	69.4	+8.1	72.0	+5.6	70.3	+6.1	52.6	-1.2	39.9	-2.0	21.8	-3.1	14.0	-5.1
1895	-4.8	-9.6	5.0	-2.7	21.4	+1.1	49.6	+3.1	51.5	-0.3	58.8	-2.5	67.7	+1.3	69.1	-1.1	52.3	-1.5	40.0	-1.9	17.0	-7.9	10.4	1.1
1896	2.0	-2.8	12.6	+4.9	4.8	-5.5	38.3	-2.2	54.5	+2.2	66.4	+5.1	63.9	+3.5	65.4	+1.2	50.2	-3.6	39.8	-2.1	3.8	-21.1	13.2	+1.1
1897	2.9	-1.9	3.6	-4.1	5.8	-19.5	40.4	-0.1	57.8	+5.5	59.9	-1.9	66.5	+0.1	63.2	-1.0	61.0	+7.2	43.4	+1.5	14.4	-10.5	9.6	1.3
1898	12.5	+7.7	9.2	+1.5	14.0	-6.3	37.6	-2.9	50.7	-1.6	59.8	-1.5	65.8	-0.6	64.0	-0.2	53.9	+0.1	35.2	-6.7	18.8	-6.1	13.8	+2.3
1899	1.9	-3.4	0.1	-7.6	5.2	-15.1	34.0	-6.5	46.6	-5.7	59.7	-1.6	65.7	-0.7	62.9	-1.8	53.1	-0.1	38.5	-3.4	37.0	+21	13.8	+2.3
1900	14.4	+3.0	0.0	-7.7	17.7	-2.6	48.8	+8.3	58.6	+6.3	64.9	+3.6	66.6	+0.2	65.4	+1.2	50.1	-3.1	45.6	+3.7	17.8	-7.1	16.2	-4.7
1901	5.0	+0.2	5.9	-1.8	23.6	+3.3	41.2	+0.1	62.7	+10.4	59.5	-1.9	68.4	+2.0	61.2	-3.0	49.6	-4.7	46.6	+4.7	27.3	+2.4	12.8	+1.5
1902	12.0	+7.2	7.4	-0.3	21.8	+1.5	38.0	-2.5	51.7	-0.6	54.4	-1.9	63.0	-3.4	63.8	-0.4	51.6	-2.2	42.0	+0.1	24.7	-0.2	1.6	-9.3
1903	1.2	+2.4	-0.9	-8.6	12.0	-8.3	40.2	-0.3	49.2	-3.1	59.2	-2.1	62.3	-4.1	59.4	-4.8	46.4	-7.4	44.6	+2.7	22.0	-2.9	14.2	+2.7
1904	3.7	-1.1	-7.0	-14.7	11.1	-9.6	37.8	-2.7	54.4	+2.1	60.4	-0.3	62.5	-3.9	60.2	-4.0	51.6	-2.2	42.8	+1.3	34.0	+9.1	13.2	+1.1
1905	0.4	-4.4	5.8	-1.9	31.8	+11.5	37.6	-2.9	47.4	-4.9	57.0	-4.3	62.1	-4.3	68.0	+3.8	54.7	+0.9	37.0	-4.9	29.3	+4.1	15.6	+4.1
1906	9.0	+3.2	6.4	-1.3	12.2	-8.1	47.2	+6.7	49.4	-2.9	60.0	-1.3	65.9	-0.5	64.5	+0.3	58.3	+4.5	44.0	+2.1	23.1	-1.8	6.4	-5.1
1907	-10.6	-15.4	7.8	+0.1	16.1	-4.2	27.0	-13.5	40.5	-11.8	57.8	-3.5	61.8	-4.6	60.8	-3.4	48.4	-5.4	41.1	-0.8	29.0	+4.1	17.8	+6.3
1908	15.1	+10.3	12.3	+4.6	17.7	-2.6	41.5	+1.0	49.1	-3.2	59.3	-2.0	66.9	+0.5	61.5	-2.7	57.8	+4.0	40.3	-1.6	31.0	+6.1	16.4	+4.9
1909	1.2	-5.6	8.0	+0.3	22.8	+2.5	31.4	-9.1	49.2	-3.1	60.8	-0.5	67.6	+1.2	67.6	+3.4	60.0	+6.2	41.6	-0.3	26.1	+1.2	5.0	-6.5
1910	10.2	-5.3	2.8	-4.9	10.2	+1.9	48.0	+7.5	49.5	-2.8	64.6	+3.3	67.5	+1.1	60.2	-4.0	53.4	-0.4	45.7	+3.8	22.0	-2.9	10.4	-1.1
1911	-3.8	-8.6	5.1	-2.6	27.8	+7.5	40.0	-0.5	53.3	+1.0	63.5	+2.2	62.4	-4.0	60.3	-3.9	51.8	-2.0	40.8	-1.1	14.7	-10.2	13.2	+1.7
1912	-4.0	-8.8	9.6	+1.9	9.6	-0.7	42.4	+1.9	52.0	-0.3	61.5	+0.2	62.4	-4.0	61.4	-2.8	48.9	-4.9	42.5	+0.4	32.8	+7.9	18.6	+7.0
1913	0.0	-4.8	7.8	+0.1	17.4	-2.9	45.8	+5.3	48.8	-3.5	67.4	+6.1	63.0	-3.4	69.8	+5.6	55.0	+1.2	31.0	-4.9	31.4	+6.5	20.6	+9.1
1914	13.7	+8.9	0.5	-7.2	25.0	+4.7	41.4	+0.9	57.1	+5.4	61.2	-0.1	71.2	+4.8	64.3	+0.1	55.4	+1.6	41.0	+5.1	30.4	+5.5	12.1	+0.6
1915	5.8	+1.0	15.9	+8.2	22.4	+2.1	49.5	+9.0	52.2	+0.1	56.2	-5.1	60.8	-5.6	61.0	+2.8	51.6	-2.2	46.4	+4.5	26.2	+1.5	15.3	+3.8
1916	-12.2	-17.0	1.1	-6.6	13.5	-6.8	36.2	-4.3	48.6	-3.1	55.8	-5.5	69.4	+3.0	63.4	-0.8	52.0	-1.8	38.4	-3.5	25.0	+0.1	3.2	-11.3
1917	2.3	-2.5	0.2	-7.5	24.4	+4.1	39.6	-0.9	53.9	+1.0	59.8	-1.5	69.8	+3.1	63.8	-0.4	55.0	+1.2	33.8	-8.1	37.2	+12.3	0.5	-11.0
1918	-0.8	-5.6	10.6	+2.9	36.2	+15.9	40.8	+0.3	49.2	-3.1	63.1	+1.8	65.1	-1.3	64.2	0.0	51.0	-2.8	45.0	+3.1	27.0	+2.1	13.4	+7.9
1919	19.5	+17.7	4.8	-2.9	14.3	-6.0	42.1	+1.6	55.4	+3.1	68.4	+7.1	68.8	+2.4	66.4	+2.2	56.1	+2.3	31.2	-10.7	13.5	-11.4	7.5	-4.0
1920	2.6	-2.2	13.3	+5.6	13.4	-0.9	31.4	-9.1	53.0	+0.7	61.8	+0.5	69.4	+3.0	68.9	+4.6	57.4	+3.6	46.6	+4.7	27.1	+2.2	16.5	+5.2
1921	16.0	+11.2	18.7	+11.0	24.6	+4.3	37.7	-2.8	51.8	-0.5	66.7	+5.4	67.5	+1.1	65.6	+1.4	56.4	+2.6	47.6	+5.7	22.6	-2.3	17.9	+6.4
1922	6.7	+1.9	-1.8	-9.5	23.9	+3.6	40.5	0.0	55.2	+2.9	64.2	+2.9	65.3	-1.1	67.7	+3.5	53.4	+5.6	44.6	+2.7	30.6	+5.7	4.4	-7.1
1923	8.6	+3.8	2.8	-4.9	18.7	-1.6	38.5	-2.0	53.2	+0.9	65.5	+4.2	70.2	+3.8	63.8	-0.4	58.8	+5.0	42.7	+0.8	35.8	+10.9	13.9	+8.4
1924	1.4	-3.4	22.0	+14.3	25.8	+5.5	38.0	-2.5	47.4	-4.9	58.0	-3.3	65.4	-1.0	62.4	-1.8	55.4	+1.6	48.8	+6.3	24.8	-0.1	0.2	-11.3
1925	3.0	-1.8	14.0	+6.3	22.4	+2.1	45.8	+5.3	54.2	+1.9	58.8	-2.5	67.6	+1.2	66.0	+1.8	55.6	+1.8	33.2	-8.7	28.5	+3.6	17.5	+6.0
1926	17.5	+12.7	24.4	+16.7	27.4	+7.1	44.0	+3.5	57.8	+5.5	60.2	-1.1	70.5	+4.1	64.5	+0.3	50.4	-3.4	43.0	+1.1	13.6	-5.3	5.8	-5.7
1927	5.5	+0.7	8.7	+1.0	28.1	+7.8	40.2	-0.3	57.8	+5.5	61.1	-0.2	65.0	-1.4	62.6	-1.6	54.1	+0.3	46.8	+4.9	19.0	-5.9	-4.3	-15.8
MEAN	2.8		7.7		20.3		40.5		52.3		61.3		66.4		64.2		53.8		41.9		24.9		11.5	

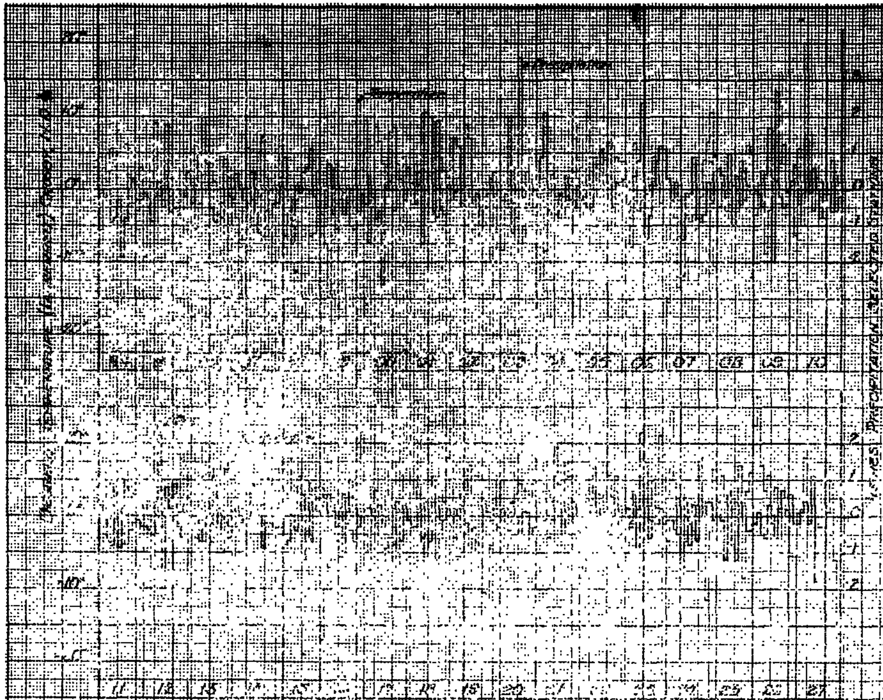
TABLE 5

TEMPERATURE CONDITIONS AT SELECTED STATIONS ON MOUSE RIVER WATERSHED TO COMPARE AVERAGE WITH CROSBY, N. D.

Station	Elevation, Sea Level Datum	Years of Record	Mean Annual Temperature Total Record	Mean Annual Temperature 1920-26	Mean Monthly Temperature Nov-Apr. 1920-27	Ave. No. Melting Days Nov-Apr. 1920-27	Ave. Temp. of Melting Days Nov-Apr. 1920-27
Qu Appelle, Sask.	2,115	(45 yrs.)	34.6°	36.3°	17.5°	12.9	40.5°
Yellow Grass, Sask.	1,889	(17 yrs.)	36.2°	37.3°	18.3°	14.5	41.0°
Crosby, N. Dak.	1,951	(21 yrs.)	37.9°	**39.3°**	**20.8°**	**15.6**	**41.8°**
Minot, N. Dak.	1,750*	(32 yrs.)	38.9°	38.9°	21.5°	17.6	43.0°
Average	1,927		36.9°	38.0°	19.5°	15.1	41.6°

*This is general elevation of the plain back from the river valley.

Elevation of Minot is given in Weather Bulletins as 1557 which is elevation of G. N. Depot in river bottom. Weather station is located in river bottom at approximately same elevation.



	Normal Monthly Temperature at Crosby, N.Dak.*	Average Precipitation Selected Sta.
January	4.5°	0.54
February	7.7°	0.57
March	20.3°	0.94
April	40.5°	1.77
May	52.5°	2.05
June	61.9°	3.39
July	66.4°	2.34
August	63.2°	1.85
September	52.1°	1.67
October	41.4°	1.30
November	23.5°	0.82
December	11.5°	0.59
Annual	37.5°	17.11

STATIONS USED FOR SELECTED PRECIPITATION AVERAGES

Bowbells, N.D.	[illegible], Sask.	Indian Head, Sask.
[illegible], N.D.	Portal, N.D.	Qu'Appelle, Sask.
Foxholm, N.D.	Alameda, Sask.	Whitewood, Sask.
McKinney, N.D.	Ardill, Sask.	Old Wives, Sask.
Minot, N.D.	Carlyle, Sask.	[illegible], Sask.
Crosby, N.D.	Minton, Sask.	[illegible], Sask.
Estevan, Sask.	Grenfell, Sask.	Yellow Grass, Sask.

* Crosby N.D. 1933 record
Portal N.D. 1894–1901

STATE OF NORTH DAKOTA
DEPARTMENT OF STATE ENGINEER
DEPARTURE FROM NORMAL TEMPERATURE & PRECIP'N MOUSE R. DRAINAGE
Drawn by: F.W.K. Recommend:
Checked by: Approved:
2-E-30 Bismarck, N.D. May 23, 1933

Fig. 5

TABLE NO. 6

WINTER PRECIPITATION AND SPRING RUN-OFF DATA MOUSE RIVER WATERSHED AREA 10,270 SQUARE MILES*

Year	Prev. Fall Soil condition	SNOW			RAIN		RECORDED RUN-OFF MINOT, N. D.					Remarks
		Probable max. melting day at Crosby, N. D.	Precipn. Available	Tye of Spring	Dates	Roughly estd. amt.	Total Surface Flow		Crest Discharge		Days in Transit	
							Ins.	Acre-feet	C. F. S.	Date		
1882												Large flood recalled by local residents, shown also in Red River record.
1894		Mar. 16		Int. wm.	1894-1903	taken	from curves					
1895	Ave.	Mar. 20	0.6	Int. wm.	05-'06 curve		0.03	18,000				
1896	V. dry	Apr. 3	2.6	Warm	Similar to '08		0.03	18,000				
1897	Dry	Apr. 8	3.7	Warm	'19-'16 curve		0.23	138,000	- 3,000			
1898	V. dry	Apr. 11	3.4	Warm	'08 curve		0.07	42,000				
1899	Wet	Apr. 11	3.1	Warm	'25-'27 curve		0.36	216,000	- 4,000			Evenly distrib. rains Oct. 1898
1900	Ave.	Apr. 2	0.9	Int.wm.	'05-'06 curve		0.04	24,000				Storms Oct. 11-16, 1899
1901	V. wet	Apr. 2	2.2	Int.wm.	Interpolated		0.22	132,000	- 3,000			Evenly distrib. rains Sept. 1900
1902	Wet	Apr. 8	3.8	Int.wm.	'25-'27 curve		0.52	312,000	- 5,000			
1903	Dry	Apr. 5	2.0	Warm	'19-'16 curve		0.06	30,000	336	Apr. 17	12	See hydrographs
1903					Aug. 27,	3.0	0.06	(36,000)	1,134	Sept. 24	28	
1904	Ave.	Apr. 4	5.5	Warm			1.10	660,000	- 12,000	Apr. 20	16	Heavy Aug. and Mar. precipn.
1905	Ave.	Mar. 2	0.2	Int. wm.			0.02	10,000				
1906	Ave.	Mar. 29	1.0	Warm			0.04	23,000	1,320	Apr. 10	12	
1906					May 29—	(?)	0.03	18,000	500	June 15	17	
1907	Dry	May 8	4.2	Cool			0.22	132,000	2,190	May 28	20	
1907					June 23—	(?)	0.02	12,000	886	July 3	10	
1908	V. dry	Apr. 8	2.3	Warm			0.02	15,000	644	Apr. 13	5	
1908					June 17-19	1.0	.....	3,000	407	June 19-21	2	
1909	Ave.	Apr. 5	1.0	Warm			0.09	55,000	1,090	Apr. 13	8	
1909					May 29-31	1.5	0.01	7,000	540	June 9	10	
1910	Dry	Mar. 12	2.0	Hot			0.04	24,000	207	Apr. 1	20	
1911	Dry	Mar. 23	2.5	Cool			0.08	46,000	744	Apr. 29	37	
1912	Wet	Apr. 2	1.1	Hot	Apr. 12-14	1.4	0.07	45,000	1,200	Apr. 20	18	Rain effect uncertain
1912					May 4-5	2.5	0.05	30,000	983	May 24	19	
1913	Ave.	Mar. 7	1.5	Int. wm.			0.01	6,000	250	Mar. 14	7	
1913	Ave.	Mar. 31	1.9	Int. wm.			0.10	61,000	1,080	Apr. 4	4	
1914	Ave.	Mar. 12	1.0	Int. wm.	Apr. 17-18	1.0	0.08	48,000	1,080	Apr. 20	39	Rain effect uncertain
1915	Dry	Apr. 2	....	Cool			.....	7,890	41			Max. for year

TABLE NO. 6 (Continued)

WINTER PRECIPITATION AND SPRING RUN-OFF DATA MOUSE RIVER WATERSHED AREA 10,270 SQUARE MILES*

Year	Prev. Fall Soil condition	SNOW			RAIN		RECORDER RUN-OFF MINOT, N. D.					Remarks
							Total Surface Flow		Crest Discharge			
		Probable max. melting day at Crosby, N. D.	Precipn. Available	Type of Spring	Dates	Roughly estd. amt.	Ins.	Acre-feet	C. F. S.	Date	Days in Transit	
1916	Dry	Apr. 10	4.3	Warm			.....		1,470	Apr. 13	3	Probably from Des Lacs
1916							0.30	180,000	3,140	May 5	25	
1917	Wet	Mar. 25	1.7	Warm			0.13	76,000	1,140	Apr. 16	22	
1917					Apr. 24	1.0	0.04	28,000	1,280	Apr. 29	4	Rain effect uncertain
1918	Dry	Mar. 16	1.3	Hot			0.03	18,000	790	Mar. 30	14	Storm Oct. 17-18, 1917
1919	Dry	Apr. 4	1.4	Warm	Apr. 5-6	1.3	0.11	67,000	1,860	Apr. 18	14	Aug. 1918 evenly distrib. excess
1920	Ave.	Mar. 30	2.5	Cool			0.01	6,000	606	Apr.1	2	Last decade Oct. 1919 stormy
1920	Ave.	Apr. 19	2.4	Cool	Apr. 20-1	0.6	0.20	120,000	2,560	May 5	16	
1921	Ave.	Mar. 23		Int. wm.			0.02	11,000	215	Apr. 21	29	
1921					June 14-17	2.5	0.04	25,000	790	July 10	23	
1922	Wet	Apr. 3	1.9	Int. wm.			0.16	96,000	2,570	Apr. 21	18	First half Sept. 21 wet.
1922					May 11-14	2.0	0.01	6,000	375	May 25	11	
1923	Ave.	Apr. 11	2.5	Warm			0.27	160,000	3,460	Apr. 30	19	
1924	Ave.	Mar. 24	0.3	Cool			0.03	21,000	472	Apr. 17	24	
1925	Wet	Mar. 25	2.7	Warm			0.27	160,000	3,450	Apr. 18	24	1½ in. rain Oct. 11-12, 1924.
1926	Wet	Mar. 15	....	Int. wm.			.....					
1927	Wet	Apr. 8	2.5	Int. wm.	Apr. 16-17	1.0	0.45	270,000	3,770	Apr. 30	22	*Drainage area impossible to measure accurately because of exceedingly flat topography, measurements made vary from 10,130 to 11,300 sq. mi., the latter being used in these computations.
1927					May 8-10	1.5	0.04	24,000	1,910	June 7	28	
1928	Wet	Mar. 19		Hot			0.20	120,000	2,900	Apr. 12	24	
1929	Dry											Conversion factor:— Acre-feet times 0.00001 / 6 equals inches.
1930	"											
1931	"											
1932												

TABLE NO. 6 (Continued)

NOTES

Previous Fall Soil Condition as Determined by Departure from Monthly Precipitation, see Table 2,

	Very dry	Dry	Ave.	Wet	Very wet
August	—1.50 in.	—1.00 in.	±0.50 in.	+1.00 in.	+1.50 in.
September	—1.00 in.	—0.75 in.	±0.30 in.	+0.75 in.	+1.00 in.
October	—0.75 in.	—0.25 in.		+0.25 in.	+0.75 in.

Type of Spring

N. B. Upward slope temp. curve is thawing, downward slope is freezing, see Fig. 4.
Cool: Slope temp. curve 5° to 10°. Ex. 1907, 1911.
Warm: Slope temp. curve 10° to 25°. Ex. 1904, 1906.
Intermittent warm: Two or more warm spells. Ex. 1913, 1921.
Hot: Slope temp. curve 25° or more. Ex. 1912, 1928.

TABLE 8

MOUSE RIVER FLOOD TRAVEL

Year	Precipitation: SNOW — Probable max. melting day at Crosby, N.D.	Precipitation: RAIN — Date	Run-off: Oxbow, Sask. 172 miles above Minot, N. D. — Date of Souris R. crest	Days in transit	Gage Ht.	Crest amt. C. F. S.	Run-off: McKinney, N. Dak. 100 miles above Minot, N. D. — Date of Mouse R. crest	Days in transit	Gage Ht.	Crest amt. C. F. S.	Run-off: Minot, N. D. — Date of Mouse R. crest	Days in transit	Gage Ht.	Crest amt. C. F. S.	Run-off: Towner, N. Dak. 122 miles below Minot, N. D. — Date of Mouse R. crest	Days in transit	Gage Ht.	Crest amt. C. F. S.
1903		Aug. 27									Sept. 24	28		1,134				
1904	Apr. 4								22.0*		Apr. 20	16	21.9	12,000				
1906	Mar. 29										Apr. 10	12		1,320				
1907	May 8										May 28	20	16.0	2,190				
1909	Apr. 5										Apr. 13	8		1,090				
1912	Apr. 2		Apr. 13	11†							Apr. 20	18		1,200				
1912		May 4-5	May 17	12		1,047					May 24	19		983				
1913	Mar. 31		Apr. 2	2							Apr. 4	4		1,080				
1914	Mar. 12	Apr. 17-18	Apr. 14								Apr. 20	39		1,080				
1916	Apr. 10		Apr. 24	14		1,674					May 5	25	19.05	3,140				
1925	Mar. 25										Apr. 16	22		1,140				
1919	Apr. 4										Apr. 18	14		1,860				
1920	Apr. 19										May 5	16	17.1	2,560				
1921		June 14-17									July 10	23		790				
1922	Apr. 3										Apr. 21	18	17.1	2,570				
1923	Apr. 11						Apr. 25	14			Apr. 30	19	19.6	3,460				
1925	Mar. 25										Apr. 18	24	19.6	3,450				
1927	Apr. 8	Apr. 16-17	Apr. 18 (?)	10	17.3		Apr. 21	13	18.4	4,500e	Apr. 30	22	20.17	3,770	May 15	37	7.9	1,600e
1927		May 8-10									June 7	28		1,910				
1928	Mar. 19		Mar. 28	9	13.1	2,400e	Apr. 2	14	17.1	3,700e	Apr. 12	24	18.35	2,900	Apr. 21	33	7.1	1,400e

NOTES: Oxbow, McKinney, and Towner discharge figures are rough estimates based on limited rating curves.
Gage heights at McKinney, and Oxbow corrected to present gages.
*From elevation of definitely indentified 1904 high water mark, local conditions not materially changed.
†Oxbow data 1912-16 taken from Glen Even record 18 miles below Oxbow by river.
e-Estimated.

WINTER MELTING DAYS ON MOUSE RIVER WATERSHED AS RECORDED AT PORTAL AND CROSBY, NORTH DAKOTA

NOVEMBER

Station	Year	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Portal, N. D.	1893																									
Portal, N. D.	1894	49	50	48	41		41	50	45	54	37										41					34
Portal, N. D.	1895						36	36	35	32	41	41	41	44	42		32									
Portal, N. D.	1896																									
Portal, N. D.	1897	44	44	35		34									38											
Portal, N. D.	1898		34		33	40	39	41	36	52	44	34	45	36	33											
Portal, N. D.	1899	60	51	56	54	37	37	36	37	41	60	46	39	43	50	57	46	52	44	41	51	49	51	48	49	36
Portal, N. D.	1900	17	42		44	35	44	39				40	45									32			35	33
Portal, N. D.	1901	30	38	39	45	51	34	45	50	40		34	39	40	44	40	34	37	38	39	39	40	42	53	59	59
Portal, N. D.	1902		44	52									42	39	44	46	38	36	40				38			
Portal, N. D.	1903	48	63	42	45	33										32						32	37	40	36	
Portal, N. D.	1904	68	60	58	54	50	55	52	54	58	52	50	46	48	44	46	44	40	32							
Portal, N. D.	1905	40	40	40	44	50	55	54	50	58	50	56	60	56	50	46	44	38	36	34						
Portal, N. D.	1906	54	57	44	35			34	49	41	33															
Portal, N. D.	1907	59	35	43	40			60			35	45	36	38	43	40	40	42	49	46	43	42	59		50	42
Crosby, N. D.	1908	56	45	42	32							40	58	55	49	54	56	53	40	35			33	35	33	
Crosby, N. D.	1909	55	43	49	55	40								48	44					40				44		44
Crosby, N. D.	1910	50	43	54											33		38	42	36	35						
Crosby, N. D.	1911	36		37																	35	35			34	36
Crosby, N. D.	1912	50	48	46	62	41	42	42	46	51	43	48	54	53	51	44	46	39	35	40	35	36	34	42	35	37
Crosby, N. D.	1913	49	39	43		42	37	39		45	35	60	55	37	43	43	42		36	45	42	42	47	42	40	40
Crosby, N. D.	1914	62	46	54	68	40	35	33	32							45	40	45	44	66	40	51	40	45	40	
Crosby, N. D.	1915	55	46	33	35					33	35				35					37	35	35				
Crosby, N. D.	1916	46	44	43	35							40	47	48	49	33	32	40	41	35	32	36	38	38	40	38
Crosby, N. D.	1917	49	52	55	52	47	43	50	44	50	45	45	39	49	60	60	51	51	42	35	33	35	47	53	35	
Crosby, N. D.	1918	48	49	52	52	43	33	39	33		36	38	34	36	48	40	35	32	34						32	34
Crosby, N. D.	1919										35	40	39	38	36	40	39	33								
Crosby, N. D.	1920	37	42	42								35	40	42	39	36	34	32		35	39	45	37	35	36	43
Crosby, N. D.	1921	53	50		45		39	36	36	38	36	32												36	37	38
Crosby, N. D.	1922	32	32	32	33	32		32		39	40	46	46	35		36	43	48	34	43	46	50	40	48	40	
Crosby, N. D.	1923	61	58	59	52	58	54	46	38	54	41	54	58	50	49	46	34	39	34	46	45		41	46	45	36
Crosby, N. D.	1924			39	37						34	34	39	38	43	42	44	43	41	33		38	32		35	35
Crosby, N. D.	1925			42	52	53	52	43				40	43	43	51	50	53	33	33	46	36	38				36
Crosby, N. D.	1926	52	40						38	34																
Crosby, N. D.	1927					35													32	35	45					

DECEMBER

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1893																															
1894					35	36								34	36			32	33	39	37										
1895						32				38	38	36	39	38	35													32			
1896										40	40	35																	33	33	
1897				33	35	37	36	41	44						32										34			38	43		
1898																33	36	34	38	36	35			37	33	42	40	42			
1899	40	39				34	40	41	42	44										32	38	39									
1900	37		33			36	35	39								35	38	37		38	40								32		
1901	36								33													38	33					36	39	37	
1902																															
1903	34	42						35										33			32					35					
1904								34	37					34	38	33			31										38	40	40
1905					35	36	35			36	33			33	41	32	33								39	33	32				
1906			35	32																											
1907	40	49		41	54	46	45	40			35	38	34	35							33	33	32			33					
1908										32	33	35	41	36						32				32	35		34	34	32		
1909	34												32																	34	33
1910														32			33				33										
1911		34		32	35	[illegible]	32	34	39	32										33			34								
1912	34	35	34			[illegible]	39	35	42			36	37	42	36			34	33			35		32			40	34		39	
1913			35	39	40	32	37	41	47	47	40	35	37	40	38	40	34											31			
1914		33	40	41		[illegible]							35	34																	
1915						[illegible]	35															37	33		35						
1916	40	39	40	45	37																										
1917																42	46		38	33											40
1918	37	40	37	39	36		43	42	39	32			34																		
1919																			34	32	36		34	35	39	35	35	35	36		
1920	36	44	38	40	36	[illegible]	40	34			33		35	32	34	32												41		36	37
1921	40	35		38	39	[illegible]			37	37	40	42	42	38	32														33		
1922																				35	36	34	35	37	42			36			
1923		35			37	40	45			35	37	39		43	45	43	45	45	46	39		36	32	36	33						
1924	38		57								36	45																			
1925	55	50	50	38	43	[illegible]	46	50	38	40	43																				
1926									32																				33	33	33
1927				36																											

JANUARY

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1894									32	34			42	49			32														
1895																															
1896								38	36	38	36																				
1897								35	35												33				34						
1898			32	33	32		35	37	35																			32			
1899													33					38	34	35	37				32						
1900						35	40		35				32				32	39	45	46	39	41									
1901													38	38	36					33											
1902	36			38	38	40	38	41	36	35			34	33	32	38	35														
1903						38									36										32	38					
1904						37						35																			
1905			32	34																											
1906																										32	36	34	32		
1907																															
1908					34	39		46	33		35							35	37	40	38			32			35				
1909																		40			40	34	34				34				37
1910																					35	36			37	36					38
1911																															
1912																						33								36	
1913																									40						
1914				40	49	44	46	39					40	38	43	42	38	40												35	
1915	32								32			32	38																		
1916																															
1917								34	32																						
1918	40	36	39	32																			35	33							
1919								35				34				32	39		36	35			38	38	35	32	34	34	34		
1920									32			32																			
1921		33			34	38			32						35									50		35					
1922		34						32	34				38	32																	
1923										35							43														
1924						36																					34	37	39	42	45
1925					32															36											
1926				32				32	38	35	34	36	40	36	38	32	45								36				38	34	
1927	38	35	36	36	33	33																						35			
1928					42	36	34	42	46	40	45	40	32																		

FEBRUARY

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1894						33																				44	41	40
1895																				37	32		44	36	45	44	44	43
1896			33																		33	36	33	40	42	40	40	
1897					33																							
1898						35		42	40			34	45															34
1899														32	32	38	37	32	39	39	38							
1900																						33						
1901														32	33	36	36										37	40
1902																					34	32	32	36				
1903										32	34																33	
1904																											33	
1905																			35	36	33	38	36	38	40	38	40	37
1906																	32	34	40	36	34		36	34				
1907								37	33		33		32	35	34	35	36	33					37					
1908										32											36	36	36	38	32			
1909	35		38	36																					32			34
1910																											35	38
1911																												
1912														35		34												
1913													37	33	40	41	42	34										
1914																34								32	33	33	42	35
1915										33				34			35	38										
1916																41	40	32	38	34	33	35	38	35				
1917						34									34	34												
1918					40	33	42		40	36	55	46										33	46	34		33		36
1919									34	41	35																	
1920																			35	34								
1921								37	35	36	42	47	37	38	32								34	41	49	47	50	50
1922																												
1923							33																32	33	34	32	35	43
1924	49	41						36	36	40	46	54	43												37	43	47	52
1925		39	42	35	40	34																	42					
1926					39	37	42	37	42	41	43	34	33								38	43	42	40	33	42	50	42
1927		33	33	35	32															34	40	38	38					
1928							42	40	41	35	41	42							40							36	36	32

MARCH

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1894	42	45	45					35	33	40	35	40	43	55	45	52	57	46	40	33		33							43	40	35
1895	41							34	40							32	37	35	40	53	54	45	53	44	38	63	62	54	53	49	43
1896																			38	42			45	45		53	38	38	40	40	39
1897																	36	33	41						33	36	41	37	40	51	35
1898						36	42	49				36		34	32	32								36							33
1899								42	38																						
1900	35						34	40	34	32	43	46	37								39	39	35	37	40	40	40	32	35	38	42
1901	38	39	45			32	32	37	35	42	39	41	35		38	44	44						35			33		33	41	44	42
1902					37			45	45	45	35	35	40					40	33	32	34	38	37	37	36	38	34	34	32		
1903	34										38														33				37	45	46
1904					34	38																						36	35	34	34
1905	42	48	46	52	48	46	42	40	34						37	55	50	40	46	65	59	60	59	60	61	60	60	44	42	42	47
1906			36	40	42	40	34	30																		38	46	44	48	54	52
1907						35				33					39	32		37	33	40	35	42	40	38	33			35			35
1908									42	48	44	38								40	44	38	37						41	39	
1909	36	35	37	34	39			38	35									36	41	45	35	38	35	38	35	35			32		38
1910		39	42	42	44	48	47	36	36	49	47	63	59	56	55	53	65	68	66	71	69	81	68	59	54	54	48	56	44	50	51
1911							38	39	41	39	39	38	42	34		40	36	36	45	55	44	37	58	57	50	41	37	48	42	39	34
1912																						33		35	33	37	40	45	47	35	39
1913		38	35	44	38	36	49	45	42	40	39	41															37	47	47	45	52
1914	34	39	41	39	34		40	36			39	50	50	56	51	42	36		33				34						32	43	45
1915											32				32	35	40		35	43	40	50	42		34	45	44	32	36	41	42
1916						36	37	33	40	40	39		36				36	32	38	30	34						47	40	38	42	40
1917					34	32	36	31	32			35	33	34	36			40	42	48	45	34	42	42	45	40	42	40	45	42	34
1918	42	36	43	32						33	32	33	50	38	70	70	66	58	51	50	61	62	64	62	74	67	60	72	63	63	50
1919											33							39	34		32	33	35	36	33		33	33	33	33	41
1920									35	38		34	36	40	45					41	38	39	33	34	37	41	42	39	37	48	38
1921	44	40	49	41		35	33									39	47	54	42			47	53	62	48	36		46	43	55	53
1922			34	35	34	32			38	40	35	38	43	42	37	35	38	37	35		39	37	32						32	35	43
1923	45				35	32		37		42	40					56			45	37				32	41		48	37		36	
1924	45	45	37							37	37	35	38	35	37	35	39	37	47	37	37	43	35	45	37	37	32			32	42
1925		40	38	41	44		36									32					37	43	44	49	51	50	51	56	64	63	62
1926	36		36	32				34	40	36	45		33	38	50	53	53	55	54	63	60	65	65	38							
1927		33	36	35	32	38	35	39	34	30	42	42	48	55	36	35				35	42	37	32		34	38	42	40	40	38	
1928	35	35	38		35	32					52		36			34	35	40	55	65	65	72	60	48	35				32	50	60

APRIL

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1894	50	48	60	53	50	61	63	51	45	52	58	60	41	58	46	45
1895	54	71	74	65	78	43	57	60	68	44	47	60	78	75	70	61
1896	32	34	50	55	45	55	45	46	72	47	38		58	65	52	
1897	37	40	42	45	36	48	38	50	40	53	48	40	44	66	53	61
1898			32	31			37	47	43	45	56	45	48	58	64	50
1899							39	43	43	47	50	52	65	45	43	54
1900	43	53	49	65	65	75	67	68	55	62	53	52	56	58	62	65
1901	44	53	56	43	50	51	50	55	55	54	57	55	54	53	52	37
1902			32	35	40	45	32	60	52	48	47	48	50	53	57	58
1903	58	39	42	46	50		44	56	54	61	70	48	34	55	60	61
1904	38	38	44	51	40	35		35	49	59	34	46	49	45	40	42
1905	65	65	52	53	59	60	77	66	44	42	40		33	42	34	47
1906		36	32		46	64	62	58	68	64	74	52	40	36	54	64
1907	35	34		34	36	45		35	33	38	40			40	32	
1908			42	44	47	42	38	55	57	45	68	68	79	64	42	65
1909	41	45	44	42	47	43	35	42	48	33	38			53	47	49
1910	53	61	58	46	62	58	73	81	59	61	62	71	60	49	40	40
1911				34	33		32	52	65	61	59	42	38	44	59	68
1912	46	56	66	68	61	44	55	71	70	61	43	38	39	36	40	50
1913	50	45	48	52	54	49	45	41	47	54	65	77	79	82	81	64
1914	48	36	39	42	46	35		41	49	38	57	56	63	69	75	68
1915	45	56	64	57	55	63	54	65	58	59	50	66	82		76	72
1916	36	42	41	33		41	31	[illegible]	[illegible]	50	50	42	50	69	69	
1917	42	50	40	60	48	42	40	48	58	42	50	52	56	45	40	42
1918	40	33	40	49	49	44	40	54	72	68	59	68	72	67	60	39
1919	42	39	47	50	46	40	37		32	41	50	47	48	48	48	52
1920							32	35	32	34	39	42	37	40	35	38
1921	55	63	64	50						46	54	54	64	50	48	49
1922	42	40	52	57	52	42	57	55	42	32	36	40	42	45	44	42
1923		32	37	45	37		36	44	46	41	57	48	30	51	50	58
1924	54	57	42	38	47	62	58	43	33	39	39	59	59	45	34	43
1925	68	42	41	62	66	63	58	68	72	74	84	62	56	49	50	46
1926		38				38	36	46	45	68	70	78	48	68	76	48
1927	45	53	50	43	43	43	45	50	50	42	41	45	50	54	41	48
1928	60	67	43	36		39	36			50	40	42				41

Figures are [illegible]

Table 7

The temperature of the winter and spring melting days is given in Table 7. With a straight edge one can pick out at a glance the character of the winter and spring that preceded the various flood years.

These spring melting temperatures are plotted graphically with the hydrographs, Figure 4, with Degree-Days as the Y-axis. They give a curve of the accumulated maximum daily temperature readings in Fahrenheit degrees above or below freezing beginning with the first practical melting day in the spring. Upward slope indicates melting and downward slope indicates freezing. The pitch of the line indicates roughly the intensity of each. The degree shown in figures on the curves are given to indicate the general rate of warming up for comparison between the years.

The "Probable maximum melting day" in column 3 of Table 6 is the first of a few days when in common parlance the snow seems to all go off at once. They are of course more pronounced in some years than others. They usually occur when the maximum daily temperature has reached around 50 degrees and about 100 degree-days have accumulated. By that time the minimum temperatures thru the night are usually about freezing or above since the average daily range is about 20 degrees.

These probable maximum melting days when pronounced throw the water out of the snow condition onto the soil in a manner comparable to a hard rain storm. This is attested by the fact that many of the snow water crests travel along the river in about the same time as do the rain water crests as may be seen in Table 8, Mouse River Flood Travel.

The occurrence of rain during the melting period has the effect of a warm melting day and contributes directly to the precipitation available. Such a coincidence has occurred several times on the Mouse River and is shown under each hydrograph, Figure 4, in the precipitation available. This was one of the primary causes of the Dayton, Ohio, flood of 1913. It is considered here a minor contingency because of the slight rainfall.

In the classification of springs, Table 6, only warm or hot springs are considered condusive to large floods. Greater refinement was not attempted.

The Snowfall—Run-off Curves: When these data were assembled and plotted as shown in Figure 3 most of the curves could be identified, some had to be interpolated, and some were entirely missing. They are necessarily rough because of the brevity and paucity of the record. But they bring a semblance of order out of what is otherwise a mere riot of figures. Four of the eighteen floods used failed to fall into the scheme. The 1904 flood fell so far out that it is not shown. It also failed to fall on the proper curve but it is thought to be due to the brevity of the early record.

Fig. 6. Location of November to March Snow Accumulation Causing Mouse River Flood at Minot, N. Dak.

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The winter precipitation of the five principal floods is plotted and shown in Figure 6. This gives an idea of what part of the watershed furnished the precipitation for each flood. It will be noticed that the 1904 flood came mostly from around Estevan. Moreover, that was the only station that showed the necessary precipitation to produce such a flood. There is no record for the entire central portion. It must have been heavily loaded with snow also.

If the curve labeled "Average Fall—Warm Spring" was extended to the 1.1 inch run-off which was recorded at Minot for the 1904 flood it would indicate a net available precipitation over the watershed of about eight inches instead of the five and one-half inches as computed from the weather records. That seems the more reasonable.

These curves are used to estimate the total amount in inches of the spring run-off that occurred prior to 1903 when the gaging station was established at Minot. The probable flood crest for these years as shown in Table 6 is the estimate used in the probability curve.

Probability of Maximum Flood

Probability: From the data given in Table 6 it may be ascertained that the small spring flow of 1917 was of such a size that 14 other spring flows of equal or greater amount exist in the record of 34 years. Greater flows must be included because that amount flowed in them also. Fourteen such flows in 34 years is one about 2½ years apart. If we had 100 years of record, chances are that the frequency of that size of run-off would still be somewhere between two and three years apart. The majority of the flows are small.

The 1927 flood was a flow of rather unusual amount. Its size has occurred three times in 34 years or about once in 11 years. The 1904 flood has occurred once in 34 years or if we wish to include the 1882 flood it has occurred twice in 48 years or once in 24 years. A longer record would reveal a still different and of course more accurate frequency. It turns out to make little difference in the location of the curve what frequency is assigned to the first two or three floods in the list.

Probability Curve: Arranging the spring flows as given in Table 6 in a consecutive order of magnitude beginning preferably with the largest we have a series of events the first one of which occurred once in 34 years, the next twice in 34 years or 17 years apart and the third one three times in 34 years of about 11 years apart and so on. Plotting these on logarithmic paper, Figure 7, a curve may be drawn thru these points which may be extended beyond the length of our present record into the upper reaches of great length of time and great floods. The upper limit of the curve must be determined by other considerations.

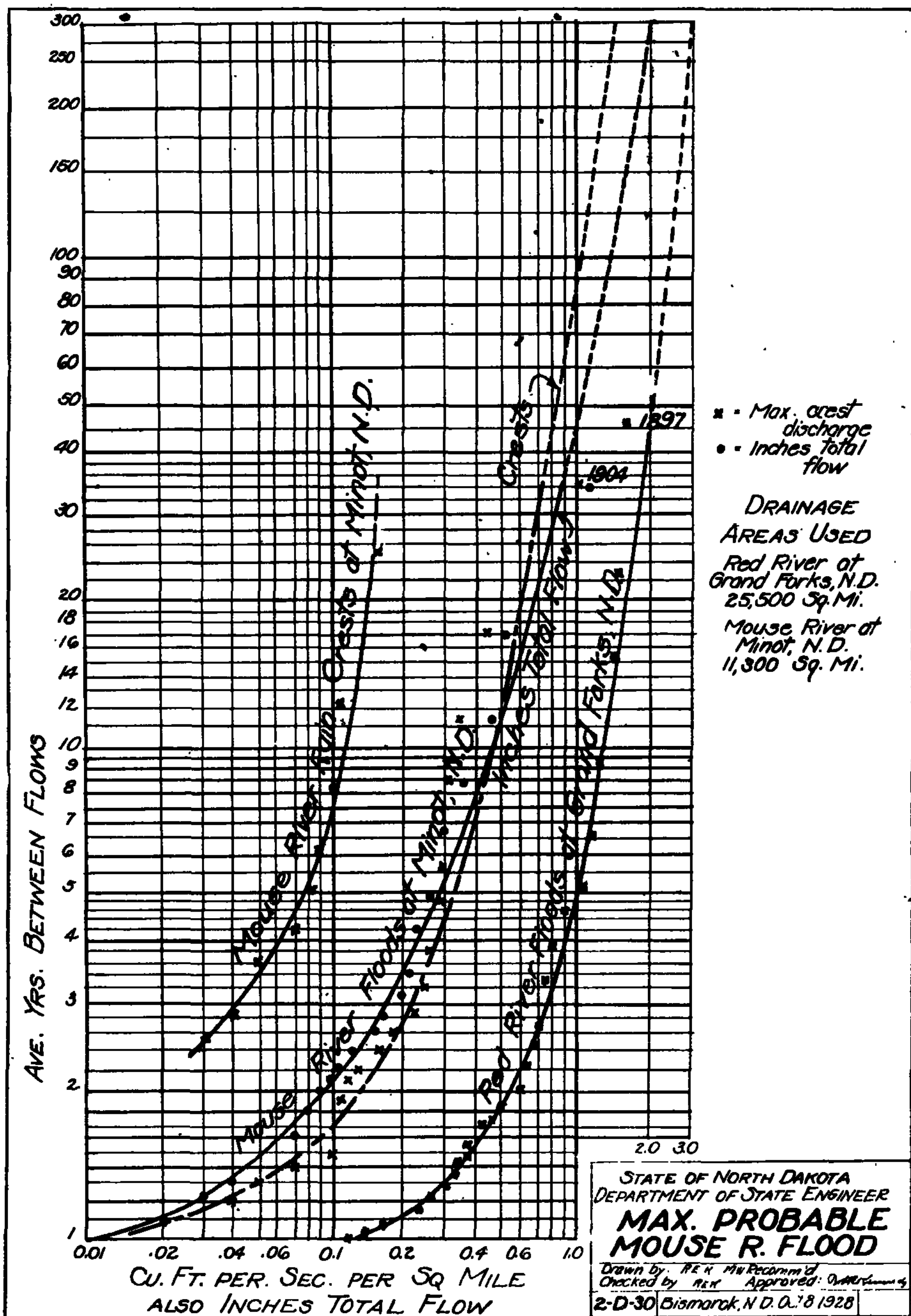

300
250
200
150
100
90
80
70
60
50
40
30
20
18
16
14
12
10
9
8
7
6
5
4
3
2
1
0.01
.02
.04
.06
0.1
0.2
0.4
0.6
1.0
2.0
3.0
Ave. Yrs. Between Flows
Cu. Ft. per. Sec. per Sq Mile
also Inches Total Flow
Mouse River Rain Crests at Minot, N.D.
Mouse River Floods at Minot, N.D.
Crests
Inches Total Flow
Red River Floods at Grand Forks, N.D.
1897
1904
× - Max. crest discharge
• - Inches total flow
Drainage Areas Used
Red River at Grand Forks, N.D. 25,500 Sq. Mi.
Mouse River at Minot, N.D. 11,300 Sq. Mi.
State of North Dakota
Department of State Engineer
MAX. PROBABLE
MOUSE R. FLOOD
2-D-30
Bismarck, N.D.

FIG. 7

Geographical Limitations: The lines of mean annual precipitation drawn upon a map of the Great Plains and eastern part of the United States show a definite decrease in amount with increase of distance from the Gulf of Mexico and the Atlantic Ocean. Maps showing the maximum storms over this area also show a decrease of intensity with distance from the seaboard. A map showing the location of maximum recorded floods also shows the influence of geographical location.

The Mouse River watershed is located about as far as possible from the general source of moisture supply of the Atlantic Ocean and the Gulf of Mexico. Some hydrologists deny the effect of geographical location on the assumption that our brevity of record has not yet revealed the tropical-like flood in the remote regions. But it seems more logical to assume that under the present geological status the above indications point to a rough limit beyond which Nature cannot go. That is our quest. The procedure is to determine the frequency of such a flood and then by applying it to the curve find the corresponding size.

Frequency of Maximum Flood: Two of the primary causes of Mouse River floods, proper soil condition and propitious spring weather, occur so often that their frequency rate is fairly reliable. A maximum flood must be preceeded, let us assume, by an average to wet fall soil condition which occurs about once in every 1.6 years. And that it will require a warm to hot spring which has occurred about once every 1.9 years. The product of these two rates of occurrence is three, meaning that the soil and temperature conditions are prepared for a flood on an average of about once every three years if the moisture is available.

If the precipitation data given in Table 6 be arranged and plotted on logarithmic paper, not shown but readily constructed and 5.5 inches is used for the year 1904 it will be noticed that the ten inch point falls entirely outside the curve. But using the 8 inches as derived from the run-off curve then the 10 inches of precipitation has a frequency of once in not less then 100 years. But assuming 100 years then the chance of these three conditions occurring at one and the same time is about once in 300 years. Entering the curve, Figure 7, with a frequency of 300 years the corresponding run-off is 1.5 second-feet per square mile, or 18,000 second-feet which is fifty percent larger than the 1904 flood.

These assumptions are more or less arbitrary. But it is thought that a dry winter soil and a slow, cold spring, which are the two conditions not included in the above consideration, would take such a toll of the available precipitation through evaporation and deep percolation that even though the maximum existed on the watershed the run-off would not be the maximum although of course it would be large.

The curve of total volume of flow indicates that floods of larger total volume are more apt to occur than those of greater peak discharge.

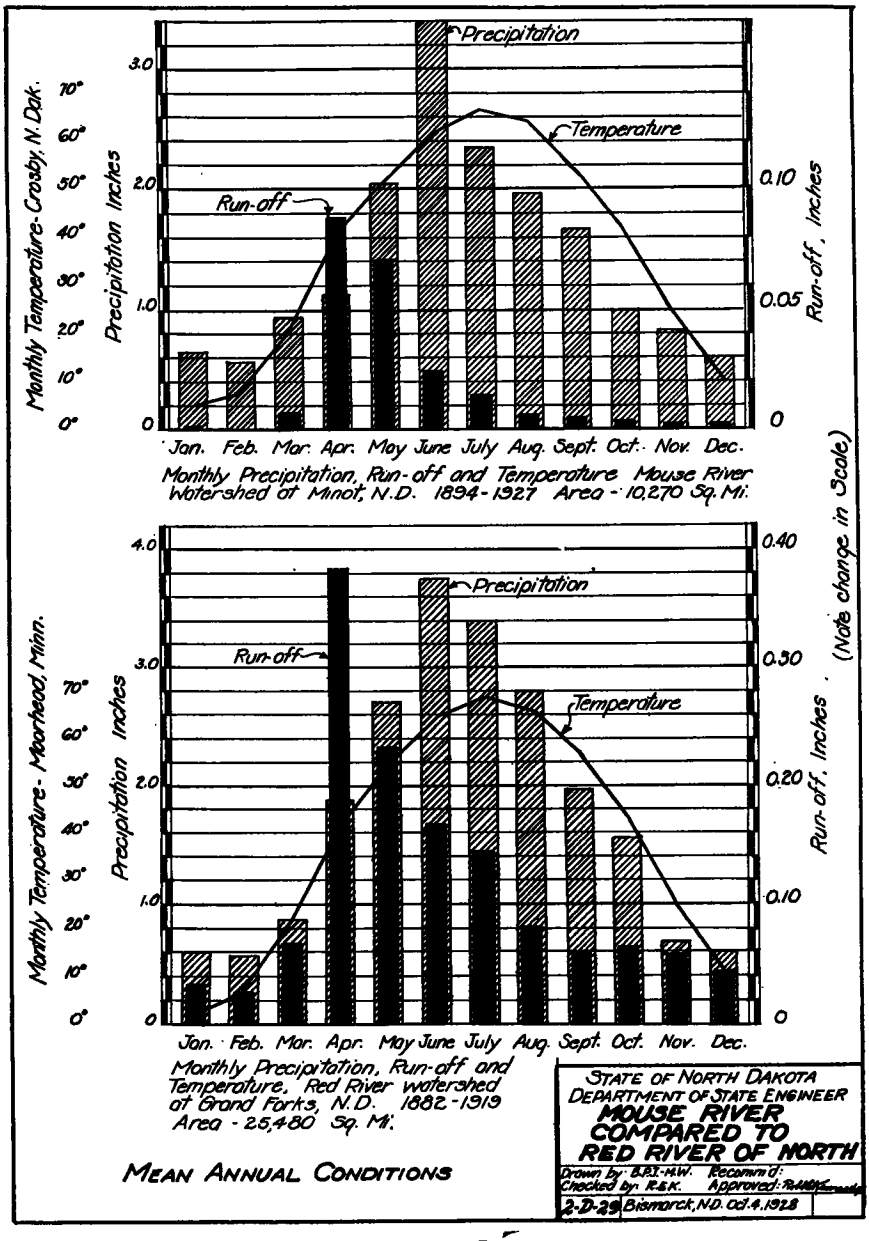

Monthly Temperature-Crosby, N. Dak.
Precipitation Inches
Run-off, Inches
Precipitation
Temperature
Run-off
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
Monthly Precipitation, Run-off and Temperature Mouse River Watershed at Minot, N.D. 1894-1927 Area - 10,270 Sq. Mi.
Monthly Temperature - Moorhead, Minn.
Precipitation Inches
Run-off, Inches (Note change in Scale)
Precipitation
Run-off
Temperature
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
Monthly Precipitation, Run-off and Temperature, Red River Watershed at Grand Forks, N.D. 1882-1919 Area - 25,480 Sq. Mi.
MEAN ANNUAL CONDITIONS
STATE OF NORTH DAKOTA
DEPARTMENT OF STATE ENGINEER
MOUSE RIVER COMPARED TO RED RIVER OF NORTH
Drawn by: B.P.I.-H.W. Recommd:
Checked by: R.E.K. Approved:
2-D-29 Bismarck, N.D. Oct. 4, 1928

FIG 8

One would infer that from the hydrographs. In fact, the extreme sharpness of the 1904 hydrograph is hard to explain. Ice jams have been suggested but the short time of travel, Table 8, from the probable maximum melting day to Minot gives no time for them to form above the city. They would hardly all accumulate and break at once. The shape of the curve does not suggest a jam, either, although it would indicate that they collected at several places a short time after the peak went through.

Comparison with Neighboring River Systems: The Red River of the North is an adjacent watershed to the east with a record dating back to 1882 at Grand Forks, N. Dak. Topographically the watersheds are similar in that both are quite flat. Comparison of the general meteorological data is shown in Figure 8. The Red River has greater proportional June and July run-off. Summer floods are proportionally larger and more frequent. The mean annual temperature is somewhat higher, the average annual rainfall is 25% greater and the average annual percent of the rainfall that runs off in stream flow is 500% greater than that of the Mouse River.

The Red River floods plotted on the probability curve in Figure 7 indicate that a fifty percent increase of its maximum recorded flood or 2.5 c. f. s. per sq. mi. has a frequency of about once in 100 years. Using this figure as a basis comparison was made with 24 other stations on five surrounding river systems. Results are given in Table 9. For simplicity the inverse ratio of the square root of the respective drainage areas was used after the Jarvis-Meyer* suggestion. No co-efficient was attempted to cover the numerous other factors such as, rainfall, temperature, elevation, and so on. The results are necessarily rough and probably unnecessarily large in many cases. However, it may be noted that this computed maximum flood exceeds by more than 50% the known maximum flood at practically all stations except two and they are on the Yellowstone and North Saskatchewan both of which drain extensive Rocky Mountain topography. Comparative probability curves indicate that the Mouse River is one of those whose maximum by area alone is unnecessarily large. If fifty percent is good for the Red River it should be ample for the Mouse River.

Factors used in other flood studies are of casual interest. Simons and King in their extensive study of the Red River flood problem propose a factor of only 20%.** The Miami Conservancy District, Dayton, Ohio, pioneers in this type of study, after making, probably, the most extensive study that has yet been made, decided upon a factor of 40%. The same engineers in studying the Pueblo, Colo., flood in 1921 decided, it is said, upon a factor of 60% increase over that flood as a basis of design.

*Paper No. 1589, "Flood Flow Characteristics," Jarvis, Am. Soc. Civil Engrs., New York.
**Bulletin 1017, U. S. Dept. of Agriculture.

TABLE 9—MAXIMUM RECORDED DISCHARGES AT STATIONS IN THE VICINITY OF THE MOUSE RIVER

Stream	Station	Years of Record (this report)	Total Years	Drainage area Sq. Mi.	Max. recorded Discharge in Second-feet			Prob. max. on Red R. basis
					Date	Total	Per Sq. Mi.	
	MISSOURI RIVER BASIN							
Yellowstone River	Intake, Mont.	1903-1927	25 yrs.	66,090	June 21, 1921	142,000	2.2	1.6
Little Missouri R.	Medora, N. D.	1903-08, 1922-26	11 yrs.	6,190	June 24, 1907	22,000	3.6	5.1
Knife River	Broncho, N. D.	1903-25, 1927	24 yrs.	1,200	April 1, 1913	6,350	5.3	11.5
Heart River	Richardton, N. D.	1903-1924	22 yrs.	1,250	June 10, 1906	8,020	6.4	11.3
Cannonball River	Stevenson, N. D.	1903-1927	25 yrs.	3,650	March 2, 1923	6,900	1.9	6.6
	RED RIVER OF THE NORTH BASIN							
Red River	Fargo, N. D.	1903-1927	25 yrs.	6,420	July 11, 1916	7,700	1.2	5.0
Red River	Grand Forks, N. D.	1882-1927	46 yrs.	25,480	April 10, 1897	43,000	1.7	2.5
Red River	Emerson, Man.	1912-1924	13 yrs.	34,600	April 24, 1916	46,200	1.3	2.1
Ottertail River	Fergus Falls, Minn.	1904-1917	14 yrs.	1,310	June 23, 1904	1,075	0.8	11.0
Sheyenne River	Haggard, N. D.	1902-07, 1919	7 yrs.	5,410	April 28, 1919	2,220	0.4	5.4
Red Lake River	Thief River Falls, Minn.	1909-18, 1920-27	18 yrs.	3,430	April 19, 1916	7,040	2.0	6.8
Red Lake River	Crookston, Minn.	1901-1927	27 yrs.	5,320	July 5, 1919	14,700	2.8	5.5
Pembina, River	Pembina, N. D.	1903-15, 1919-27	22 yrs.	2,960	May 2, 1904	3,870	1.3	7.3
Roseau River	Caribou, Minn.	1917, 1920-27	9 yrs.	1,650	May 24, 1927	3,160	1.9	9.8
	ASSINIBOINE RIVER BASIN							
Assiniboine River	Millwood, Man.	1913-1924	12 yrs.	7,590	April 29, 1922	17,800	2.3	4.6
Assiniboine River	Brandon, Man.	1912-1924	13 yrs.	34,500	May 7, 1923	23,000	0.7	2.1
Moosejaw Creek	near Pasqua, Sask.	1910-1924	15 yrs.	1,960	April 18, 1916	2,958	1.5	9.0
Souris (Mouse) River	Wawanesa, Man.	1912-1924	13 yrs.	20,056	April 19, 1916	6,100	0.3	2.8
Souris (Mouse) River	Minot, N. D.	1903-1927	25 yrs.	10,270*	April 20, 1904	12,000	1.1	3.8
Souris (Mouse) River	Estevan, Sask	1911-1923	13 yrs.	4,900	April 18, 1923	1,680	0.3	5.7
	DAUPHIN RIVER BASIN							
Swan River	Swan River, Man.	1912-1924	13 yrs.	1,215	April 25, 1922	8,460	7.0	11.5
Valley River	Valley River, Man.	1912-1924	13 yrs.	1,028	May 5, 1922	5,080	4.9	12.5
	SASKATCHEWAN RIVER BASIN							
N. Sask. River	Prince Albert, Sask.	1911-1924	14 yrs.	46,100	July 2, 1915	200,000	4.3	1.9
Battle River	Battleford, Sask.	1911-1924	14 yrs.	11,850	April 19, 1921	11,500	1.0	3.7
	SWIFTCURRENT CREEK BASIN							
Swiftcurrent Creek	Swiftcurrent, Sask.	1909-1924	16 yrs.	1,160	April 10, 1917	6,300	5.4	11.7
			433 yrs					

*Official area, 11,300 Sq. Mi. used here.

The Rainfall Cycle: An interesting report upon the fluctuations of the Great Lakes made by John R. Freeman in 1925 contains the following paragraph.*

> There is every reason to expect from the behavior of the lake levels during the past sixty-five or more years, in course of which they have presented cycles of years of low lake levels—from three to seven years in duration—followed by years of high lake levels, that soon the lakes will again begin to rise from natural causes, chief among which causes is a probable return of larger annual rainfall.

It is a matter of record that the lake levels have begun to rise. To what extent it will continue of course no one can tell but it may be that our data have all been taken from what will prove to be a dry section of the rainfall cycle. This is known to go in great irregular oscillations with, say, fifty to seventy-five years between peaks with lesser but more erratic cycles within these cycles. A series of increased rainfall years may be just ahead of us which would indeed be a great material blessing but it would bring an increased flood hazard. It would change somewhat our computations.

It is immaterial, however, just what particular computed frequency a maximum flood has. We do not know when Nature began counting her time. Such a flood is inevitable and the city intends to stay in these bottoms, apparently, as long as the river does.

HYDRAULIC COMPUTATIONS AT MINOT

General hydraulic data are given in Table 10. These are based upon a study of the rise and fall of the 1927 flood with the aid of about 17 gage staffs, about 450 daily water surface elevation readings, and 31 measured cross sections. See Fig. 10 and Table 11.

River Encroachment: While Nature is primarily to blame for these floods yet it must be admitted that Minot herself has inadvertantly contributed to a certain extent. These bottoms were originally swampy. They have been filled in and crossed by railway and street grades. The river banks have been raised. Computations reveal the fact that the top width of the water surface at bank full stage is 30% less thru the city than thru the country section below the city for the same discharge. To accommodate itself, the river has dug a little deeper channel thru the city—the average water depth is about 1.5 feet more than thru the country section—but that is evidently not enough to meet the situation entirely for during flood a hump appears in the profile as may be seen at Figure 9 where the water is forced to back up behind this funnel-like section in order to get thru.

*Regulation of the Great Lakes. John R. Freeman, Conclusion (5), distributed by Sanitary District, Chicago.

TABLE 10—COMPARISON OF ENCROACHED MOUSE RIVER SECTION THRU MINOT TO COUNTRY SECTION BELOW

	City Section			Country Section		Entire Length		
Quantity c. f. s.	1890	2700	3770	1890	3770	1890	2700	3770
Ave. top width	108	130	141	153		126		
Ave. side slopes	2 :1							
Ave. Kutters "n"	.0474	.0521	.0587	.048		.048		
Ave. slope w. s.	0.00019	0.00019	0.00030	0.00010	0.00010	0.00013	0.00013	0.00014
Ave. water depth	17.1			15.5		16.4		

Encroached river section thru city as taken from 1927 flood profile is from Davis Ice House to 9th St. S. E. Bridge, 11 measured cross sections; total river dist. is 2.36 mi., direct valley dist. is 1.2 mile.

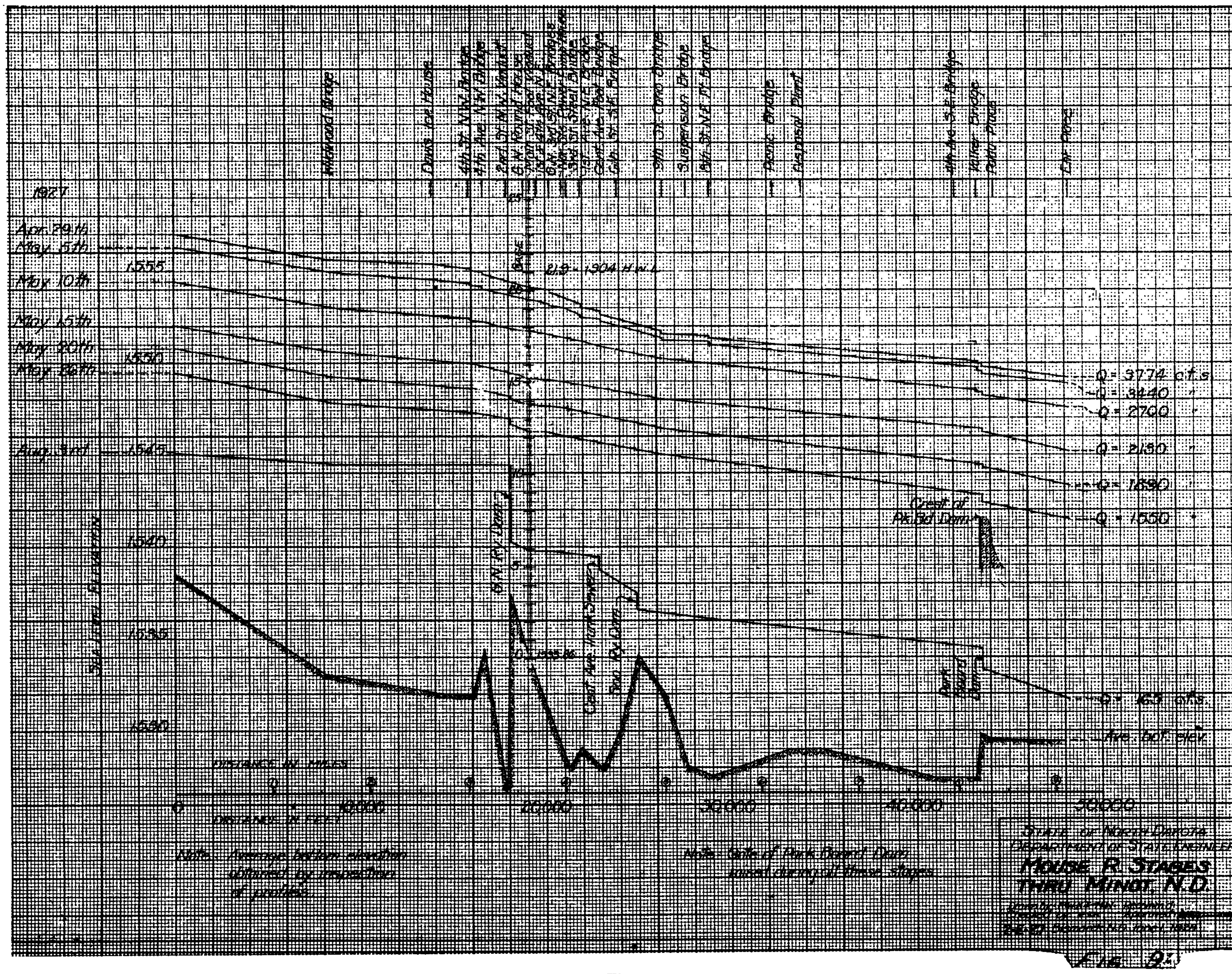
Country section is taken from Palda Place to Saugstad Bridge, 11 measured cross sections; total river distance is 6.12 miles, direct valley distance is 3.1 miles.

Entire length from Soo Bridge in western edge of city to Saugstad Bridge about 5 mi. east of city has 31 measured cross sections; total river dist. is 14.48 mi., direct valley dist. is 6. mi.

WATER SURFACE ELEVATIONS FOR VARIOUS FLOOD DISCHARGES

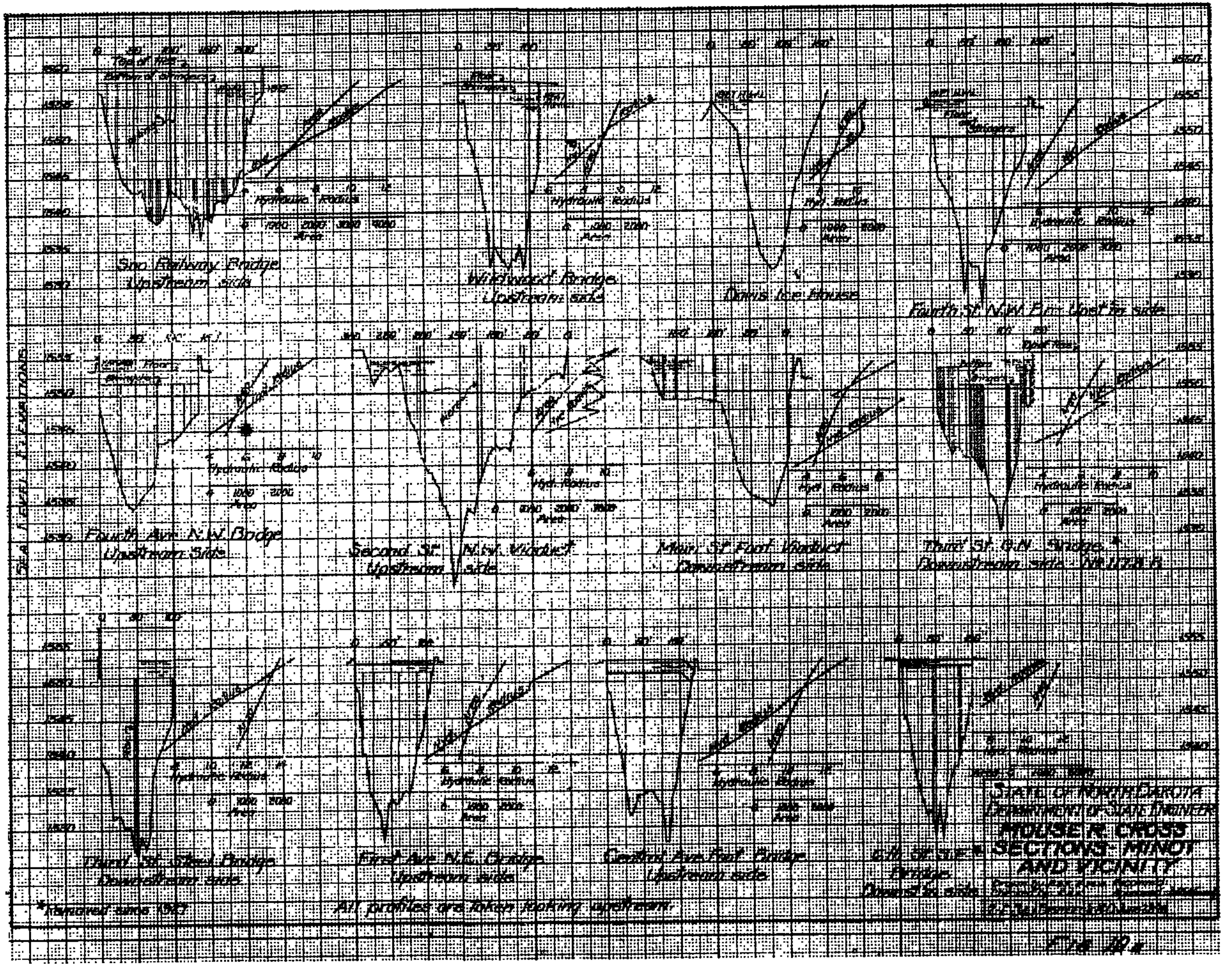
	3,770 c. f. s. in 1927		12,000 c. f. s. in 1904		12,000 c. f. s. in 1927		18,000 c. f. s. in 1927	
	Gage Height	U. S. G. S. Elevation	Gage Height	U. S. G. S. Elevation	Gage Height	U. S. G. S. Elevation	Gage Height	U. S. G. S. Elevation
Main St. Ft. Br.	20.17	1,554.03	21.9	1,555.76	23.0	(1,556.8)	24.2	(1,558.0)
4th Ave. S. E.		1,550.00				(1,552.8)		(1,554.5)
Ehr Farm		1,549.18		1,551.50		1,551.5		(1,553.3)
Saugstad Br.		1,546.00		1,549.72		1,549.72		(1,550.6)

Elevations are on observed water surfaces or known high water marks except where shown in ( ) which are computed.



1927
Apr. 29th
May 5th
May 10th
May 15th
May 20th
May 26th
Aug. 3rd
1555
1550
1545
1540
1535
1530
Q = 3774 c.f.s.
Q = 3440
Q = 2700
Q = 2150
Q = 1890
Q = 1550
Q = 163 c.f.s.
Ave. bot. elev.
Crest of Pk. Bd. Dam
Park Board Dam
Cent. Ave. Park Dam
Rock Dam
0
10,000
20,000
30,000
40,000
50,000
Distance in Feet
Distance in Miles
Note: Average bottom elevation obtained by inspection of profiles.
Note: Gate of Park Board Dam raised during all these stages.
State of North Dakota
Department of State Engineer
Mouse R. Stages
Thru Minot, N.D.
Fig. 9

Fig. 9


Soo Railway Bridge
Upstream side
Hydraulic Radius
Area
Top of Rail
Bottom of Stringers
Winkwood Bridge
Upstream side
Davis Ice House
Hyd. Radius
Fourth St. N.W. Bridge Upstream side
Fourth Ave. N.W. Bridge
Upstream Side
Second St. N.W. Viaduct
Upstream side
Main St. Foot Viaduct
Downstream side
Third St. G.N. Bridge
Downstream side
Third St. Steel Bridge
Downstream side
First Ave. N.E. Bridge
Upstream side
Central Ave. Foot Bridge
Upstream side
Bridge
Downstream side
* Removed since 1923
All profiles are taken looking upstream.
STATE OF NORTH DAKOTA
DEPARTMENT OF STATE ENGINEER
MOUSE R. CROSS
SECTIONS MINOT
AND VICINITY
SEA LEVEL ELEVATIONS

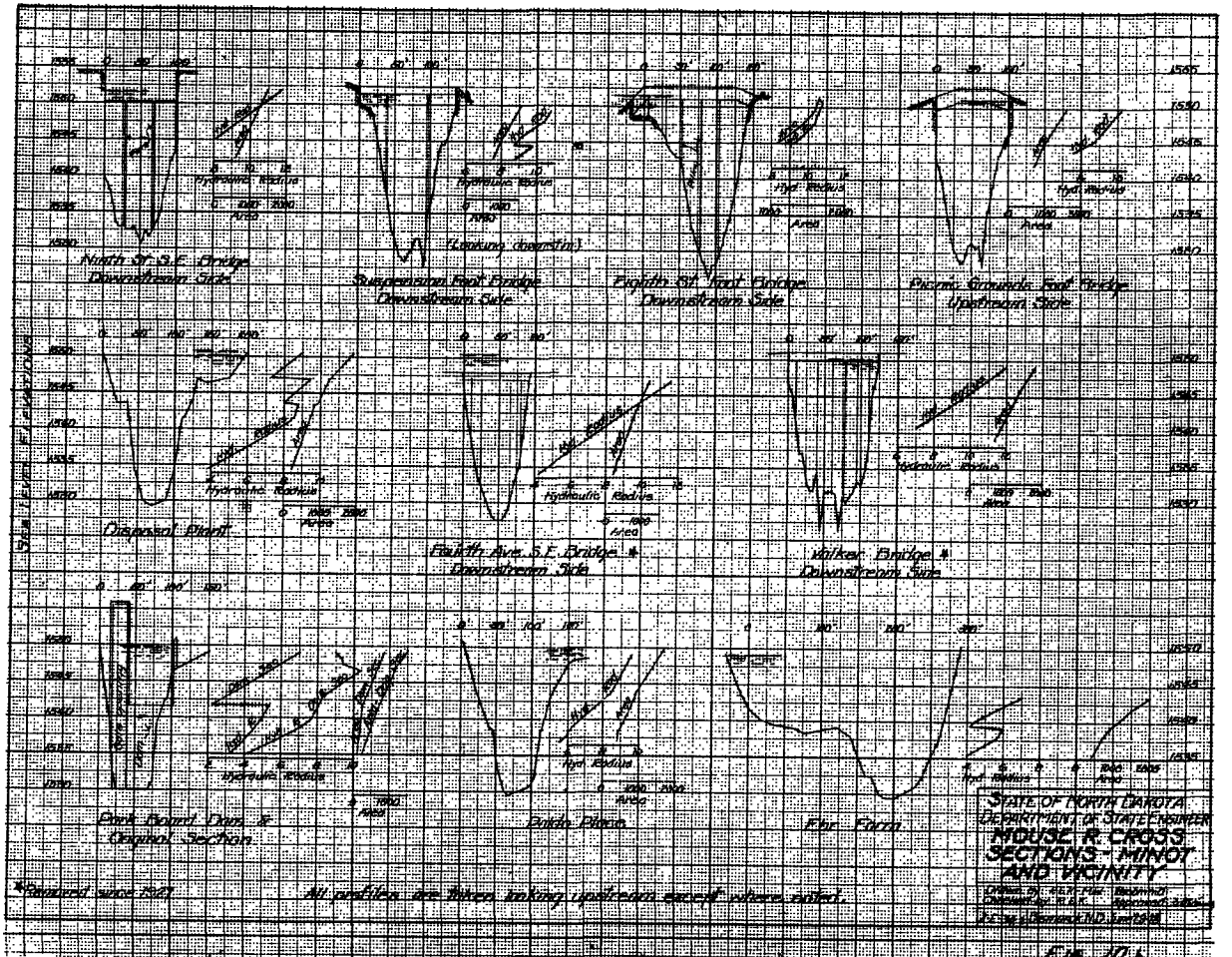

North Dr. S.E. Bridge
Downstream Side
Suspension Foot Bridge
Downstream Side
(Looking downstream)
Eighth St. Foot Bridge
Downstream Side
Picnic Grounds Foot Bridge
Upstream Side
Disposal Plant
Fourth Ave. S.E. Bridge
Downstream Side
Walker Bridge
Downstream Side
Dam Power Plant
Original Section
Power Plant
For Farm
STATE OF NORTH DAKOTA
DEPARTMENT OF STATE ENGINEER
MOUSE R. CROSS
SECTIONS - MINOT
AND VICINITY
File 10-4

TABLE 11—SAMPLE HYDRAULIC COMPUTATIONS MOUSE RIVER AT MINOT, N. D.
DISCHARGE 1890 C. F. S. MAY 20, 1927 (GAGE HEIGHT AT MAIN ST. FT. BRIDGE 13.93)

Station & dist. bet.	Water Depth	Top Width	Hyd. Rad.	Area Sq. Ft.	"n"	Eng. Gr. Slope	Vel.	Vel. Head h^v	Head Losses Frict. h^f	Head Losses Bdge. h^b	Elev. Engy. Grad.	Elevation Water Surf. Compd.	Elevation Water Surf. Obsvd.
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)
G. N. Bridges[1]	16.6	115	7.3	930		0.00036	2.03	0.06			1547.71	1547.65	1547.65
725					.057	0.00009			0.16	0.03*	00.19		
3rd St. Steel Br.	19.5	98	10.8	1300		0.00007	1.47	0.03			47.52	47.49	47.49
885					.050				0.09	0.06*	0.15		
1st Ave. NE Br.	18.3	94	9.7	1050		0.00014	1.80	0.05			47.37	47.32	
1040					.050				0.12		0.12		
Cent'l Ave. Ft. Br.	19.2	104	9.9	1180		0.00010	1.60	0.04			47.25	47.21	
1000					.050				0.17	0.04*	0.21		
6th St. S. E. Br.[1]	17.0	94	8.0	910		0.00024	2.08	0.07			47.04	46.97	
2350					.050	0.00018			0.49	0.03*	0.52		
9th St. S. E. Br.	14.5	98	8.9	1000		0.00016	1.89	0.06			46.52	46.46	46.46
1150					.047				0.16		0.16		
Suspension Ft. Br.	18.3	105	9.4	1100		0.00011	1.72	0.05			46.36	46.31	
1450					.047				0.15	0.03*	0.18		
8th St. SE Ft. Br.	18.6	113	9.6	1200		0.00010	1.58	0.04			46.18	46.14	
3100					.047				0.31		0.31		
Picnic Ft. Br.	17.8	100	9.2	1200		0.00010	1.58	0.04			45.87	45.83	
1800					.047				0.21		0.21		
Disposal Plant	16.6	114	8.9	1100		0.00013	1.72	0.05			45.66	45.61	
7000					.047				0.84	0.03*	0.87		
4th Ave. S. E. Br.[1]	17.2	87	10.3	1010		0.00011	1.87	0.05			44.79	44.74	
2450					.047				0.24	0.06*	0.30		
Valker Bridge[1]	17.0	108	9.3	1220		0.00009	1.55	0.04			44.49	44.45	44.45

[1]Bridge since replaced by present structure.

*Estimated from observed bridge losses for other stages.

All computations are in feet.

N. B. Observed water surface elevation is for down stream side of bridge. Head loss due to the bridge is included in the section above.

Explanation of Computations (See next page).

EXPLANATION OF COMPUTATIONS

Column (a) and (b) are taken from profile and placed here for reference in other computations. (c) is hydraulic radius and is equal to area divided by wetted perimeter. Hyd. Rad. (c) and area (d) were taken from curves shown on the profiles. (e) (f) (g) are three factors which together with (c) exists in equilibrium for any section. They comprise Kutters formula and are arranged in tables for convenient use. (h) is the velocity head and is the vertical distance from the water surface to the energy gradient. It is also the distance a particle of water or any object would have to fall in order to attain a vertical velocity equal to the velocity of the water passing that point as given in column (g). It is derived from the law of falling bodies $V^2=2gh$ where "g" is acceleration due to gravity.

Column (i) is the average slope of the energy gradient multiplied by the distance between stations. (j) is difference in water surface above and below bridge. This is assumed for convenience to be a loss in energy gradient elevation which is not correct in theory.

Check on the work is contained in columns (k) (l) and (m). (k) must equal computed water surface elevation (l) plus velocity head h^v (column h). Change in elevation of (k) is by sum of head losses (i) plus (j). Changes in the value of "n" will affect (f) and (i) so that (l) will agree with (m). Where (m) is not known "n" must be assumed. Then changes in (l) must be made until the head losses (i) and (j) will produce a water surface elevation (l) corresponding to (c) and (d).

Probable High Water Marks: This same condition appears in computations for large floods. A 1904 flood repeated under present conditions, as computed from high water marks found below the city where conditions have not materially changed, would reach a foot higher on the gage than it did then. An 18,000 second-foot flood, if conditions developed as computed, would rise four feet higher than the 1927 flood. Of course, this is little better than a scientific guess since it has not yet occurred and no high water marks are available. It was obtained by trying water surface elevations in the computations until the energy gradient was practically parallel with that computed for the 1904 flood with a slight divergence upstream. Mr. Stratton, in his irrigation report on the Mouse River, gives a figure for the elevation of this sized flood which is 0.6 feet higher.*

FLOOD DAMAGES

The great building activity in the Mouse River bottoms at Minot occurred after the 1904 flood while the river was quiescent for eleven years and thus encouraged a sense of unwarranted security. The flood in 1927 was the third of a series of biennial floods of about the same size which is indeed a freak of Nature, but a smaller flood again in 1928 put on the cap sheaf. The city is fully aroused to the seriousness of its flood hazard problem.

It is the earnest solicitation of this Department that this interest be crystallized into concrete action before it becomes dissapated, especially should the Mouse River become quiescent again for a few years. When it arouses itself the next time the city may not escape so easily.

Estimate of Damages: Let us assume for purposes of estimate that the city has been in existence in its present size since the flood of 1882

*Exhibit F, Report on Mouse River Project, Stratton, 1927, Bureau of Reclamation, Department of Interior.

or about 47 years. During that time it would then have experienced ten floods. Three of these would have overtopped any feasible system of diking along the present river channel. This is assuming that a 4000 second-foot flood,—which is 0.4 feet higher than the 1927 stage,—is the largest that can be thus handled. Two of these floods, the 1904 and the 1882 flood would have cost the city a half million dollars apiece, surely a conservative estimate. The 1902 flood would cost, say, $150,000 and the seven other floods $40,000 each. The total is roughly $1,180,000 in 47 years or about $25,000 a year. This is interest at 8% on three million dollars, and a continual outlay with no end in sight. In fact it may be decidedly increased in the next fifty year period if a few wet years intervene.

Temporary diking has saved the city once and is held by many to be sufficient. Mr. Wolff in his report has shown that the cost of cleaning and diking the present river channel to make it carry a little more water is merely a continuation of the present policy of throwing money into the river. There is no protection worthy of the name that does not include a probable maximum flood.

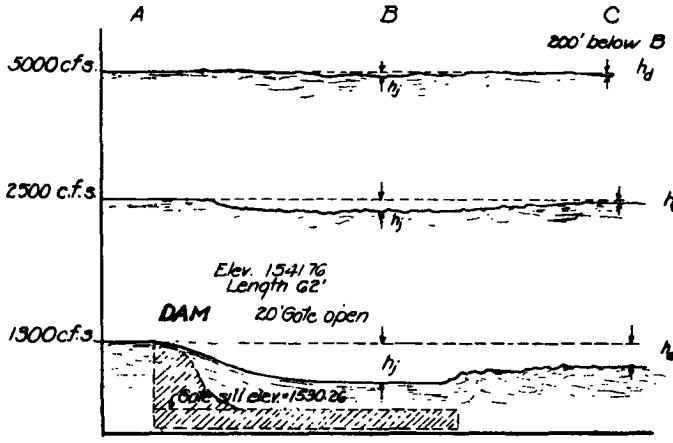
MISCELLANEOUS MOUSE RIVER PROBLEMS

The Park Board Dam

A word has been promised relative to the effect of the Park Board Dam upon the present flood stages. This has been a bone of contention since it was built in 1922 whenever highwater occurred. On the face of the records there is ground for complaint. The 1916 flood, which was the last one before the dam was built, was rated at 4,340 second-feet with a gage height of 19.05 feet. The flood of 1923, the year after the dam was built, was rated at 3,460 second-feet or about 900 second-feet less, while the gage height was 19.65 or 0.6 feet higher. Plaintiffs naturally figured that the dam made the difference.

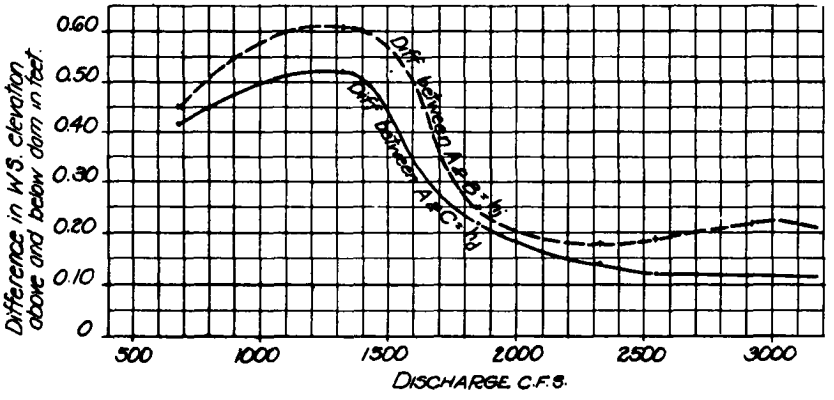
Dean Chandler has explained the discrepancy, however. No flood of any size occurred between 1904 and 1916. The 1904 measurements were uncertain because the river was so torn up by that flood. In 1916. he got a measurement before the crest arrived but the crest got by without a measurement. So his rating curve for quantities above what he measured had to be more or less of an approximation. He got the necessary measurements in 1923 and reconstructed his rating curve. Applying it to the 1916 gage height gives a crest discharge of only about 3,140 second-feet. From that it is evident that the stream flow data offer no actual light upon the subject.

The effect of a dam upon a stream is to raise the water surface above the original elevation in the form of a wedge, the maximum rise being right at the dam and the tapered end extending upstream. It is known as a back water curve. Measurement of this difference at the dam was made for several stages and are given in Figure 11. It was



OBSERVED DATA

DATE	DISCHARGE c.f.s	WATER SURFACE ELEVATIONS At "A"	At "B"	At "C"	A-B = h_j	A-C = h_d
April 27, 1928	694	1537.43	1536.98	1537.01	0.45	0.42
April 20, 1928.	1313	1542.42	1541.81	1541.90	0.61	0.52
April 18, 1927	1850	1544.04	1543.79	1543.82	0.25	0.22
April 16, 1928	2320	1547.31	1547.13	1547.17	0.18	0.14
April 15, 1928	2546	1547.87	1547.68	1547.75	0.19	0.12
April 11, 1928	2927	1548.65	1548.43	1548.53	0.22	0.12



Maximum obstruction to river occurs when water just begins flowing over dam.

STATE OF NORTH DAKOTA
DEPARTMENT OF STATE ENGINEER
EFFECT OF PARK BOARD DAM ON MOUSE R. STAGES
Drawn by R.E.K. & H.W. Beam m'd'
Checked by: R.E.K. Approved
2-D-25 Bismarck, N.D. June 15, 1928

FIG 11

greatest when the water was just going over the top of the dam. The amount was about six inches.

The reason for this will be seen if one will follow the water as it rises behind the dam. Very small flows, of course, go thru the gate opening without obstruction. But as the water rises the amount of the cross section of the stream which is blocked by the dam remains practically the same until the crest of the dam is reached. Or, one might put it another way and say that that area of the dam which is wet compared to the total cross section of the river just upstream from the dam remains practically constant. For instance, at a water surface elevation of about 2 feet below the crest 64% of the cross sectional area of the channel is in concrete. Just at the crest of the dam 66% of the cross section is in concrete.

But when the water begins to rise above the crest and flows over it then the cross section of the stream increases but the area in the dam remains the same of course. When the water has reached the 1927 stage only 25% of the total cross section of the stream is in the dam.

The obstructive effect is not directly proportional to these percentages of constriction but may be considered for easy computation more nearly proportional to their squares. The squares of 66 and 25 are in the ratio of about 7 to 1. The obstructive effect of the dam upon the river at the 1927 flood stage is according to that about one-seventh of what it is when the water is just going over the crest. Actual measurements show about one-fifth. In any event it is small, about an inch or so, and that tapering off less and less upstream.

Land Drainage on Canadian Watershed

The Souris River (Mouse on our side of the line) in the vicinity of Yellow Grass, Sask., has been confined in a ditch about 13 miles long and an area of about 10,000 acres of land has been reclaimed and become a prosperous farming section. A question was raised as to the effect of what is presumed to be an increased run-off facility upon the crest of the floods at Minot.

It is the opinion of the writer that the effect is negligable. First, the area benefitted, 10,000 acres, is very small compared to the area of the watershed that must be covered to produce even a moderate flood. If one-third of the water-shed produced the 1927 flood that would be about 2½ million acres. Ten thousand acres is four-tenths of one percent. That is closer than that sized flood can be measured with a current meter. Second, this drainage district is located about 10 miles above Weyburn, see Figure 12, or about 340 miles upstream by river channel above the city. That is a long distance for a small swell to travel and be detected.

Finally argument can be advanced that drainage ditches actually tend to reduce the crest of a flood to a certain more or less theoretical

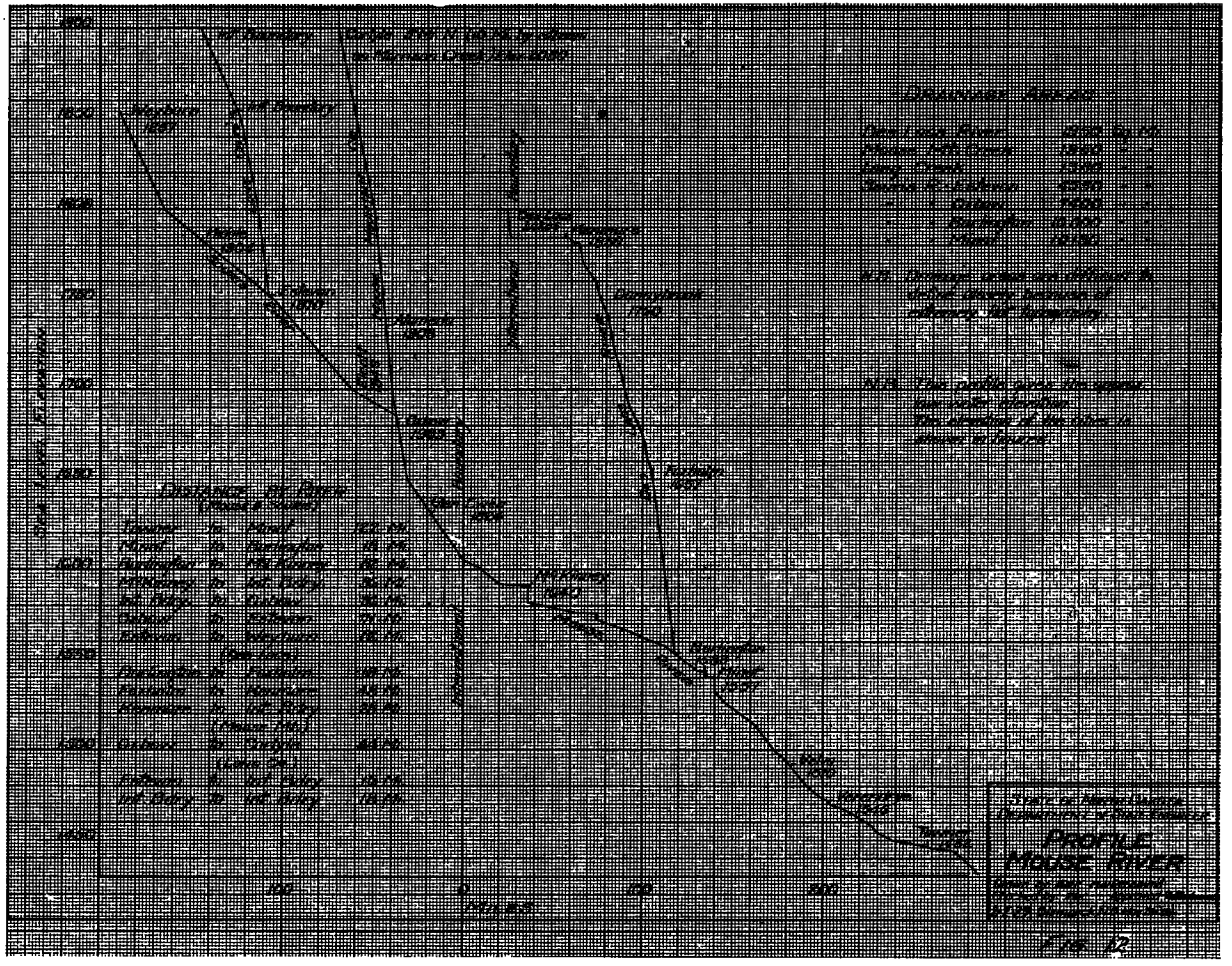


Fig. 12. Profile of Mouse River and Tributaries.

degree rather than increase it. As previouly explained, the saturation of the subsoil is one of the dominant influences affecting spring run-off. The snow water is first going to saturate the soil before the rest of it can run off. The effect of drainage ditches, if they function at all, is to lower the ground water table and increase the subsoil storage capacity. The spring run-off is reduced, therefore, by the amount that first goes down to fill this additional subsoil capacity.

Incidentally there are almost 1½ million acres of land within a half mile of drainage ditches in North Dakota and Minnesota on the watershed of the Red River of the North which occasionally causes flood damage in Canada.* About 300,000 acres of it is in North Dakota.

Flood Prediction

Floods of any size must come thru the newly established gaging station at Oxbow, Sask., 172 miles above Minot. Daily gage readings are sent to the City Engineer during the flood season. Arrangements have been made whereby this Department receives the weather data directly from the six Canadian stations. They are,

Carlyle, Sask.
Francis, Sask.
Grenfell, Sask.
Ceylon, Sask.
Midale, Sask.
Yellow Grass, Sask.

This should give us an idea of the soil conditions and the amount of moisture available on the watershed for spring run-off. The maximum melting day, if at all pronounced, will be readily recognized. Then we should have about three weeks warning at least. The total amount can be estimated from the curves, Figure 3, but the amount of the crest flow is a refinement not warranted yet except in a very general way based upon the crest discharge at stations up stream from Minot. This will give the curves of Figure 3 a rigid test with a chance to modify and improve them.

*Simons and King, op. cit., Page 57.

PART III

DAILY DISCHARGE OF NORTH DAKOTA RIVERS

Thirteenth Biennial Report
of
State Engineer of
North Dakota

DAILY DISCHARGE OF NORTH DAKOTA RIVERS

1923-1927

The following tabulation is furnished by Dean E. F. Chandler, (P. O. University, North Dakota) Hydraulic Engineer, U. S. Geological Survey, who has had charge of this region since 1903.

Data prior to 1923 are published in various Water Supply papers of the U. S. Geological Survey, index of which is given in the previous biennial report.

The letters at the foot of the monthly columns indicate Dean Chandler's opinion of their accuracy. A, B and C being presumably correct, within 5%, 10% and 15% respectfully. D and E are partial or entire estimates. These are subject to final review by the Washington office of which Nathan C. Grover is Chief Hydraulic Engineer. They are published usually about four years in arrears by the Survey.

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HUDSON BAY DRAINAGE

MISSOURI RIVER DRAINAGE

HUDSON BAY DRAINAGE

BOIS DES SIOUX RIVER NEAR TENNEY, MINN.

LOCATION.—Near center of Sec. 22, T. 130 N., R. 47 W. at Soo Railway bridge 5 miles west of Tenney, Wilkin County, Minn., and 2 miles east of Fairmount, North Dakota.

DRAINAGE AREA.—1,460 square miles.

RECORDS AVAILABLE.—April 1, 1919 to September 30, 1927.

GAGE.—Vertical staff attached to the piling pier of the Soo Railway bridge; read by Math Schmit and Harry Voss.

DISCHARGE MEASUREMENTS.—Made from highway bridge, from railway bridge, or by wading.

CHANNEL AND CONTROL.—Bed composed of silt and fine clay, overgrown with weeds, which clog the channel by an amount varying with the season. No considerable shifts in channel likely because normal velocities insufficient to erode.

EXTREMES OF DISCHARGE.—1919-1927: Maximum discharge, 390, second-feet April 22, 1922; no flow during several long periods.

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

DIVERSIONS.—None.

REGULATION.—There are no reservoirs or power plants which affect the flow. The station is 15 miles below the outlet of Lake Traverse with no considerable tributaries entering between, so that abrupt changes in discharge are unlikely. Very extensive ditching and drainage work in the tributary area during the past 15 years may affect the distribution of flow.

ACCURACY.—Stage-discharge relation not permanent; affected by ice and by heavy aquatic growth. Rating curve fairly well defined below 400 second-feet. Gage read to half-tenths two or three times a week. Daily discharge ascertained by applying gage height to rating table by direct or indirect method and by interpolating for days when gage was not read. Records poor.

DAILY DISCHARGE IN SECOND-FEET OF BOIS DES SIOUX RIVER NEAR TENNEY, MINN., FOR THE YEAR ENDING SEPT. 30, 1924

Dry channel throughout except May 26, when 0.6 c. f. s. is recorded.

DAILY DISCHARGE IN SECOND-FEET OF BOIS DES SIOUX RIVER NEAR TENNEY, MINN., FOR THE YEAR ENDING SEPT. 30, 1925.

Channel dry or water merely standing in pools throughout entire year.

DAILY DISCHARGE IN SECOND-FEET OF BOIS DES SIOUX RIVER NEAR TENNEY, MINN., FOR THE YEAR ENDING SEPT. 30, 1926

March	8	9	10	11	12	13	14	15	16	17	18	19
c. f. s.	11	11	10	8	6	4	4	11	18	25	32	32

March	20	21	22	23	24	25	26	27	28	29
c. f. s.	30	28	27	23	24	22	18	14	10	5

Monthly discharge for March 1926 ..... Mean = 12 c. f. s.
Run-off = 744 ac-ft.

DAILY DISCHARGE IN SECOND-FEET, OF BOIS DES SIOUX RIVER NEAR TENNEY, MINN. FOR THE YEAR ENDING SEPTEMBER 30, 1927

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	D	D	.....	.....	P	4	.....	.....	.....	.....	.....	4
2	.....	.....	.....	.....	.....	.....	70*	16	.....	32	.....	.....
3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9	4
4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	D	.....	.....	D	.....	.....	.....	.....	.....	25	4	4
7	.....	.....	.....	.....	.....	4	58	13	.....	.....	.....	.....
8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	.....	.....	.....	.....	.....	.....	.....	.....	.....	25	4	.....
10	.....	D	D	.....	P	.....	.....	.....	.....	.....	.....	11
11	.....	.....	.....	.....	.....	.....	44	.....	16	.....	.....	.....
12	D	.....	.....	D	.....	.....	.....	.....	.....	.....	.....	.....
13	.....	.....	.....	.....	.....	.....	44	.....	.....	.....	2	.....
14	.....	.....	.....	.....	.....	.....	.....	.....	16	.....	.....	4
15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
16	.....	.....	.....	.....	.....	.....	.....	.....	.....	22	.....	.....
17	.....	.....	.....	D	.....	11	.....	11	19	.....	.....	4
18	.....	.....	D	.....	.....	.....	.....	.....	19	.....	.....	.....
19	.....	.....	.....	.....	P	.....	36	.....	.....	22	.....	.....
20	.....	D	.....	.....	.....	.....	.....	11	25	.....	1	4
21	.....	.....	D	.....	.....	.....	.....	.....	.....	.....	.....	.....
22	D	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
23	.....	.....	.....	D	1	25	.....	.....	.....	19	.....	.....
24	.....	.....	.....	.....	.....	.....	32	9	.....	.....	.....	4
25	.....	D	.....	.....	.....	.....	.....	9	28	13	.....	.....
26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
27	.....	.....	.....	.....	.....	.....	19	.....	.....	.....	1	.....
28	.....	.....	.....	D	.....	.....	.....	.....	32	.....	.....	.....
29	.....	.....	D	.....	.....	44	.....	.....	.....	.....	.....	.....
30	D	D	.....	.....	.....	.....	16	.....	.....	11	.....	.....
31	D	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....
Accuracy	A	A	A	A	B	C	D	D	D	C	C	C

Note—*Gage height 3.5 ft. D—channel dry. P—standing in pools.

MONTHLY DISCHARGE OF BOIS DES SIOUX RIVER NEAR TENNEY, MINN.

Month	Discharge in second-feet			Run-off in acre-feet
	Maximum	Minimum	Mean	
1926-1927				
October	0	0	0	0
November	0	0	0	0
December	0	0	0	0
January	0	0	0	0
February	3	1	0	24
March	44	4	17	1,070
April	70	16	42	2,480
May	16	9	12	716
June	32	16	20	1,220
July	32	11	21	1,310
August	9	0	3	180
September	11	3	5	284
The year	70	0	10	7,280

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

LOCATION—Above dam half a 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.—May 27, 1901, to September 30, 1927.

GAGE.—Vertical staff attached to tree on left bank 6 rods above dam; 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.—1901-1927; Maximum open-water stage recorded, 17.34 feet July 11, 1916 (discharge 7,740 second-feet); minimum stage, 0.50 feet September 3, 1924 (discharge 8 second-feet).

ICE.—Stage-discharge relation affected by ice.

DIVERSION.—None.

REGULATION.—No power plants or storage above the station nearer than 60 miles, and storage not great enough ordinarily to affect 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 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.

DAILY DISCHARGE, IN SECOND-FEET, OF RED RIVER OF THE NORTH AT FARGO, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1924

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	98	98	78	.....	.....	.....	125†	490	235†	175	109	43†
2	98	98	.....	.....	.....	.....	125	450	235	205	90	24
3	88	98	88	.....	.....	.....	138	430	235	235	108†	8
4	98	98	.....	.....	.....	.....	175	402†	228	220†	125	24
5	98	98	.....	60	.....	.....	205	375	220	205	112	35
6	88	98	.....	.....	.....	.....	235	340	235	190†	100	125
7	88	98	.....	69	.....	.....	252	305	235	175	100	102†
8	88	98	88	.....	.....	.....	340	270	228†	150	80	80
9	78	98	.....	.....	.....	.....	450	270	220	150	63	63
10	78	98	88	.....	.....	.....	450	305	205	150	56†	48
11	78	98	.....	.....	.....	.....	358	305†	205	150	48	63
12	88	98	.....	.....	.....	.....	270	305	205	175	48	80
13	88	104	.....	.....	.....	.....	252†	305	190	190†	42	100
14	83	109	.....	.....	.....	.....	235	288	190	205	63	100†
15	78	109	88	.....	.....	.....	220	270	190†	175	72	100
16	78	109	.....	.....	.....	.....	235	270	190†	150	63	100
17	78	109	78	.....	.....	.....	246	270	190	138	56†	125
18	78	109	.....	.....	.....	.....	205	270†	190	112	48	125
19	78	109	69	.....	.....	.....	205	270	190†	100	48	175
20	78	99	.....	.....	.....	.....	205†	270	190	168	48	125
21	78	88	.....	.....	.....	.....	205	270	190	235	42	102†
22	78	85	78	.....	.....	.....	205	252	190†	235	125	80
23	98	82	.....	.....	.....	.....	190	270	190	235	112	80
24	98	78	78	.....	.....	.....	205	270	190	205	116†	125
25	98	75	.....	.....	.....	.....	235	288†	175	150	121†	125
26	98	72	69	.....	.....	.....	270	305	175	112	125	150
27	98	69	.....	.....	.....	125	340	270	190	112†	162	125
28	98	71	12	.....	.....	.....	410	261†	252	112	125	112†
29	98	73	.....	.....	.....	125	490	252	214†	112	100	100
30	88	76	.....	.....	.....	.....	530*	244†	175	100	80	100
31	88	.....	.....	50	.....	125	.....	235	.....	100	61†	.....
Accuracy	B	B	C	D	D	D	A	A	A	A	A	A

Note—*Gage height 2.5 feet. Jan. 12 to Mar. 20, Fishway in dam removed during rebuilding, small opening in dam discharge estimated from adjoining stations and Weather Bureau records.
†No gage heights recorded.

DAILY DISCHARGE, IN SECOND-FEET, OF RED RIVER AT FARGO, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1925

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	100	205	74	63	59	91	375	340	340	340	175	100
2	125	178	80	63	56	91	490	340	270	410	175†	80
3	150	150	64	63	52	72	670	340†	235	410	175	80
4	125	115	48	63	48	63	575	340	270	472†	175	100
5	112	80	64	63	59	75	422†	235	270	534†	175	125
6	100	125	80	63	69	88	270	175	235	575	150	118†
7	100	205	64	63	80	100	235	175	232†	490	175	109†
8	100	188	48	58	80	112	235	305	270	410	175	100
9	175	134	64	53	80	125	235	305	375	340	162†	100
10	175	80	80	48	80	138	235	270†	510	305	150	125
11	205	80	80	48	80	150	270	235	645	305	150	150
12	228	80	80	48	80	158	252†	270	720	330†	175	175
13	252	80	80	48	80	167	235	235	775	375	150	162†
14	235	125	72	48	80	175	235	205	747†	375	125	150
15	252	150	63	53	76	162	205	175	720	340	80	125
16	252	115	63	58	72	150	205	175	720	270	90	125
17	220	80	63	63	68	142	205	175†	720	235	100	175
18	162	80	63	56	68	133	270	175	720	205	125	205
19	131	125	63	49	75	125	270†	150	775	180†	100	150
20	100	125	63	42	88	168	270	150	885*	175	100	125†
21	100	150	54	35	100	150	235	150	885†	175	125	100
22	125	220	44	44	91	178	205	175	885	175	125	80
23	175	198	34	54	82	205	235	205	775	150	132†	125
24	235	175	24	63	72	238	340	220†	670	150	150	205
25	205	128	32	60	63	270	375	235	620	175	150	205
26	178	80	40	56	75	270	305†	205	620	162†	125	125
27	150	74	43	52	88	270	235	235	575	150	100	125†
28	100	69	52	48	100	288	270	235	532†	125	125	125
29	100	63	56	53	.....	314	270	270	490	150	150	100
30	150	39	60	58	.....	340	270	297†	410	150	125†	100
31	205	.....	63	63	.....	340	.....	323†	.....	162†	100	.....
Accuracy	A	B	C	C	C	B	A	A	A	A	B	B

Note—*Gage height 3.2 ft. Stout correction for ice=0.1 ft., Dec. 1, to March 24.
†No gage heights recorded.

DAILY DISCHARGE, IN SECOND-FEET, OF RED RIVER AT FARGO, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1926

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	205	138	125	50	80	125	575	305	235	150	48†	63
2	205	150	100	50	.....	.....	530	288†	270	150	48	48
3	175	150	100	48	.....	.....	490	270	270	150	35	35
4	150	175	125	.....	.....	175	490†	305	305	150†	63	24
5	125	175	100	.....	.....	.....	490	340	305	150	63	28†
6	125	150	100	.....	80	.....	450	340	255†	125	63	31†
7	125	175	100	.....	.....	.....	375	270	205	125	80	35
8	205	175	93	.....	80	175	340	235	205	48	64†	35
9	235	175	87	125	.....	.....	340	252†	235	35	48	35
10	305	150	80	.....	.....	.....	375	270	235	48	35	48
11	255	150	85	.....	.....	.....	392†	270	205	42†	35	63
12	205	150	90	.....	.....	175	410	305	175	35	24	72†
13	205	144	95	80	.....	.....	530	270	190†	35	24	80
14	175	138	100	.....	.....	.....	410	235	205	48	35	125
15	150	131	88	.....	125	175	530	205	205	63	42†	100
16	150	125	75	125	.....	.....	575	190†	175	63	48	100
17	175	125	63	.....	.....	.....	490	175	205	63	48	80
18	187	125	63	.....	.....	.....	432†	175	205	63	35	125
19	199	150	63	.....	.....	.....	375	205	175	63	48	102†
20	211	150	63	.....	150	340	340	235	190†	48	63	80
21	223	125	63	.....	.....	.....	270	235	205	63	48	80
22	235	138	63	.....	.....	910	305	235	175	63	56†	63
23	205	150	60	100	.....	1,240	305	235†	175	48	63	63
24	150	125	60	.....	80	1,520*	305	235	205	63	63	63
25	162	80	60	.....	.....	1,300	322†	205	175	56†	63	80
26	175	102	55	.....	.....	1,300	340	235	205	48	80	80†
27	175	125	55	.....	.....	1,240	305	235	190	48	150	80
28	125	175	55	.....	.....	1,050	305	235	175	48	150	63
29	80	150	55	100	.....	860	270	205	175	35	106†	80
30	125	125	55	.....	.....	720	340	215†	150	48	63	80
31	125	.....	55	.....	.....	620	.....	225†	.....	48	63	.....
Accuracy	B	B	C	C	C	C	B	B	B	B	C	C

Note—*Gage height 4.3 ft. Stout correction, 0.1 foot, applied to gage-heights Jan. 1, to Mar. 31, for effect of ice.
†No gage heights recorded.

DAILY DISCHARGE, IN SECOND-FEET, OF RED RIVER AT FARGO, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1927

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	66	83	38	.....	.....	402	1,170	466†	632	488	254	194
2	66	66	38	.....	.....	402	1,370r	444	582	444	254	223
3	66	66	66	38	.....	362	1,370	444	632	444†	254	223
4	66	102	38	.....	38	288	1,370	444	632	444†	223	213†
5	66	102	.....	.....	.....	288	1,696	402	632†	444	223	204†
6	122	144	.....	.....	.....	306	1,440	402	582	444	194	194
7	122	133	.....	.....	.....	324	1,300	444	632	402	209†	194
8	102	122	51	.....	.....	362	1,040	466†	582	362	223	144
9	144	83	.....	.....	.....	402	1,100	488	582	324	223	168
10	133	66	66	66	.....	444	1,040†	488	582	343†	223	223
11	122	66	66	.....	66	488	974	488	582	362	194	223†
12	102	83	.....	.....	.....	582	974	488	582†	362	194	223
13	102	102	51	.....	.....	632	738	488	632	324	144	254
14	83	92	.....	.....	.....	684	738	488	738	324	144†	254
15	102	83	.....	18	.....	1,100	794	488†	738	324	144	288
16	122	102	38	.....	.....	1,600	738	488	738	324	144	288
17	102	83	.....	.....	27	2,270	794†	534	738	324†	144	288
18	83	83	.....	.....	.....	2,470	852	534	794	324	122	306†
19	51	83	.....	.....	.....	2,650*	912	534	766†	324	144	324
20	102	66f	.....	38	.....	2,220	912	534	738	324	168	254
21	122	58	18	.....	27	1,780	852	534	684	324	168	223
22	122	51	.....	38	.....	1,170	794	534†	632	324	168	254
23	122	38	.....	.....	83	852	738	534	582	324	168	223
24	112	51	51	.....	122	738	684†	534	582	306†	144	194
25	102	45	.....	.....	.....	632	632	582	582	288	144	209†
26	83	38	.....	.....	194	444	582	632	558†	288	168	223
27	102	51	.....	51	.....	423	489	684	534	324	194	223
28	122	51	66	.....	254	402	488	632	582	288	194	223
29	144	51	.....	18	.....	362	488	632†	534	254	223	194
30	122	38	.....	.....	.....	402	488	632†	488	223	194	194
31	102	.....	38	.....	.....	738	.....	632	.....	238†	194	.....
Accuracy	B	B	C	C	C	C	B	B	B	B	B	B

Note—*Gage height 5.4 ft. f—frozen across channel. r—ice running. Stout correction applied for effect of ice on control (crest of dam) Dec. 1 to Feb. 25.
†No Gage heights recorded.

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

Month	Discharge in second-feet			Run-off in acre-feet
	Maximum	Minimum	Mean	
1923-1924				
October	98	78	88	5,400
November	109	69	93	5,560
December	.....	.....	73	4,480
January	.....	.....	52	3,180
February	.....	.....	50	2,880
March	.....	.....	72	4,410
April	530	125	267	15,900
May	490	235	302	18,600
June	235	175	205	12,200
July	235	100	165	10,200
August	162	42	85	5,230
September	175	8	91	5,440
The year	530	8	128	93,400
1924-1925				
October	252	100	162	10,000
November	220	63	124	7,390
December	80	24	60	3,700
January	63	42	55	3,370
February	100	48	75	4,166
March	340	63	173	10,600
April	670	205	297	17,600
May	340	150	236	14,500
June	885	235	563	33,500
July	575	125	284	17,500
August	175	80	138	8,510
September	205	80	129	7,670
The year	885	24	191	138,000
1925-1926				
October	305	80	179	11,000
November	175	80	143	8,520
December	125	55	78	4,820
January	125	48	96	5,900
February	150	80	104	5,770
March	1,520	125	490	30,150
April	575	270	400	23,810
May	340	175	246	15,140
June	305	150	209	12,460
July	150	35	72	4,410
August	150	24	60	3,670
September	125	24	68	4,050
The year	1,520	24	179	129,700
1926-1927				
October	144	51	103	6,300
November	144	38	76	4,580
December	66	18	46	2,820
January	66	18	40	2,420
February	254	27	70	3,900
March	2,650	288	846	52,000
April	1,690	488	918	54,600
May	684	402	520	32,000
June	794	488	629	37,400
July	488	223	343	21,100
August	254	122	186	11,500
September	324	144	228	13,600
The year	2,650	18	334	242,000

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, Minn., half a mile below mouth of Red Lake River.

DRAINAGE AREA.—25,500 square miles.

RECORDS AVAILABLE.—May 26, 1901, to September 30, 1927. 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 Great Northern Railway bridge a quarter of a mile above gage.

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

EXTREMES OF DISCHARGE.—1882-1927: Maximum stage recorded, 50.2 feet April 10, 1897 (discharge, 43,000 second-feet); minimum discharge 100 second-feet during early part of February, 1912 (stage-discharge relation 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.

DAILY DISCHARGE, IN SECOND-FEET, OF RED RIVER OF THE NORTH AT GRAND FORKS, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1924

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	505	424	526	311	200	300	1,400	2,420	1,350	970	443	345
2	505	424	526	322	205	311	1,400	2,530*	1,310	1,050	443	345
3	477	424	526	315	205	322	1,400	2,470	1,260	1,090	443	322
4	477	424	526	307	205	322	1,440	2,360	1,220	1,130	443	279
5	477	424	555	300	197	322	1,580	2,300	1,220	1,180	443	240
6	477	424	585	300	189	315	1,630	2,250	1,180	1,180	443	205
7	477	450	615	300	189	307	1,680	2,200	1,180	1,130	470	205
8	477	450	615s	300	189	300	1,730	2,090	1,180	1,050	470	205
9	450	477	585	300	189	311	1,780	1,980	1,180	970	498	189
10	450	505	585	280	189	322	1,830	1,930	1,130	930	470	222
11	450	505	555	260	189	334	1,880	1,880	1,130	891	470	240
12	450	533	555	240	206	345	1,930	1,980	1,090	891	443	259
13	450	533	498f	231	222	353	1,980	2,090	1,090	780	443	279
14	450	561	417	222	222	353	2,140	2,140	1,050	745	443	300
15	477	561	392	214	222	368	2,140	2,200	1,050	711	443	300
16	477	590	392	205	222	330	2,090	2,200	1,010	678	417	300
17	505	590	368	205	222	392	1,980	2,140	1,010	646	417	322
18	533	619	368	205	222	431	1,830	2,090	970	615	417	368
19	533	619	345	205	222	470	1,680	2,090	930	585	417	368
20	505	590	345	197	222	518	1,680	2,040	891	585	417	368
21	505	561	322	189	211	567	1,780	1,980	930	555	417	417
22	477	533	322	197	200	615	1,930	1,930	970	555	417	443
23	477	505	322	205	182	663	2,090	1,880	970	526	392	443
24	477	477	322	200	197	711	1,980	1,830	970	526	392	443
25	477	477	322	189	205	782	1,730	1,780	930	498	392	443
26	477	450	345	189	232	853	1,580	1,730	930	498	392	417
27	477	450	345	187	259	945	1,540	1,680	891	470	368	417
28	477	477	345	174	273	1,040	1,580	1,630	891	470	368	447
29	477	477	322	187	286	1,130	1,880	1,540	853	470	368	470
30	450	505	322	189	.....	1,220	2,200	1,490	853	443	368	470
31	450	.....	300	194	.....	1,310	.....	1,400	.....	443	345	.....
Accuracy	A	A	C	C	C	D	A	A	A	A	A	A

Note—*Gage height 8.2 ft. s—frozen at margin. f—frozen.

DAILY DISCHARGE, IN SECOND-FEET, OF RED RIVER AT GRAND FORKS, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1925

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	470	498	.....	.....	.....	.....	6,770	1,830	1,400	4,790	498	498
2	470	443	.....	.....	.....	.....	6,090	1,880	1,310	4,610	498	498
3	470	443	.....	.....	.....	.....	5,270	1,930	1,350	4,380	470	443
4	443	392	.....	.....	.....	.....	4,200	1,930	1,350	4,140	470	443
5	443	392	.....	.....	.....	.....	3,730	1,880	1,490	3,910	443	417
6	470	417	.....	.....	.....	.....	3,390	1,880	2,300	3,620	443	443
7	498	417	.....	.....	.....	.....	2,870	1,780	3,000	3,330	443	470
8	498	417	.....	.....	.....	.....	2,530	1,780	4,380	2,980	443	470
9	498	392	.....	.....	.....	.....	2,250	1,680	6,630	2,580	443	470
10	498	392	.....	.....	.....	.....	2,040	1,580	7,640	2,530	417	417
11	498	392	.....	.....	.....	.....	1,880	1,490	8,320	2,530	443	417
12	498	392	.....	.....	.....	.....	1,730	1,350	9,690*	2,420	443	417
13	526	392	.....	.....	.....	.....	1,490	1,260	9,120	2,470	417	443
14	585	392	.....	.....	.....	.....	1,400	1,220	8,950	2,420	417	443
15	585	392	.....	.....	.....	.....	1,260	1,220	8,870	2,300	417	498
16	615	.....	.....	.....	.....	.....	1,260	1,180	8,790	2,250	392	498
17	615	.....	.....	.....	.....	.....	1,180	1,180	8,790	2,040	392	526
18	646	.....	.....	.....	.....	.....	1,090	1,180	7,940	1,930	368	526
19	678	.....	.....	.....	.....	.....	970	1,050	7,640	1,730	368	555
20	678	.....	.....	.....	.....	.....	646	1,050	7,050	1,630	368	555
21	678	.....	.....	.....	.....	.....	646	1,010	7,050	1,400	368	555
22	615	.....	.....	.....	.....	615	711	1,050	6,700	1,260	368	470
23	585	.....	.....	.....	.....	1,310	930	1,090	6,500	970	392	470
24	585	.....	.....	.....	.....	1,580	1,440	1,130	6,030	891	392	498
25	585	.....	.....	.....	.....	2,360	1,540	1,310	5,710	711	392	526
26	615	.....	.....	.....	.....	3,330	1,680	1,440	5,330	615	443	526
27	615	.....	.....	.....	.....	4,320	1,680	1,400	5,090	585	443	555
28	585	.....	.....	.....	.....	5,770	1,680	1,310	4,910	526	443	526
29	555	.....	.....	.....	.....	6,030	1,780	1,180	4,910	526	555	526
30	555	.....	.....	.....	.....	6,430	1,780	1,050	4,790	498	498	526
31	498	.....	.....	.....	.....	6,630	.....	1,260	.....	498	526	.....
Accuracy	B						B	B	B	B	D	D

Note—*Gage height 19.0 ft.

DAILY DISCHARGE, IN SECOND-FEET, OF RED RIVER AT GRAND FORKS, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1926

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	555	678	646	.....	.....	.....	6,490	1,400	.....	.....	.....	.....
2	555	678	646	.....	.....	.....	490	1,350	.....	.....	.....	.....
3	555	678	646	.....	.....	600	5,770	1,310	.....	.....	.....	.....
4	526	615	646	.....	.....	.....	5,390	1,310	.....	.....	.....	.....
5	526	585	646	.....	.....	.....	5,160	1,310	.....	.....	.....	.....
6	526	585	646	.....	.....	.....	4,920	1,310	.....	.....	.....	.....
7	585	585	646	.....	.....	.....	4,680	1,260	.....	.....	.....	.....
8	585	585	646	.....	.....	600	4,450	1,260	.....	.....	.....	.....
9	615	555	646	.....	.....	.....	4,220	1,090	.....	.....	.....	.....
10	555	555	646	.....	.....	.....	4,020	1,090	.....	.....	.....	.....
11	555	615	646	.....	.....	.....	4,220	1,090	.....	.....	.....	.....
12	615	615	646	.....	.....	.....	4,610	1,010	.....	.....	.....	.....
13	646	615	646	.....	.....	600	5,090	1,000	.....	.....	.....	.....
14	678	615	646	.....	.....	.....	5,090	1,000	.....	.....	.....	820
15	678	615	636	.....	.....	.....	5,090	1,000	.....	.....	.....	.....
16	678	615	625	.....	.....	850	4,730	.....	.....	.....	.....	.....
17	745	615	615	.....	.....	930	4,320	.....	.....	.....	.....	.....
18	745	615	615	.....	.....	896	3,970	1,000	.....	.....	.....	.....
19	745	646	615	.....	.....	1,050	3,970	.....	.....	.....	.....	.....
20	711	745	615	.....	.....	1,090	3,270	.....	.....	.....	.....	.....
21	711	711	615	.....	.....	1,490	3,270	.....	.....	.....	.....	.....
22	711	711	615	.....	.....	1,830	2,420	.....	.....	.....	.....	.....
23	780	711	608	.....	.....	2,580	2,250	1,000	.....	.....	.....	.....
24	780	711	600	.....	.....	4,850	2,250	.....	.....	.....	.....	.....
25	780	745	592	.....	.....	6,290	1,680	.....	.....	.....	.....	.....
26	780	780	585	.....	.....	6,910	1,680	.....	.....	.....	.....	.....
27	816	816	585	.....	.....	7,490	1,580	.....	.....	.....	.....	.....
28	816	816	585	.....	.....	7,720*	1,580	1,000	.....	650	.....	.....
29	780	646	585	.....	.....	7,640	1,580	.....	.....	.....	.....	.....
30	745	646	585	.....	.....	7,490	1,440	.....	.....	.....	.....	.....
31	745	.....	585	.....	.....	7,340	.....	1,000	.....	.....	.....	.....
Accuracy	C	C	C	D	D	D	C	D	D	D	D	D

Note—*Gage height 18.1 ft. Stout corrections applied to gage-heights Nov. 8 to Mar. 30 for effect of ice in channel and Jan. 1 to May 13 for effect of dam being constructed one mile below gage and offering increasing obstruction. Jan. Feb. May 13 to Sept. 30 estimated from records of tributary stations.

DAILY DISCHARGE, IN SECOND-FEET, OF RED RIVER OF GRAND FORKS, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1927

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	816	891	555	.....	279	240	5,520	4,910	7,340	2,980	1,260	1,050
2	816	745	555	360	.....	.....	6,220	4,730	6,980	2,980	1,260	1,050
3	816	816	555	345	.....	.....	7,270	4,910	6,630	2,840	1,400	1,010
4	816	816	526	.....	.....	.....	8,320	5,030	6,290	2,700	1,400	1,010
5	816	780	526	.....	300	646	9,280	5,960	6,290	2,700	1,260	1,010
6	816	711	526	.....	.....	874	9,690	6,290	5,960	2,700	1,260	1,010
7	816	678	498	.....	.....	1,080	9,690	6,290	5,960	2,700	1,260	1,010
8	816	678	498	345	345	1,310	9,280	6,290	5,640	2,700	1,180	1,010
9	816	711	498	.....	.....	1,400	9,200	6,290	5,330	2,700	1,260	1,010
10	816	718	470	368	.....	1,400	8,790	6,430	5,090	2,700	1,260	1,010
11	816	725	470	.....	.....	1,580	9,120	7,860	4,970	2,420	1,260	1,010
12	816	731	443	.....	300	1,780	9,690	8,870	4,670	2,420	1,260	1,010
13	816	738	443	.....	.....	2,200	10,550*	9,360	4,440	2,420	1,180	1,010
14	816	745	443	.....	.....	2,700	9,780	9,440	4,140	2,420	1,260	1,010
15	816	816	417	368	259	3,440	9,690	9,440	4,140	2,250	1,180	1,010
16	816	780	417	.....	.....	4,790	9,610	9,360	3,910	2,250	1,180	1,010
17	853	1,090	417	.....	.....	6,430	9,120	9,200	3,910	2,090	1,260	1,010
18	853	1,050	417	345	.....	8,090	8,870	8,870	3,560	1,880	1,180	1,010
19	745	1,050	443	.....	259	8,870	8,798	8,480	3,560	1,880	970	1,010
20	816	1,050s	436	.....	.....	9,360	8,640	7,850	3,440	1,880	970	1,010
21	816	816f	430	.....	.....	9,280	8,640	7,340	3,270	1,880	970	1,010
22	853	245	423	322	279	9,280	8,400	6,980	3,500	1,880	970	1,010
23	816	678	417	.....	.....	9,120	8,090	6,630	3,730	1,880	970	1,010
24	816	646	392	.....	.....	8,560	7,420	6,910	4,020	1,780	970	1,010
25	891	585	368	322	.....	8,250	6,770	7,860	3,560	1,780	970	1,010
26	816	526	368	317	240	7,420	6,290	8,480	3,560	1,780	970	1,010
27	816	498	345	311	.....	6,770	5,960	8,870	3,110	1,780	970	1,010
28	853	555	345	306	.....	6,090	5,770	9,280	3,390	1,680	970	1,010
29	891	555	345	300	.....	5,520	5,420	9,280	3,270	1,680	970	1,010
30	891	585	392	.....	.....	5,450	4,790	8,480	3,050	1,680	970	1,010
31	891	.....	392	.....	.....	5,330	.....	7,720	.....	1,490	1,050	.....
Accuracy	C	C	D	D	D	D	B	B	B	C	C	C

Note—*Gage height 20.0 ft. s—frozen at margin. f—frozen across channel. Flow estimated, Oct. 1 to 15, from adjoining station records. Stout correction applied to gage-heights Nov. 20 to April 4, for effect of ice.

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

Month	Discharge in second-feet			Run-off in acre-feet
	Maximum	Minimum	Mean	
1923-1924				
October	533	450	478	29,400
November	619	424	501	29,800
December	615	300	434	26,700
January	322	174	236	14,500
February	286	189	213	12,300
March	1,310	300	546	33,600
April	2,200	1,400	1,780	106,000
May	2,530	1,400	2,010	123,000
June	1,350	853	1,050	62,700
July	1,180	443	750	46,100
August	498	345	423	26,000
September	470	189	336	20,000
The year	2,530	174	730	531,000
1924-1925				
October	678	443	553	34,000
November	.....	.....	.....	.....
December	.....	.....	.....	.....
January	.....	.....	.....	.....
February	.....	.....	.....	.....
March	.....	.....	.....	.....
April	6,770	646	2,197	130,700
May	1,930	1,010	1,405	86,400
June	9,690	1,310	5,768	343,000
July	4,790	498	2,165	133,000
August	526	368	433	26,600
September	555	417	487	29,000
The period	9,690	368	1,084	782,700
1925-1926				
October	816	526	672	41,300
November	816	583	657	39,100
December	646	585	623	38,300
January	.....	.....	650	40,000
February	.....	.....	600	33,300
March	7,720	600	2,434	149,600
April	6,910	1,440	3,870	230,300
May	1,400	1,000	1,090	67,000
June	.....	.....	1,900	113,000
July	.....	.....	1,100	67,600
August	.....	.....	600	36,900
September	.....	.....	700	41,600
The year	7,720	526	1,241	898,000
1926-1927				
October	891	745	828	50,900
November	1,050	498	750	44,600
December	.....	.....	444	27,300
January	.....	.....	340	20,900
February	.....	.....	281	15,600
March	9,360	240	4,470	274,800
April	10,550	4,790	8,156	485,300
May	9,440	4,730	7,539	463,400
June	7,340	3,050	4,557	271,100
July	2,980	1,490	2,223	136,600
August	1,400	970	1,137	69,900
September	1,050	1,010	1,013	60,300
The year	10,550	240	2,645	1,921,000

PEMBINA RIVER AT NECHE, N. DAK.

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

DRAINAGE AREA.—2,960 square miles (revised).

RECORDS AVAILABLE.—April 29, 1903, to September 30, 1915, and April 1, 1919, to September 30, 1927.

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

DISCHARGE MEASUREMENTS.—Made from highway bridge 20 rods below railway bridge or 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; 1919-1927; Maximum open water stage recorded, 20.9 feet May 2, 1904 (discharge, 3,870 second-feet); minimum stage recorded, 1.3 feet September 15, 16, 18, 19, and 21-24, 1911 (discharge, 1.0 second-feet).

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

REGULATION.—None.

ACCURACY.—Stage-discharge relation not permanent; affected by ice and by shift of control on April 15. Both rating curves fairly well defined. Gage read to tenths once daily. Daily discharge ascertained by applying daily gage height to rating table except as shown in footnote to table of daily discharge. Records fair.

DAILY DISCHARGE, IN SECOND-FEET, OF PEMBINA RIVER AT NECHE, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1924

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	121	104	59	.....	.....	.....	30	259	117	84	30	5
2	121	104	.....	.....	.....	.....	42	237	117	84	20	5
3	121	104	.....	.....	.....	.....	55	237	117	69	20	5
4	121	88	.....	.....	.....	.....	69r	215	117	69	20	5
5	121	88	.....	5	.....	.....	100	215	100	69	20	5
6	121	88	.....	.....	.....	.....	117	194	100	69	20	3
7	121	88	.....	.....	.....	.....	117F	194	100	69	20	3
8	121	88	34	.....	.....	.....	117	174	100	69	20	3
9	121	88	.....	.....	.....	.....	117	154	100	69	20	3
10	121	88	.....	.....	.....	.....	117F	154	100	69	20	3
11	121	88	.....	.....	.....	.....	135	154	100	69	20	3
12	121	88	.....	4	.....	.....	135	154	100	55	20	3
13	121	88	.....	.....	.....	.....	135	154	100	55	20	3
14	121	104	.....	.....	.....	.....	135	135	100	55	20	3
15	121	104	23	.....	.....	.....	174	135	100	55	13	5
16	121	104	.....	.....	.....	.....	174	135	100	55	13	5
17	121	104	.....	.....	.....	.....	215	135	100	55	13	5
18	121	104	.....	.....	.....	.....	282	135	100	55	13	5
19	104	104	.....	.....	.....	.....	400	135	100	55	8	5
20	104	104	.....	.....	.....	.....	674*	135	100	55	8	5
21	104	88	.....	.....	.....	.....	471	135	100	42	8	8
22	104	88	8	.....	.....	.....	424	135	100	42	8	13
23	104	88	.....	.....	.....	.....	376	135	100	42	8	20
24	104	88F	.....	.....	.....	.....	328	135	84	42	8	30
25	104	83	.....	.....	.....	.....	282	135	84	42	8	42
26	104	79	.....	.....	.....	.....	282	135	84	30	8	69
27	104	75	.....	.....	.....	13	282	135	84	30	8	84
28	104	71	.....	.....	.....	20	282	117	84	30	8	84
29	104	67	5	.....	.....	30	259	117	84	30	8	84
30	104	63	.....	.....	.....	30	259	117	84	30	8	100
31	104	.....	.....	.....	.....	30	.....	117	.....	30	8	.....
Accuracy	C	C	D	E	E	E	B	B	B	C	C	C

Note—*Gage height 6.7 ft. F—Frozen. r—ice running. Stout correction for effect of ice applied Dec. 1, to April 10.

DAILY DISCHARGE, IN SECOND-FEET, OF PEMBINA RIVER AT NECHE, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1925

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	100	174	.....	.....	.....	.....	960r	257	144	257	43	28
2	100	154	.....	.....	.....	.....	960	257	144	234	43	28
3	100	154	50	1	1	2	696	257	144	234	28	62
4	100	154	.....	.....	.....	.....	608k	234	144	234	28	62
5	117	154	.....	.....	.....	.....	494	234	166	234	28	62
6	135	135F	.....	.....	.....	5	494	234	166	211	28	62
7	154	135	.....	.....	.....	15	494	234	166	211	28	62
8	154	135	30	1	3	62	371	234	166	188	28	62
9	174	135	.....	.....	.....	62	471	234	188	166	28	62
10	174	135	.....	.....	.....	20	471	234	304	144	28	62
11	174	.....	.....	.....	.....	10	471	211	328	102	18	62
12	194	.....	.....	.....	.....	5	471	211	352	102	18	62
13	194	110	20	1	2	4	448	211	400	82	18	62
14	194	.....	.....	.....	.....	3	424	188	400	82	18	62
15	194	.....	.....	.....	.....	3	400	188	376	82	18	62
16	194	.....	.....	.....	.....	.....	352	188	376	82	18	62
17	194	.....	.....	.....	.....	.....	328	188	328	82	13	62
18	194	90	10	2	1	2	280	188	280	82	13	62
19	194	.....	.....	.....	.....	.....	280	166	257	62	9	62
20	194	.....	.....	.....	.....	.....	280	166	257	62	9	62
21	194	.....	.....	.....	.....	2	280	166	234	62	6	62
22	194	.....	.....	.....	.....	2	280	166	234	62	6	62
23	194	80	8	2	2	2	280	166	234	62	4	62
24	194	.....	.....	.....	.....	2	280	166	257	62	6	62
25	194	.....	.....	.....	.....	3	280	166	257	62	6	62
26	174	.....	.....	.....	.....	1,710	280	166	257	62	9	62
27	174	.....	.....	.....	.....	2,280	280	166	257	43	9	82
28	174	60	5	2	1	2,350*	280	166	257	43	18	82
29	174	.....	.....	.....	.....	2,300	257	166	257	43	18	102
30	174	.....	.....	.....	.....	1,730	257	144	257	43	18	102
31	174	.....	3	2	.....	1,360	.....	144	.....	43	28	.....
Accuracy	B	D	E	E	F	D	C	B	B	B	C	C

Note—*Gage height 18.3 ft. F—frozen. r—ice running. k—channel clear. Stout correction for effect of ice applied Nov. 6 to Mar. 4.

DAILY DISCHARGE, IN SECOND-FEET, OF PEMBINA RIVER AT NECHE, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1926

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	102	123	28	16	4	2	191	110	82	96	18	13
2	102	123	28	16	4	2	174	110	82	69	18	13
3	123	123	28	16	4	2	174	110	69	48	13	13
4	123	123	28	14	4	2	174	110	69	48	13	18
5	123	123	28	14	4	2	174	110	69	82	13	18
6	123	102	28	14	4	2	174	110	69	318*	13	18
7	123	102	28	14	4	2	157	110	69	262	13	24
8	144	90F	28	14	4	2	157	110	69	226	13	58
9	144	80	28	14	4	2	157	110	69	208	13	141
10	144	80	28	14	4	2	157	110	58	141	13	69
11	144	80	28	14	4	2	157	110	58	141	13	69
12	144	80	28	14	4	2	157	110	58	125	13	58
13	166	70	28	14	4	2	157	110	58	125	13	58
14	166	65	28	14	4	2	157	110	58	110	13	48
15	166	62	28	14	3	2	157	110	58	110	13	48
16	188	60	28	12	3	2	157	96	48	96	13	48
17	188	60	28	12	3	2	157	96	48	96	13	48
18	188	55	28	12	3	2	157	96	48	82	13	48
19	188	55	28	10	2	2	141	96	48	82	13	48
20	188	50	28	10	2	2	141	96	48	69	13	48
21	166	40	28	8	2	2	125	96	110	58	13	48
22	166	28	26	8	2	96	125	96	141	58	13	48
23	144	28	24	6	2	174	110	96	157	39	13	48
24	123	28	22	6	2	280	110	96	174	31	13	48
25	123	28	20	6	2	157	110	96	191	31	13	48
26	123	28	20	6	2	141	110	96	208	31	13	48
27	123	28	18	6	2	141	110	82	191	24	13	58
28	123	28	18	4	2	191	110	82	174	24	13	69
29	123	28	18	4	.....	208	110	82	157	18	13	58
30	123	28	18	4	.....	191	110	82	141	18	13	48
31	123	.....	16	4	.....	191	.....	82	.....	18	13	.....
Accuracy	B	D	E	E	E	E	C	C	C	C	B	B

Note.—*Gage height 5.0 ft. F—frozen acress channel. Stout correction applied to gage heights, Dec. 15 to Feb. 1, for effect of ice, and March 23 to 28.

DAILY DISCHARGE, IN SECOND-FEET, OF PEMBINA RIVER AT NECHE, N. DAK., FOR THE YEAR ENDING SEPTEMBER, 30, 1927

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	48	58	.....	31	.....	.....	157	542	806	542	208	208
2	48	48	.....	.....	.....	.....	226	564	784	520	208	208
3	48	48	.....	.....	.....	.....	318	608	762	457	191	226
4	58	48	31	.....	.....	.....	416	652	740	396	191	226
5	58	48	.....	.....	.....	4	608	740	740	396	191	226
6	58	48	.....	.....	.....	.....	1,400	938	696	376	191	244
7	69	.....	.....	.....	.....	.....	2,060	1,000	652	356	191	244
8	69	.....	.....	.....	.....	.....	1,970	1,160	608	337	191	262
9	69	.....	.....	.....	.....	.....	1,600	1,330	542	337	174	262
10	69	F	.....	.....	.....	.....	1,580	1,710	499	318	174	299
11	69	.....	.....	.....	.....	.....	1,510	2,596	478	318	157	299
12	58	.....	.....	.....	.....	4	1,470	3,050*	478	299	157	299
13	58	48	31	.....	.....	4	1,360	2,650	499	289	141	299
14	58	.....	.....	.....	.....	4	1,220	2,060	436	280	141	299
15	58	.....	.....	.....	.....	499	1,360	1,620	436	244	141	299
16	58	.....	.....	.....	.....	960	1,350	1,490	416	226	141	299
17	58	.....	.....	.....	.....	1,140	1,380	1,220	416	318	141	299
18	48	.....	.....	.....	.....	1,160	1,380	1,050	396	299	174	299
19	58	.....	.....	.....	4	894	1,290	916	396	280	191	299
20	58	39	.....	.....	.....	652	1,208	894	396	262	226	280
21	58	.....	.....	9	.....	478	1,070	740	416	262	226	280
22	58	.....	.....	.....	.....	416	960	630	416	244	226	280
23	58	.....	.....	.....	.....	499	850	828	674	244	226	280
24	58	.....	.....	.....	.....	318	806	938	718	226	226	280
25	58	.....	31	.....	.....	299	740	894	696	226	208	280
26	58	.....	.....	.....	.....	318	696	894	630	226	208	280
27	58	.....	.....	.....	.....	262	630	894	608	226	208	280
28	58	.....	.....	.....	.....	226	608	872	608	226	208	280
29	58	.....	.....	4	.....	191	586	850	586	226	208	280
30	58	.....	.....	.....	.....	174	564	828	564	226	208	280
31	58	.....	.....	.....	.....	174	.....	817	.....	208	208	.....
Accuracy	C	C	D	D	D	D	B	B	B	B	B	B

Note—*Gage height observed 17.8 ft. at 8 P. M. F—frozen across channel. Stout correction applied to gage-heights Nov. 10 to April 15, for effect of ice in channel.

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

Month	Discharge in second-feet			Run-off in acre-feet
	Maximum	Minimum	Mean	
1923-1924				
October	121	104	114	7,000
November	104	63	90	5,370
December	59	5	23	1,430
January	5	4	4	234
February	.....	.....	3	172
March	30	3	7	424
April	674	30	220	13,100
May	259	117	157	9,620
June	117	84	98	5,860
July	84	30	54	3,320
August	30	8	14	885
September	100	3	20	1,200
The year	674	3	67	48,635
1924-1925				
October	194	100	169	10,400
November	174	60	106	6,270
December	50	3	20	1,230
January	2	1	2	93
February	3	1	2	95
March	2,350	2	385	23,700
April	960	257	420	25,000
May	257	144	197	12,100
June	400	144	253	15,100
July	257	43	114	6,970
August	43	4	19	1,170
September	102	28	64	3,790
The year	2,350	1	146	105,918
1925-1926				
October	188	102	143	8,800
November	123	28	67	3,960
December	28	16	25	1,560
January	16	4	11	660
February	4	2	3	170
March	280	2	59	3,670
April	191	110	145	8,630
May	110	82	101	6,170
June	208	48	96	5,710
July	318	18	93	5,720
August	18	13	13	820
September	141	13	48	2,830
The year	318	2	67	48,700
1926-1927				
October	69	48	58	3,600
November	58	39	43	2,530
December	31	31	31	1,900
January	31	4	15	950
February	4	4	4	220
March	1,160	4	281	17,300
April	2,060	157	1,046	62,200
May	3,050	542	1,160	71,300
June	806	396	570	33,900
July	542	208	303	18,600
August	226	141	190	11,700
September	299	208	273	16,200
The year	3,050	4	332	240,400

MOUSE RIVER AT MINOT, N. DAK.

LOCATION.—At Anne Street footbridge, now known as Main St. footbridge; 100 feet northeast of Great Northern Railway roundhouse until April 1, 1924, then at Valker bridge in southeast part of Minot, Ward County, about 150 feet above Park Board Dam.

DRAINAGE AREA.—10,270 square miles.

RECORDS AVAILABLE.—May 5, 1903, to September 30, 1927.

GAGE.—Vertical staff gage attached to piling of Main St. footbridge; read by Ephraim Cox, until April 1, 1924, then by H. H. Valker who lives near Park Board Dam and read a staff gage on the Valker bridge.

DISCHARGE MEASUREMENTS.—Made from the Main St. 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. During winter 1922-1923, the Minot Park Board completed a concrete dam with a Taintor gate 20 feet wide 4⅞ miles below gage, the crest of which was originally at 9.07 feet on Main St. footbridge.

EXTREMES OF DISCHARGE.—1903-1927; Maximum stage, 21.9 feet April 20, 1904 (discharge, 12,000 second-feet); minimum stage, 1.8 feet February 28, 1913 (discharge, 0.1 second-foot).

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

DIVERSIONS.—None.

REGULATION.—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 seriously 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 except as indicated in footnote to daily-discharge table. Records fair.

DAILY DISCHARGE, IN SECOND-FEET, OF MOUSE RIVER AT MINOT, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1924

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	30	13	13	.....	.....	15	108	75	112	28	34	6
2	30	13	.....	.....	1.1	30	109	82	127	56	41	6
3	30	10	.....	.....	.....	45	116	95	110	117	34	6
4	30	10	.....	.....	.....	60	122	105	8	92	37	7
5	30	13	.....	7	.....	75	133	109	64	97	34	8
6	30	13	.....	.....	.....	70	143	144	56	105	41	8
7	30	10	.....	.....	.....	60	184	161	64	105	34	8
8	30	10	13	.....	.....	52	222	174	64	101	34	9
9	30	10	.....	.....	1.1	51	211	161	68	101	41	8
10	30	10	.....	.....	.....	45	262	158	73	101	41	10
11	30	13	.....	.....	.....	42	290	144	78	92	34	14
12	30	17	.....	7	.....	40	320	151	78	86	41	14
13	30	17	.....	.....	.....	45	335	158	82	82	34	14
14	30	13	.....	.....	.....	48	373	171	78	68	34	12
15	30	10	13	.....	.....	53	425	138	82	68	34	14
16	13	10	.....	.....	1.1	56	450	151	68	68	37	14
17	17	10	.....	.....	.....	62	472*	119	122	51	22	12
18	17	7	.....	.....	.....	67	465	151	258	51	14	12
19	13	7	.....	7	.....	83	434	212	159	51	14	10
20	10	10	.....	.....	.....	171	395	234	309	48	18	10
21	10	10	.....	.....	.....	240	368	216	268	64	14	10
22	13	10	7	.....	.....	253	390	212	372	64	14	10
23	17	10	.....	.....	0.7	244	401	216	388	92	22	10
24	21	10	.....	.....	1	215	240	192	300	92	28	9
25	21	10	.....	.....	1	199	270	192	240	73	34	10
26	17	11	.....	3	.....	179	144	132	64	48	110	12
27	17	11	.....	.....	.....	165	94	117	160	48	6	14
28	13	11	.....	.....	.....	153	82	116	140	48	6	14
29	13	12	7	.....	.....	159	76	155	159	45	6	12
30	10	12	.....	.....	.....	137	75	137	92	41	6	10
31	10	.....	.....	.....	.....	123	.....	120	.....	34	6	.....
Accuracy	D	B	C	C	C	B	B	E	C	B	B	D

Note—*Gage height 9.75 ft. Stout correction for ice effect applied March 20, to April 1. Gate in dam opened partially and shut, Oct. 1 to October 14. Gate in dam partly open, 6 P. M. April 24 to 8 P. M. June 3, June 19, to June 22, open a little, June 22, to evening June 25. Gate in dam open March 1 to April 24, 8 A. M. June 17 to 1 P. M. June 18; 7 P. M. June 26, to 10 A. M. June 28; 8 P. M. August 25, to 6 A. M. August 26. Gate in dam closed 8 P. M. June 3, to 8 A. M. June 17; evening June 25, to 7 P. M. June 26; 10 A. M. June 28, to 8 P. M. August 25; 6 A. M. August 26, to October 1. Gate in dam 150 feet below gage.

DAILY DISCHARGE, IN SECOND FEET, OF MOUSE RIVER AT MINOT, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1925

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	580	50	.....	.....	.....	30	654	1,180	118	94	6	7
2	340	50	28	.....	19	.....	892	677	115	87	34	6
3	25	50	.....	.....	.....	25	1,100	605	112	94	48	6
4	21	45	30	25	17	.....	1,190	511	115	94	48	6
5	21	40	.....	.....	.....	.....	1,280	434	115	94	48	6
6	19	35	30	.....	.....	30	1,360	467	115	87	34	6
7	19	30	30	.....	19	.....	1,530	478	115	87	41	6
8	21	25	.....	.....	.....	35	1,720	484	137	80	34	6
9	30	25	.....	25	21	.....	1,980	434	153	71	41	6
10	40	25	25	.....	.....	.....	2,290	357	169	68	48	6
11	40	30	.....	21	.....	30	2,540	315	153	68	41	6
12	30	25	30	.....	.....	.....	2,810	295	145	62	34	6
13	30	30	28	.....	.....	.....	2,960	276	137	62	34	6
14	28	25	30	21	19	40	3,120	267	137	6	41	295
15	30	25	.....	.....	19	40	3,200	231	145	6	48	195
16	25	25	30	.....	.....	.....	3,320	204	149	177	48	145
17	25	25	.....	21	25	35	3,370	204	153	62	401	115
18	25	28	.....	.....	29	.....	3,450*	204	161	62	45	87
19	28	25	.....	21	.....	45	3,410	186	153	28	47	68
20	76	25	.....	.....	.....	.....	3,320	169	161	36	48	45
21	168	30	.....	21	40	45	3,280	161	161	46	49	42
22	108	32	.....	.....	40	68	3,240	165	153	54	51	40
23	101	30	.....	.....	.....	122	3,040	161	145	56	52	35
24	94	30	.....	21	30	222	3,000	153	137	56	52	25
25	87	29	.....	.....	.....	379	2,920	153	122	56	54	21
26	80	28	.....	17	.....	412	2,850	149	115	52	6	21
27	74	29	.....	.....	.....	477	2,730	145	108	51	6	21
28	62	30	20	.....	25	575	2,400	137	108	51	6	17
29	56	30	.....	.....	.....	595	2,070	133	101	51	6	17
30	50	30	.....	.....	.....	580	1,760	122	101	51	7	21
31	50	.....	25	21	.....	605	.....	115	.....	52	7	.....
Accuracy	C	C	D	D	D	C	B	B	C	D	E	D

Note—*Gage height 21.8 ft. Abrupt variations in discharge caused by opening or closing of gates in dam, releasing stored water, or storing. Gate closed Sept. to Oct. 1, 1924; July 14, 15, Aug. 1 to 16; Aug. 26 to Sept. 13. Gate partly open, Oct. 20, 21; July 19 to 31; Aug. 18 to 25. Gate in dam open Oct. 1 to 19; Oct. 22 to July 13; July 16 to 18; Aug. 17; Sept. 14 to 30.

DAILY DISCHARGE, IN SECOND-FEET, OF MOUSE RIVER AT MINOT, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1926

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	25	25	.....	17	13	12	38	59	73	194*	101	64
2	21	28	21	.....	.....	.....	42	50	82	182	101	64
3	25	28	.....	19	.....	11	45	56	64	194	101	64
4	25	25	.....	.....	15	.....	47	63	73	182	92	64
5	25	23	23	.....	.....	.....	48	70	.....	.....	.....	.....
6	21	25	21	17	13	13	47	78	64	169	101	64
7	25	25	.....	.....	11	11	47	84	73	182	82	48
8	30	28	.....	.....	.....	.....	45	92	64	169	82	48
9	30	30	23	17	.....	.....	40	92	64	157	101	41
10	25	35	.....	17	13	9	45	92	73	169	92	48
11	25	32	.....	.....	.....	.....	50	101	64	169	82	48
12	25	30	21	.....	.....	.....	56	101	64	157	82	48
13	25	32	25	19	13	11	65	92	64	145	82	41
14	23	35	23	.....	13	13	68	101	64	145	73	35
15	25	35	21	.....	.....	.....	74	101	64	134	64	36
16	25	30	.....	17	.....	.....	77	92	73	134	73	35
17	21	28	.....	17	17	17	80	101	65	122	82	36
18	21	29	.....	.....	.....	.....	80	92	60	122	73	35
19	23	29	23	17	.....	.....	80	101	70	134	64	35
20	25	29	.....	.....	13	25	84	92	80	122	64	34
21	28	30	23	.....	13	25	87	92	85	122	64	34
22	28	28	.....	.....	.....	.....	87	82	95	134	64	34
23	30	26	.....	17	.....	.....	87	82	105	122	64	36
24	28	25	.....	17	.....	25	90	82	120	122	73	38
25	25	24	21	.....	.....	.....	87	92	140	122	64	64
26	28	23	.....	15	.....	.....	80	82	169	122	64	78
27	25	22	21	.....	.....	28	80	82	169	122	64	94
28	25	21	.....	.....	13	25	77	82	182	112	73	103
29	25	21	21	.....	.....	.....	74	92	194	122	64	94
30	28	21	.....	13	.....	.....	62	82	169	112	64	103
31	25	.....	.....	13	.....	30	.....	82	.....	101	73	.....
Accuracy	C	C	D	D	D	D	B	B	B	B	B	C

Note—*Gage height 14.6 ft. Gate in dam somewhat open Oct. 1 to April 7; Gate wide open Apr. 8 to May 3; Gate closed May 4 to June 17; somewhat open June 17 to 19; closed June 19 to Sept. 14; open a little Sept. 14 to 15; closed but leaking Sept. 15 to 30. Stout correction for effect of ice, Nov. 17 to March 29.

DAILY DISCHARGE, IN SECOND-FEET, OF MOUSE RIVER AT MINOT, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1927

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	112	31	21	21	13	24	456	3,620*	992	267	188	115
2	37	31	21	19	13	25	445	3,530	1,260	250	174	108
3	36	31	.....	.....	13	.....	500	3,530	1,360	233	167	101G
4	35	.....	21	13	.....	.....	522	3,530	1,450	233	153	105
5	35	.....	21	.....	13	30	544	3,490	1,480	220	149	110G
6	36	30	.....	.....	13	35	544	3,450	1,550	182G	120G	115
7	36	30	.....	.....	.....	45	562	3,280	1,580	144	92	108
8	36	.....	21	13	.....	56	575	3,200	1,550	162	64	94
9	36	.....	.....	13	13	50	605	3,120	1,520	202	73	87G
10	36	25	.....	.....	.....	68	630	3,000	1,360	202	64	87
11	36	.....	19	.....	.....	68	660	2,850	1,260	202	64	87G
12	36	.....	19	13	11	129	701	2,650	1,010	214	73	87
13	36	25	.....	.....	9	137	766	2,650	809	192	82	87
14	34	25	.....	.....	.....	169	905	2,360	680	181	82	80
15	33	.....	.....	13	.....	186	1,020	2,180	635	181	64G	80
16	32	25	21	13	9	169	1,150	2,040	580	162	112	77
17	31	.....	.....	.....	.....	153	1,290	1,960	522	162	161	80
18	31	.....	21	13	.....	108	1,420	1,790	478	172G	153	74
19	31	.....	21	.....	9	87	1,520	1,680	445	148	186	74
20	31	23	.....	.....	11	87	1,650	1,580	412	154	166G	74
21	31	21	.....	.....	.....	108	1,900	1,520	379	152	147	80
22	31	.....	21	13	.....	145	2,140	1,440	368	150	128G	87
23	31	.....	.....	13	11	186	2,510	1,390	346	150G	108	101
24	31	21F	21	.....	.....	254	2,810	1,360	325	181	101	115
25	31	.....	.....	.....	17	412	3,120	1,230	285	181	104	153
26	31	.....	21	13	19	379	3,220	1,120	267	181	87	153
27	31	21	.....	.....	21	445	3,450	1,090	249	181	87G	145
28	31	21	.....	.....	.....	456	3,620	905	249	202	96	141
29	31	.....	21	13	.....	467	3,620	905	258	225	106G	129
30	31	.....	.....	13	.....	478	3,620	969	262	237	115	115
31	31	.....	.....	.....	.....	478	.....	.....	.....	202G	118	
Accuracy	D	D	D	D	D	D	B	B	B	D	D	C

Note—*Gage height 22.2 ft. Stout correction applied for effect of ice Nov. 20 to March 14. F—channel frozen over. G—change in Taintor gate in dam, which was almost closed Oct. 1 to (about) Nov. 6.

Gate open until July 2, 7 P. M. closed. July 6, opened a little. July 18 opened wider. July 23 open only a little. July 31 opened. August 6, 7 P. M. closed. August 15, 7 P. M. opened. August 26, 4 P. M. closed. August 22, 11 A. M. opened. August 27, P. M. closed. August 29, 3 P. M. opened. September 3, 11 A. M. closed Sept. 5 opened. September 10, closed. September 12, opened until Sept. 30.

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

Month	Discharge in second-feet			Run-off in acre-feet
	Maximum	Minimum	Mean	
1923-1924				
October	30	10	22	1,350
November	13	7	11	660
December	13	7	10	645
January	7	3	6	359
February	6	1	1	78
March	253	15	104	6,420
April	472	75	257	15,300
May	234	75	152	9,320
June	388	8	141	8,420
July	117	28	72	4,400
August	110	6	29	1,800
September	14	6	10	621
The year	472	1	68	49,373
1924-1925				
October	580	19	77	4,710
November	50	25	31	1,860
December	30	25	29	1,780
January	25	17	22	1,340
February	40	17	24	1,360
March	605	25	154	9,430
April	3,450	654	2,426	144,200
May	1,180	115	309	19,000
June	169	101	134	7,940
July	177	6	65	3,970
August	401	6	47	2,905
September	295	5	43	2,560
The year	3,450	6	280	201,200
1925-1926				
October	30	21	25	1,560
November	35	21	27	1,630
December	25	19	22	1,340
January	19	13	17	1,030
February	17	11	14	750
March	30	9	18	1,110
April	90	38	66	3,900
May	101	50	86	5,230
June	194	60	93	5,530
July	194	101	144	8,850
August	101	64	78	4,800
September	103	34	54	3,230
The year	194	9	53	38,960
1926-1927				
October	112	31	36	2,200
November	31	21	25	1,480
December	21	19	21	1,270
January	21	13	14	830
February	21	9	13	700
March	478	25	177	10,900
April	3,620	445	1,549	92,200
May	3,620	905	2,175	133,700
June	1,580	249	797	47,400
July	267	144	190	11,700
August	188	64	115	7,100
September	153	80	102	6,050
The year	3,620	9	435	315,600

MISSOURI RIVER DRAINAGE

Little Missouri River at Medora, N. Dak.

LOCATION.—In T. 140 N., R. 102 W., at highway bridge 200 feet below Northern Pacific Railway bridge at Medora, Billings County.

DRAINAGE AREA.—6,190 square miles.

RECORDS AVAILABLE.—May 12, 1903, to October 31, 1908; October 11, 1921 to May 1, 1926.

GAGE.—Staff gage, on downstream face of middle concrete pier of highway bridge 200 feet below railway bridge; read by John H. Ryder.

DISCHARGE MEASUREMENTS.—Made from highway bridge or from railway bridge.

CHANNEL AND CONTROL.—Bed composed of gravel and silt; One channel; no overflow at any stage. Continual erosion and silting causes changes in the channel, but these changes are not very great, and are largely compensating from year to year.

EXTREMES OF DISCHARGE.—1903-1908; 1921-1926: Maximum stage recorded, 16.0 feet June 24, 1907 (discharge, 22,200 second-feet); minimum stage, 2.4 feet September 28, 1905 (discharge, 2 second-feet.)

ICE.—Stage-discharge relation affected by ice.

DIVERSIONS.—No diversions large enough to have any considerable effect at the station.

REGULATION.—None.

ACCURACY.—Stage-discharge relation fairly permanent except as affected by ice. Rating curve fairly well defined. Gage read to tenths once daily. Daily discharge ascertained by applying daily gage height to rating table and as explained in footnote to table of daily discharge. Records fair.

DAILY DISCHARGE, IN SECOND-FEET, OF LITTLE MISSOURI RIVER AT MEDORA, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1924

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	2,980	205	240	50	.....	2,450	4,000	590	110	400	400	140
2	10,660	205	205	50	.....	2,150	5,000	590	110	790	320	110
3	8,260	175	175	50	40	2,150	12,130	540	110	720	280	110
4	4,040	150	175	50	.....	2,610	18,520*	540	110	650	245	80
5	3,720	128	150	50	.....	2,450	16,360	540	110	445	210	80
6	2,700	128	128	41	.....	2,450	11,020	490	110	400	175	55
7	2,700	128	109	41	.....	2,000	11,900	445	80	360	175	55
8	2,020	128	93	40	40	1,720	11,240	400	80	360	140	55
9	1,780	128	93	40	.....	1,590	9,120	400	80	320	110	55
10	1,330	128	80	40	.....	1,590	9,330	590	110	320	110	55
11	1,130	109	80	.....	50	.....	9,120	540	400	320	110	35
12	2,020	109	80	.....	60	.....	9,120	445	400	320	80	35
13	1,230	109	103	35	80	600	8,700	280	360	280	80	35
14	950	120	128	.....	360†	.....	5,850	210	320	245	80	35
15	2,150	128	128	.....	540	.....	5,670	175	280	245	80	35
16	3,420	128	128	.....	720	.....	2,930	140	280	210	110	35
17	2,700	128	128	.....	870	.....	2,610	140	720	175	110	35
18	1,440	128	128	35	790	400	2,450	140	1,040	175	175	35
19	1,550	128	128	.....	650	.....	2,450	110	4,100	175	175	35
20	1,440	109	109	.....	650	.....	2,150	110	2,300	360	140	35
21	1,130	205	109	.....	590	.....	1,460	175	2,770	1,040	110	35
22	730	240	109	.....	590	.....	1,230	140	1,340	490	650	35
23	560	240	109	30	540	300	1,080	140	870	1,130	540	35
24	500	205	109	.....	650	.....	1,040	140	590	1,460	446	35
25	500	205	93	.....	650	.....	870	140	445	1,860	400	23
26	440	205	93	.....	590	1,000	790	140	400	1,130	400	23
27	330	205	80	.....	720	4,610	650	140	360	490	360	23
28	280	205	80	40	1,460	4,100	790	140	360	650	280	23
29	280	240	69	.....	1,720	3,930	790	140	245	540	280	23
30	240	240	69	.....	.....	3,900	650	110	445	245	245	23
31	240	240	59	40	.....	3,900	.....	110	.....	445	210	.....
Accuracy	B	C	C	E	E	E	B	B	B	B	B	C

Note—†Ice gone or going. *Gage height, 13.8 ft. Stout correction for effect of ice applied Dec. 26 to March 29.

DAILY DISCHARGE, IN SECOND-FEET, OF LITTLE MISSOURI RIVER AT MEDORA, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1925

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	15	86	.....	.....	15	4,270	1,340	176	210	790	210	32
2	15	86	.....	.....	30	5,130	1,130	176	400	720	210	22
3	22	86	26	15	60	4,780	1,040	176	5,850	1,860	210	22
4	46	86	.....	.....	64	4,950	950	176	2,610	870	176	22
5	112	86	.....	.....	400	5,670	790	142	1,460	455	112	22
6	112	86	.....	.....	345	3,930	650	142	870	400	86	22
7	86	86	.....	.....	870	1,230	515	112	790	1,590	46	22
8	86	86	20	12	1,040	5,130	515	112	2,610	790	32	22
9	250	112	.....	.....	950	5,490	515	112	2,150	580	32	22
10	580	112	.....	.....	870	5,860	455	86	1,720	400	32	46
11	650	112	.....	.....	870	3,090	455	86	870	345	32	64
12	950	86	.....	.....	650	4,270	455	86	950	345	32	295
13	2,300	86	15	10	790	5,490	400	86	650	295	22	295
14	2,450	86	.....	.....	455	3,930	400	86	720	250	22	176
15	1,720	86	.....	.....	345	4,100	400	86	790	250	142	345
16	1,720	.....	.....	.....	295	4,440	345	64	790	210	142	345
17	1,040	.....	.....	.....	295	4,950	345	64	1,720	210	86	295
18	870	64	15	11	295	5,850	295	64	3,590	176	64	295
19	580	.....	.....	.....	250	6,570	250	46	2,450	176	64	250
20	455	.....	.....	.....	250	5,130	210	46	2,000	176	46	176
21	400	.....	.....	.....	250	12,400*	210	46	2,930	176	46	142
22	400	.....	.....	.....	250	2,930	210	46	5,850	142	32	142
23	345	46	15	15	250	5,310	210	46	5,490	112	32	86
24	295	.....	.....	.....	950	5,670	210	46	4,950	112	32	86
25	176	.....	.....	.....	720	4,780	176	46	3,930	86	32	64
26	142	.....	.....	.....	345	6,030	176	46	3,090	64	32	64
27	142	.....	.....	.....	455	4,610	176	46	1,130	64	32	64
28	112	32	15	15	6,210	3,590	176	46	1,130	46	32	64
29	112	.....	.....	.....	.....	3,420	176	46	1,040	250	32	46
30	112	.....	.....	.....	.....	2,450	176	46	1,040	250	32	46
31	86	.....	15	15	.....	2,150	.....	46	.....	210	32	.....
Accuracy	B	C	E	E	E	E	B	B	B	B	C	C

Note—*Gage Height 14.2 ft. Stout correction for estimated effect of ice applied Nov. 16 to March 30.

DAILY DISCHARGE, IN SECOND FEET, OF LITTLE MISSOURI RIVER AT MEDORA, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1926.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	46	15	20	.....	.....	176	1,720	112	.....	.....	.....	.....
2	46	15	23	15	.....	176	1,720	.....	.....	.....	.....	.....
3	46	15	26	.....	.....	176	1,590	.....	.....	.....	.....	.....
4	32	15	29	.....	.....	720	1,590	.....	.....	.....	.....	.....
5	32	15	32	.....	.....	176	1,590	.....	.....	.....	.....	.....
6	32	15	.....	.....	10	86	1,590	.....	.....	.....	.....	.....
7	32	15	.....	.....	.....	176	1,460	.....	.....	.....	.....	.....
8	32	15	.....	.....	.....	142	1,230	.....	.....	.....	.....	.....
9	32	15	.....	15	.....	176	1,130	.....	.....	.....	.....	.....
10	32	15	.....	.....	.....	112	1,040	.....	.....	.....	.....	.....
11	32	15	.....	.....	.....	112	580	.....	.....	.....	.....	.....
12	32	15	32	.....	.....	1,130	400	.....	.....	.....	.....	.....
13	32	15	30	.....	10	720	400	.....	.....	.....	.....	.....
14	32	15	29	.....	10	1,130	345	.....	.....	.....	.....	.....
15	22	.....	27	.....	11	790	295	.....	.....	.....	.....	.....
16	22	.....	26	15	12	790	295	.....	.....	.....	.....	.....
17	22	.....	25	14	13	650	295	.....	.....	.....	.....	.....
18	22	.....	24	14	14	2,300	250	.....	.....	.....	.....	.....
19	22	.....	22	13	15	3,590	250	.....	.....	.....	.....	.....
20	22	.....	21	12	15	2,450	210	.....	.....	.....	.....	.....
21	22	15	20	11	15	4,100	210	.....	.....	.....	.....	.....
22	22	.....	15	11	.....	5,490	210	.....	.....	.....	.....	.....
23	22	.....	18	10	210	5,850*	176	.....	.....	.....	.....	.....
24	22	.....	17	.....	176	5,850*	176	.....	.....	.....	.....	.....
25	22	.....	16	.....	176	4,780	176	.....	.....	.....	.....	.....
26	22	.....	15	.....	176	3,760	176	.....	.....	.....	.....	.....
27	22	.....	.....	.....	210	3,090	142	.....	.....	.....	.....	.....
28	22	15	.....	.....	176	2,300	142	.....	.....	.....	.....	.....
29	22	15	.....	.....	.....	1,860	112	.....	.....	.....	.....	.....
30	15	15	.....	10	.....	1,860	112	.....	.....	.....	.....	.....
31	15	.....	15	.....	.....	1,720	.....	.....	.....	.....	.....	.....
Accuracy	C	C	D	D	D	C	B					

Note—*Gage height, 8.0 ft. Stout correction for effect of ice applied Dec. 1, to March 17.

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

Month	Discharge in second-feet			Run-off in acre-feet
	Maximum	Minimum	Mean	
1923-1924				
October	10,660	240	2,048	126,000
November	240	109	163	9,710
December	240	59	115	7,090
January	50	30	38	2,360
February	1,720	40	437	25,200
March	4,610	300	1,584	97,400
April	18,520	650	5,634	335,000
May	590	110	288	17,800
June	4,100	80	634	37,800
July	1,860	175	547	33,600
August	650	80	233	14,300
September	140	23	47	2,820
The year	18,520	23	980	709,000
1924-1925				
October	2,450	15	528	32,500
November	112	32	69	4,120
December	26	15	18	1,080
January	15	10	13	793
February	1,040	15	663	36,800
March	12,400	1,230	4,761	293,000
April	1,340	176	445	26,500
May	176	46	85	5,220
June	5,850	210	2,130	126,000
July	1,860	46	400	24,600
August	210	22	70	4,290
September	345	22	120	7,130
The year	12,400	10	775	562,000
1925-1926				
October	46	15	27	1,690
November	15	15	15	890
December	32	15	24	1,460
January	15	10	13	800
February	210	10	49	2,730
March	5,850	86	1,821	111,900
April	1,720	112	654	38,900
May	.....	.....	.....	.....
June	.....	.....	.....	.....
July	.....	.....	.....	.....
August	.....	.....	.....	.....
September	.....	.....	.....	.....
The Period	5,850	10	372	158,400

KNIFE RIVER NEAR BRONCHO, N. DAK.

LOCATION.—In S.E.¼ Sec. 4, T. 142 N., R. 90 W., at C. D. Smith's ranch, half a mile below mouth of Elm Creek, 6 miles from Broncho, Mercer County, and 15 miles above Spring Creek.

DRAINAGE AREA.—1,200 square miles.

RECORDS AVAILABLE.—May 29, 1903, to October 31, 1919; October 10, 1921 to September 30, 1925; March 1 to September 30, 1927.

GAGE.—Cantilever chain gage on left bank near observer's house; datum unchanged since March 23, 1905. Read by Arthur C. Smith, and Robert Crowley.

DISCHARGE MEASUREMENTS.—Made from cable 500 feet below gage or by wading.

CHANNEL AND CONTROL.—Stream bed below gage composed of large gravel and stones, slightly shifting. Channel narrow with steep banks, overflowing at gage height 20 feet.

EXTREMES OF DISCHARGE.—1903-1919; 1921-1927: Maximum stage recorded, 24.0 feet June 26, 1914 (discharge, 7,700 second-feet); river dry September 6-8, 1905, and September 18, and 19, 1908.

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

DIVERSIONS.—None.

REGULATION.—None.

ACCURACY.—Stage-discharge relation permanent except as affected by ice. Rating curve fairly well defined between 4 and 2,500 second-feet. Gage read to tenths once daily. Daily discharge ascertained by applying daily gage height to rating table. Records fair.

DAILY DISCHARGE, IN SECOND-FEET, OF KNIFE RIVER NEAR BRONCHO, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1924.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	46	18	12	.....	.....	66	61	96	33	101	33	25
2	61	18	18	.....	.....	121	101	91	33	91	33	25
3	65	25	18	.....	5	132	359	91	33	91	25	25
4	69	25	12	.....	.....	271	1,210r	91	33	91	25	25
5	73	25	18	.....	.....	416	1,580*	81	33	81	25	25
6	77	18	12	.....	.....	239	844	71	33	51	25	25
7	81	18	12	.....	.....	209	359	71	33	51	25	25
8	71	25	12	.....	5	195	195	61	33	359	25	25
9	51	33	12	.....	.....	168	111	51	33	323	25	25
10	51	42	12	.....	.....	138	91	51	33	271	25	25
11	42	42	18	.....	.....	111	91	51	71	132	25	25
12	42	42	12	.....	.....	101	81	51	121	111	25	25
13	42	33	12	.....	5	91	71	42	255	91	25	25
14	42	33	12	.....	.....	81	71	42	209	51	25	25
15	42	25	12	.....	.....	71	71	42	651	42	25	25
16	33	25	12	.....	.....	71	61	42	436	33	25	25
17	25	25	12	.....	.....	51	61	42	288	33	25	25
18	25	33	18	.....	5	51	61	42	224	33	25	25
19	25	33	12	.....	.....	51	61	42	844	33	25	25
20	25	25	12	.....	.....	33	61	42	1,070	51	25	33
21	18	25	12	.....	.....	25	61	42	1,520	96	25	33
22	18	18	12	.....	.....	25	61	42	436	126	25	33
23	18	18	12	.....	5	25	51	33	188	91	25	33
24	18	18	12	.....	.....	33	51	33	155	81	25	33
25	25	25	12	.....	.....	42	51	33	132	51	25	33
26	18	18	7f	.....	5	101	61	33	111	42	25	33
27	18	18	6	.....	8	91	61	33	121	42	25	33
28	18	18	6	.....	10	71	101	33	149	42	25	33
29	18	18	6	.....	56	51	106	33	132	33	25	33
30	18	18	6	.....	.....	42	101	33	132	33	25	33
31	18	.....	6	.....	.....	51	.....	33	.....	33	25	.....
Accuracy	C	C	D	E	E	D	C	B	B	B	C	C

Note—*Maximum observed gage height 11.7 ft. f—frozen, r—ice running. Stout correction applied for effect of ice Nov. 29 to March 24.

DAILY DISCHARGE, IN SECOND-FEET, OF KNIFE RIVER NEAR BRONCHO, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1925.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	25	25	12	.....	.....	7	91	33	7	12	2	2
2	25	25	12	.....	.....	7	91	33	188	12	2	2
3	25	25	12	9	10	10	81	33	1,850*	12	2	2
4	25	25	12	.....	.....	33	81	33	768	12	2	2
5	33	25	12	.....	.....	101	71	33	175	12	2	2
6	33	25	12	.....	15	.....	61	33	132	12	2	2
7	33	25	12	.....	33	.....	61	33	91	12	2	2
8	33	25	12	9	51	22	51	33	71	12	2	2
9	33	25	12	.....	81	.....	51	33	81	12	2	2
10	33	25	12f	.....	155	.....	51	33	91	12	2	2
11	33	18	12	.....	181	.....	42	33	91	7	2	2
12	174	18	.....	.....	168	.....	42	33	81	7	2	2
13	202	18	15	8	111	10	42	33	81	7	2	4
14	239	18	.....	.....	91	.....	51	33	71	7	2	4
15	497	18	.....	.....	81	.....	42	33	71	7	2	4
16	436	18	.....	.....	33	.....	42	33	61	7	2	4
17	255	18	.....	.....	18	.....	42	33	61	4	2	4
18	101	18	12	7	15	10	51	4	42	4	2	4
19	51	25	.....	.....	12	.....	42	4	42	4	2	4
20	33	25	.....	.....	10	.....	42	4	33	4	2	4
21	33	18	.....	.....	.....	10	33	4	25	4	2	4
22	33	18	.....	.....	.....	20	33	4	25	2	2	4
23	33	18	10	7	8	323	33	4	25	2	2	4
24	33	25	.....	.....	.....	224	33	4	18	2	2	4
25	25	25	.....	.....	.....	606	33	4	18	2	2	4
26	25	25	.....	.....	.....	923	33	4	18	2	2	4
27	25	18	.....	.....	8	476	33	4	18	2	2	4
28	25	12	9	7	.....	397	33	4	12	2	2	4
29	25	12	.....	.....	.....	397	33	4	12	2	2	4
30	25	12	.....	.....	.....	300	33	4	12	2	2	7
31	25	.....	9	7	.....	200	.....	4	.....	2	2	.....
Accuracy	C	D	E	E	E	E	B	C	B	C	C	C

Note—*Gage height 11.9 ft. f—frozen. Stout correction for effect of ice applied November 11 to March 29.

DAILY DISCHARGE, IN SECOND-FEET, OF KNIFE RIVER NEAR BRONCHO, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1927.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	.....	.....	.....	.....	.....	10	66	33	46	138	38	33
2	.....	.....	.....	.....	.....	10	66	42	29	106	33	33
3	.....	.....	.....	.....	.....	18	66	33	29	101	33	33
4	.....	.....	.....	.....	.....	12	56	25	21	96	33	33
5	.....	.....	.....	.....	.....	7	61	25	25	96	33	33
6	.....	.....	.....	.....	.....	18	71	25	33	86	33	33
7	.....	.....	.....	.....	.....	25	66	76	38	71	33	33
8	.....	.....	.....	.....	.....	51	56	126	33	46	33	33
9	.....	.....	.....	.....	.....	61	66	2,310	25	42	33	33
10	.....	.....	.....	.....	.....	121	61	3,940*	33	46	33	33
11	.....	.....	.....	.....	.....	195	56	3,680	46	51	33	33
12	.....	.....	.....	.....	.....	224	56	3,510	51	71	33	33
13	.....	.....	.....	.....	.....	255	51	2,920	42	181	33	51
14	.....	.....	.....	.....	.....	288	46	2,090	46	195	33	81
15	.....	.....	.....	.....	.....	397	61	1,880	42	168	42	71
16	.....	.....	.....	.....	.....	397	66	1,620	51	168	42	51
17	.....	.....	.....	.....	.....	323	51	1,430	42	181	42	42
18	.....	.....	.....	.....	.....	323	56	1,240	106	188	33	42
19	.....	.....	.....	.....	.....	323	46	896	106	232	33	42
20	.....	.....	.....	.....	.....	271	51	651	101	280	33	46
21	.....	.....	.....	.....	.....	224	38	378	91	209	33	46
22	.....	.....	.....	.....	.....	209	46	288	96	216	33	51
23	.....	.....	.....	.....	.....	195	46	224	96	239	38	51
24	.....	.....	.....	.....	.....	155	42	155	106	280	42	51
25	.....	.....	.....	.....	.....	76	33	132	116	271	38	42
26	.....	.....	.....	.....	.....	76	33	116	111	188	33	42
27	.....	.....	.....	.....	.....	86	38	116	91	116	33	42
28	.....	.....	.....	.....	.....	66	33	101	91	71	33	42
29	.....	.....	.....	.....	.....	71	25	76	111	46	33	42
30	.....	.....	.....	.....	.....	76	25	46	126	42	33	42
31	.....	.....	.....	.....	.....	66	.....	46	.....	42	33	.....
Accuracy						D	B	B	B	B	C	C

Note—* Observed gage height at 5 P. M. 17.3 ft. Stout correction applied for effect of ice March 1 to 18.

MONTHLY DISCHARGE OF KNIFE RIVER NEAR BRONCHO, N. DAK.

Month	Discharge in second-feet			Run-off in acre-feet
	Maximum	Minimum	Mean	
1923-1924				
October	81	18	38	2,370
November	42	18	25	1,500
December	18	6	12	728
January	----------	----------	6	369
February	56	5	7	405
March	416	25	104	6,390
April	1,580	51	210	12,500
May	96	33	51	3,120
June	1,520	33	252	15,000
July	359	33	90	5,530
August	33	25	26	1,570
September	33	25	28	1,660
The year	1,580	5	71	51,200
1924-1925				
October	497	25	85	5,210
November	25	12	21	1,240
December	15	9	12	712
January	9	7	8	480
February	181	8	42	2,320
March	923	7	137	8,420
April	91	33	49	2,890
May	33	4	20	1,220
June	1,850	7	142	8,470
July	12	2	7	401
August	2	2	2	123
September	7	2	3	196
The year	1,850	2	44	31,700
1926-1927				
October	----------	----------	----------	----------
November	----------	----------	----------	----------
December	----------	----------	----------	----------
January	----------	----------	----------	----------
February	----------	----------	----------	----------
March	397	7	149	9,180
April	71	25	51	3,040
May	3,940	25	911	55,990
June	126	21	66	3,930
July	280	42	138	8,460
August	42	33	35	2,130
September	81	33	42	2,520
The Period	3,940	7	177	85,200

SPRING CREEK AT ZAP, N. DAK.

LOCATION.—On Northern Pacific bridge at Zap, N. Dak.

DRAINAGE AREA.—547 square miles.

RECORDS AVAILABLE.—Station established March 4, 1924.

GAGE.—Staff on piling of bridge, read by Peter Koppi and Robert Stroup.

DISCHARGE MEASUREMENTS.—Wading.

DIVERSIONS.—None.

ACCURACY.—Very uncertain, because of lack of high water measurements. Published as a record of the occurrence of flood flows and as a guide to a more intelligent estimate than available otherwise.

DAILY DISCHARGE, IN SECOND-FEET OF SPRING CREEK AT ZAP N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1924

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	.....	.....	.....	.....	.....	20	112	112	11	172	13	4
2	.....	.....	.....	.....	.....	40	291	112	8	105	13	4
3	.....	.....	.....	.....	.....	50	304	112	8	50	13	3
4	.....	.....	.....	.....	.....	87	345	58	11	35	13	3
5	.....	.....	.....	.....	.....	205	622	58	8	19	13	3
6	.....	.....	.....	.....	.....	216	291	65	8	13	10	3
7	.....	.....	.....	.....	.....	228	304	65	8	13	10	3
8	.....	.....	.....	.....	.....	205	291	58	8	27	10	3
9	.....	.....	.....	.....	.....	183	72	58	8	23	10	3
10	.....	.....	.....	.....	.....	161	52	58	8	23	7	3
11	.....	.....	.....	.....	.....	141	58	40	8	16	7	3
12	.....	.....	.....	.....	.....	131	52	35	8	16	7	3
13	.....	.....	.....	.....	.....	121	35	25	8	13	7	3
14	.....	.....	.....	.....	.....	121	46	17	8	13	7	3
15	.....	.....	.....	.....	.....	112	46	17	8	13	7	3
16	.....	.....	.....	.....	.....	72†	46	11	8	13	7	3
17	.....	.....	.....	.....	.....	58	46	11	8	13	7	3
18	.....	.....	.....	.....	.....	65	46	11	72	13	7	3
19	.....	.....	.....	.....	.....	65	46	11	58	13	7	3
20	.....	.....	.....	.....	.....	58	46	11	40	13	7	3
21	.....	.....	.....	.....	.....	58	52	11	30	13	7	3
22	.....	.....	.....	.....	.....	58	58	11	21	14	7	3
23	.....	.....	.....	.....	.....	72	58	11	14	13	7	3
24	.....	.....	.....	.....	.....	79	65	10	14	13	5	3
25	.....	.....	.....	.....	.....	95	87	8	14	13	5	3
26	.....	.....	.....	.....	.....	121	103	8	14	13	5	3
27	.....	.....	.....	.....	.....	131	95	8	878*	13	5	3
28	.....	.....	.....	.....	.....	131	112	8	478	13	5	3
29	.....	.....	.....	.....	.....	131	112	8	252	13	5	3
30	.....	.....	.....	.....	.....	131	112	11	228	13	5	3
31	.....	.....	.....	.....	.....	121	.....	11	.....	13	4	.....
Accuracy						E	D	B	D	B	D.	D

Note—*Maximum gage height 16.3 ft. †Ice gone. Stout correction for assumed effect of ice applied March 1 to April 8.

DAILY DISCHARGE, IN SECOND-FEET, OF SPRING CREEK AT ZAP, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1925.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	3	3	.....	.....	.....	.....	.....	.....	.....	.....	3	4
2	3	3	.....	.....	.....	.....	.....	.....	.....	.....	3	4
3	3	3	.....	.....	.....	.....	.....	.....	.....	.....	3	4
4	3	3	.....	.....	.....	.....	.....	.....	.....	.....	5	3
5	3	3	.....	.....	.....	.....	.....	.....	.....	.....	5	3
6	3	3	.....	.....	.....	.....	.....	.....	.....	.....	5	3
7	3	3	.....	.....	.....	.....	.....	.....	.....	.....	5	3
8	5	3	.....	.....	.....	.....	.....	.....	.....	.....	5	3
9	5	3	.....	.....	.....	.....	.....	.....	.....	.....	4	4
10	7	3	.....	.....	.....	.....	.....	.....	.....	.....	4	4
11	5	3	.....	.....	.....	.....	.....	.....	.....	.....	4	4
12	10	3	.....	.....	.....	.....	.....	.....	.....	.....	4	4
13	19	3	.....	.....	.....	.....	.....	.....	.....	.....	4	4
14	10	3	.....	.....	.....	.....	.....	.....	.....	.....	4	4
15	75	3	.....	.....	.....	.....	.....	.....	.....	.....	4	4
16	105*	3	.....	.....	.....	.....	.....	.....	.....	.....	4	4
17	75	3	.....	.....	.....	.....	.....	.....	.....	.....	4	4
18	50	3	.....	.....	.....	.....	.....	.....	.....	.....	4	4
19	40	2	.....	.....	.....	.....	.....	.....	.....	.....	4	4
20	31	2	.....	.....	.....	.....	.....	.....	.....	.....	3	4
21	23	2	.....	.....	.....	.....	.....	.....	.....	3	3	4
22	13	2	.....	.....	.....	.....	.....	.....	.....	3	4	5
23	10	2	.....	.....	.....	.....	.....	.....	.....	3	4	5
24	5	2	.....	.....	.....	.....	.....	.....	.....	3	4	5
25	3	2	.....	.....	.....	.....	.....	.....	.....	3	3	5
26	3	2	.....	.....	.....	.....	.....	.....	.....	3	3	5
27	3	2	.....	.....	.....	.....	.....	.....	.....	3	3	5
28	3	2	.....	.....	.....	.....	.....	.....	.....	3	3	6
29	3	2	.....	.....	.....	.....	.....	.....	.....	3	3	5
30	3	2	.....	.....	.....	.....	.....	.....	.....	3	3	5
31	3	.....	.....	.....	.....	.....	.....	.....	.....	3	4	.....
Accuracy	B	C								D	C	C

Note—*Gage height 10.8 ft. Stout correction for effect of ice applied after Nov. 19.

DAILY DISCHARGE, IN SECOND-FEET, OF SPRING CREEK AT ZAP, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1926

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	5	9	.....	.....	.....	.....	4	7	27	5	2	3
2	5	7	.....	.....	.....	.....	4	7	27	4	2	4
3	5	7	.....	.....	.....	.....	4	6	20	4	2	4
4	4	8	.....	.....	.....	.....	4	6	15	4	3	4
5	4	10	.....	.....	.....	.....	16	4	13	4	2	7
6	5	10	.....	.....	.....	.....	23	8	11	4	2	7
7	5	10	.....	.....	.....	.....	29	11	8	5	3	6
8	5	5	.....	.....	.....	.....	50	19	7	447*	2	3
9	6	13	.....	.....	.....	.....	75	31	6	432	3	3
10	6	13	.....	.....	.....	.....	172	30	5	417	3	3
11	6	7	.....	.....	.....	.....	172	25	5	65	3	6
12	6	7	.....	.....	.....	.....	172	18	5	62	2	6
13	6	16	.....	.....	.....	.....	172	13	6	50	5	6
14	6	10	.....	.....	.....	.....	172	10	5	19	3	6
15	6	27	.....	.....	.....	.....	89	11	4	6	4	6
16	5	3	.....	.....	.....	.....	18	9	5	7	3	6
17	6	5	.....	.....	.....	.....	12	8	4	4	3	6
18	6	5	.....	.....	.....	.....	12	5	5	4	3	6
19	7	5	.....	.....	.....	.....	12	6	4	4	2	6
20	7	4	.....	.....	.....	.....	12	9	5	4	3	6
21	7	3	.....	.....	.....	.....	11	8	9	3	3	7
22	6	10	.....	.....	.....	.....	11	7	5	3	3	6
23	6	5	.....	.....	.....	.....	9	6	5	3	3	45
24	10	27	.....	.....	.....	.....	9	7	4	3	4	10
25	14	4	.....	.....	.....	.....	9	8	4	3	4	43
26	6	7	.....	.....	.....	.....	8	8	4	2	3	10
27	27	6	.....	.....	.....	.....	9	11	4	3	3	7
28	10	7	.....	.....	.....	.....	8	20	3	3	3	9
29	10	7	.....	.....	.....	.....	8	291	4	3	3	9
30	10	7	.....	.....	.....	.....	9	252	3	2	3	9
31	10	.....	.....	.....	.....	.....	.....	45	.....	2	3	.....
Accuracy	C	D					D	C	C	D	D	C

Note—*Gage height 13.6 ft. Stout correction for effect of ice applied Nov. 7 to April 8.

DAILY DISCHARGE, IN SECOND-FEET, OF SPRING CREEK AT ZAP, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1927

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	10	.....	.....	.....	.....	105	216	10	97	23	27	9
2	6	.....	.....	.....	.....	40	216	13	65	25	27	9
3	6	.....	.....	.....	.....	3	183	13	40	40	27	9
4	6	.....	.....	.....	.....	23	113	11	40	53	27	9
5	6	.....	.....	.....	.....	31	31	13	45	27	27	9
6	5	.....	.....	.....	.....	40	31	13	45	15	27	9
7	5	.....	.....	.....	.....	50	31	13	45	33	31	9
8	5	.....	.....	.....	.....	97	31	82	45	10	31	9
9	5	.....	.....	.....	.....	82	31	131	35	10	31	9
10	5	.....	.....	.....	.....	97	31	122	252	10	31	9
11	6	.....	.....	.....	.....	68	31	82	122	10	31	9
12	10	.....	.....	.....	.....	89	31	105	86	6	31	9
13	10	.....	.....	.....	.....	113	36	542	97	28	31	9
14	10	.....	.....	.....	.....	161	36	472	22	17	31	9
15	10	.....	.....	.....	.....	216	56	402	20	26	31	9
16	10	.....	.....	.....	.....	265	56	161	18	26	31	9
17	6	.....	.....	.....	.....	331	56	82	50	72	31	9
18	6	.....	.....	.....	.....	331	23	62	75	75	31	9
19	6	.....	.....	.....	.....	304	97	45	59	72	31	9
20	6	.....	.....	.....	.....	240	75	40	33	48	14	7
21	6	.....	.....	.....	.....	183	75	45	56	34	31	7
22	6	.....	.....	.....	3	131	19	35	27	542	40	7
23	6	.....	.....	.....	.....	89	19	62	31	1,210*	40	7
24	6	.....	.....	.....	.....	131	19	45	18	766	31	7
25	6	.....	.....	.....	.....	131	19	42	17	766	23	9
26	6	.....	.....	.....	.....	131	16	44	16	240	23	9
27	6	.....	.....	.....	.....	151	11	40	13	82	23	9
28	6	.....	.....	.....	.....	151	10	40	25	62	31	9
29	6	.....	.....	.....	.....	151	10	35	27	42	10	9
30	6	.....	.....	.....	.....	161	10	35	240	40	10	9
31	7	.....	.....	.....	.....	216	.....	31	.....	27	31	.....
Accuracy	C	E	E	E	E	E	B	D	C	D	B	C

Note.—*Observed gage height July 23, at 8 A. M., 19.3 ft., discharge estimated 1360 second-feet. Stout correction applied for ice effect, from Nov. 10 to March 30.

MONTHLY DISCHARGE OF SPRING CREEK AT ZAP, N. DAK.

Month	Discharge in second-feet			Run-off in acre-feet
	Maximum	Minimum	Mean	
1923-1924				
October	.....	.....	.....	.....
November	.....	.....	.....	.....
December	.....	.....	.....	.....
January	.....	.....	.....	.....
February	.....	.....	.....	.....
March	228	20	112	6,880
April	622	35	134	7,930
May	112	8	34	2,080
June	878	8	75	4,400
July	172	13	24	1,510
August	13	4	8	480
September	4	3	3	182
The Period	878	3	55	23,500
1924-1925				
October	105	3	17	1,050
November	3	2	3	155
December	.....	.....	2	123
January	.....	.....	.....	.....
February	.....	.....	.....	.....
March	.....	.....	.....	.....
April	.....	.....	.....	.....
May	.....	.....	.....	.....
June	.....	.....	.....	.....
July	3	3	1	60
August	5	3	4	234
September	6	3	4	248
The Period	105	2	6	1,870
1925-1926				
October	27	4	7	450
November	27	3	9	540
December	.....	.....	6	370
January	.....	.....	5	310
February	.....	.....	4	220
March	.....	.....	10	620
April	172	4	44	2,610
May	291	4	29	1,800
June	27	3	8	460
July	447	2	51	3,140
August	5	2	3	180
September	45	3	9	510
The year	447	2	15	11,200
1926-1927				
October	10	5	6	400
November	.....	.....	5	300
December	.....	.....	4	250
January	.....	.....	4	250
February	.....	.....	3	170
March	331	3	139	8,550
April	216	10	54	3,210
May	542	10	93	5,690
June	252	13	59	3,490
July	1,210	6	143	8,800
August	40	10	28	1,730
September	9	7	9	520
The year	1,210	3	46	33,300

Monthly flow, Dec. 1 to Mar. 31, where shown, estimated from Weather Bureau temperature precipitation records, and adjoining streams.

HEART RIVER NEAR RICHARDTON, N. DAK.

LOCATION.—In sec. 21, T. 138 N., R. 92 W., 11 miles south of Richardton, Stark County, near house of Charles W. Church, 1 mile below steel highway bridge.

DRAINAGE AREA.—1,250 square miles.

RECORDS AVAILABLE.—May 18, 1903, to April 1, 1924.

GAGE.—Chain gage near observer's house on right bank of river. In case of accident to regular gage, readings are made at former chain gage located at highway bridge 1 mile upstream. The two gage datums are so related that readings at the bridge are approximately 20 feet less than at gage regularly used; read by Mrs. W. F. Church.

DISCHARGE MEASUREMENTS.—Made from bridge or by wading.

CHANNEL AND CONTROL.—Bed composed of gravel and sand. Control of same material one-fourth mile below; gage may shift.

EXTREMES OF DISCHARGE.—1903-1924: Maximum stage recorded, 25.9 feet at highway bridge June 10, 1906 (discharge, 8,020 second-feet); river dry during periods in 1903, 1905, 1914, and 1919.

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

DIVERSIONS.—None.

REGULATION.—No storage above that appreciably affects the discharge.

ACCURACY.—Stage-discharge relation permanent except as affected by ice. Rating curve fairly well defined. Gage read to half-tenths once daily except during winter when observations were discontinued and for several periods during summer. Daily discharge ascertained by applying daily gage height to rating table. Records fair.

DAILY DISCHARGE, IN SECOND-FEET, OF HEART RIVER NEAR RICHARDTON, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1923

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	1.2	10	.....	.....	.....	139	862	124	110	294	83	139
2	1.2	10	.....	.....	.....	450	836	110	110	50	96	139
3	1.2	10	.....	.....	.....	390	762	50	96	71	96	139
4	1.2	13	.....	.....	.....	370	601	50	96	60	96	139
5	1.2	19	.....	.....	.....	390	535	60	96	667	96	154
6	1.2	44	.....	.....	.....	154	557	71	96	220	110	154
7	1.6	39	.....	.....	.....	96	535	71	96	170	110	154
8	1.6	35	.....	.....	.....	83	513	71	83	203	124	154
9	1.6	35	.....	.....	.....	60	470	71	96	238	110	154
10	1.6	35	.....	.....	.....	32	450	71	96	256	124	154
11	1.6	35	.....	.....	.....	71	370	71	96	332	60	154
12	1.6	30	.....	.....	.....	83	645	71	96	50	71	154
13	1.6	26	.....	.....	.....	32	1,380*	71	110	60	83	154
14	1.6	23	.....	.....	.....	154	1,130	71	124	71	96	154
15	1.6	19s	1	8	3	203	966	71	124	83	110	154
16	1.6	19	.....	.....	.....	220	836	71	124	96	110	154
17	2.2	19	.....	.....	.....	203	410	71	139	110	110	139
18	2.2	23	.....	.....	.....	96	390	71	139	110	110	139
19	3	19f	.....	.....	.....	110	370	71	154	110	124	139
20	3	19w	.....	.....	.....	124	351	71	154	430	124	110
21	4.1	19	.....	.....	.....	83	332	83	124	410	124	124
22	4.1	19	.....	.....	.....	60	275	83	139	470	124	124
23	5.5	19	.....	.....	.....	124	294	83	124	220	124	139
24	5.5	19	.....	.....	.....	170	238	96	124	170	139	139
25	5.5	19f	.....	.....	.....	124	186	96	83	203	110	450
26	5.5	8	.....	.....	.....	124	170	96	110	170	332	50
27	5.5	13	.....	.....	50	645	154	96	862	256	71	238
28	5.5	12	.....	.....	.....	579	154	110	557	294	110	738
29	5.5	11	.....	.....	.....	1,100	124	96	313	41	110	491
30	8	10	4	.....	.....	966	124	96	60	60	110	351
31	8	.....	.....	3	.....	645	.....	96	.....	60	124	.....
Accuracy	C	D	E	E	E	E	D	D	D	D	D	D

Note—*Gage height 31.1 ft. f—frozen. w—water running over ice. s—frozen at margin. Stout correction for effect of ice applied Nov. 24 to April 1.

DAILY DISCHARGE, IN SECOND-FEET, OF HEART RIVER NEAR RICHARDTON, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1924

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	836	23	3	.....	.....	23	67	.....	.....	.....	.....	.....
2	1,020*	16	f	.....	.....	38	.....	.....	.....	.....	.....	.....
3	668	16	.....	.....	.....	57	.....	.....	.....	.....	.....	.....
4	332	16	.....	.....	.....	153	.....	.....	.....	.....	.....	.....
5	410	16	.....	.....	.....	332	.....	.....	.....	.....	.....	.....
6	211	16	.....	.....	.....	167	.....	.....	.....	.....	.....	.....
7	139	16	.....	.....	.....	196	.....	.....	.....	.....	.....	.....
8	101	16	.....	.....	.....	167	.....	.....	.....	.....	.....	.....
9	89	10	.....	.....	.....	126	.....	.....	.....	.....	.....	.....
10	167	10	.....	.....	.....	113	.....	.....	.....	.....	.....	.....
11	78	10	.....	.....	.....	89	.....	.....	.....	.....	.....	.....
12	277	16	.....	.....	.....	67	.....	.....	.....	.....	.....	.....
13	181	23	.....	.....	.....	57	.....	.....	.....	.....	.....	.....
14	139	23	.....	.....	.....	47	.....	.....	.....	.....	.....	.....
15	126	23	.....	.....	.....	30	.....	.....	.....	.....	.....	.....
16	101	23	.....	.....	16	23	.....	.....	.....	.....	.....	.....
17	67	23	10	.....	.....	16	.....	.....	.....	.....	.....	.....
18	67	16	10	.....	.....	10	.....	.....	.....	.....	.....	.....
19	57	16	10	.....	.....	10	.....	.....	.....	.....	.....	.....
20	47	16	9	.....	.....	10	.....	.....	.....	.....	.....	.....
21	38	16	.....	.....	.....	10	.....	.....	.....	.....	.....	.....
22	30	16	.....	.....	.....	10	.....	.....	.....	.....	.....	.....
23	30	16	.....	.....	.....	10	.....	.....	.....	.....	.....	.....
24	30	10	.....	.....	.....	16	.....	.....	.....	.....	.....	.....
25	30	10	.....	.....	.....	23	.....	.....	.....	.....	.....	.....
26	23	10	.....	.....	.....	30	.....	.....	.....	.....	.....	.....
27	23	10	.....	.....	.....	38	.....	.....	.....	.....	.....	.....
28	23	10	.....	.....	.....	47	.....	.....	.....	.....	.....	.....
29	23s	10	.....	.....	.....	67	.....	.....	.....	.....	.....	.....
30	23	6	.....	.....	.....	67	.....	.....	.....	.....	.....	.....
31	23	.....	6	0.6	.....	67	.....	.....	.....	.....	.....	.....
Accuracy	C	C	D	E	E	E						

Note.—*Gage height 29.8 ft. s—frozen at margin. f—frozen.

MONTHLY DISCHARGE OF HEART RIVER NEAR RICHARDTON, N. DAK.

Month	Discharge in second-feet			Run-off in acre-feet
	Maximum	Minimum	Mean	
1922-1923				
October	8	1	3	191
November	39	8	21	1,250
December	4	1	3	184
January	8	3	5	307
February	50	3	8	444
March	1,100	32	261	17,000
April	1,380	124	501	29,800
May	124	50	80	4,940
June	862	60	158	9,380
July	667	41	195	12,000
August	332	60	114	6,980
September	738	50	192	11,500
The year	1,380	1	128	93,900
1923-1924				
October	1,020	23	174	10,700
November	23	6	15	910
December	10	6	7	430
January	.....	.....	3	170
February	16	16	3	179
March	332	10	68	4,200
April	.....	.....	.....	.....
May	.....	.....	.....	.....
June	.....	.....	.....	.....
July	.....	.....	.....	.....
August	.....	.....	.....	.....
September	.....	.....	.....	.....
The Period	1,020	6	45	16,600

HEART RIVER NEAR SUNNY, N. DAK.

LOCATION.—Highway bridge ¾ miles west of Sunny station of Northern Pacific Railway in Twp. 139 N., R. 82 W., about 8 miles from mouth of river near Mandan, N. Dak.

DRAINAGE AREA.—3320 square miles.

RECORDS AVAILABLE.—Station established April 1, 1924.

GAGE.—Staff in sections or piers of bridge. Read by Robert Christiansen, G. P. Eckroth, and Roy Morrell.

DISCHARGE MEASUREMENTS.—Made from bridge or by wading.

CHANNEL AND CONTROL.—Section fairly permanent.

ICE.—Stage-discharge affected by ice.

DIVERSIONS.—None.

ACCURACY.—Good. Backwater from ice jams in Missouri River may affect it for short period at extremely rare intervals.

DAILY DISCHARGE, IN SECOND-FEET, OF HEART RIVER NEAR SUNNY, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1924

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	.....	.....	.....	.....	.....	.....	50	200	49	1,200	83	5
2	.....	.....	.....	.....	.....	.....	100	261	49	916	65	5
3	.....	.....	.....	.....	.....	.....	200	293	49	449	49	5
4	.....	.....	.....	.....	.....	.....	500	230	49	318	49	5
5	.....	.....	.....	.....	.....	.....	1,000	192	49	284	49	5
6	.....	.....	.....	.....	.....	.....	2,000	184	36	236	49	5
7	.....	.....	.....	.....	.....	.....	2,060	178	36	206	49	5
8	.....	.....	.....	.....	.....	.....	1,830	173	52	178	49	2
9	.....	.....	.....	.....	.....	.....	1,300	178	65	152	36	5
10	.....	.....	.....	.....	.....	.....	738	173	62	127	36	9
11	.....	.....	.....	.....	.....	.....	489	157	69	127	30	5
12	.....	.....	.....	.....	.....	.....	410	152	83	104	25	5
13	.....	.....	.....	.....	.....	...	335	152	62	318	25	5
14	.....	.....	.....	.....	.....	.....	300	127	74	236	16	5
15	.....	.....	.....	.....	.....	.....	267	127	200	178	16	5
16	.....	.....	.....	.....	.....	.....	267	127	251	127	16	5
17	.....	.....	.....	.....	.....	.....	230	104	300	116	16	5
18	.....	.....	.....	.....	.....	.....	200	104	1,010	104	16	5
19	.....	.....	.....	.....	.....	.....	184	104	2,530*	104	36	5
20	.....	.....	.....	.....	.....	.....	178	104	1,400	83	25	5
21	.....	.....	.....	.....	.....	.....	178	83	1,720	267	49	5
22	.....	.....	.....	.....	.....	.....	157	83	1,300	267	104	5
23	.....	.....	.....	.....	.....	.....	152	74	2,290	284	65	5
24	.....	.....	.....	.....	.....	.....	139	74	1,400	221	49	4
25	.....	.....	.....	.....	.....	.....	139	65	825	410	25	2
26	.....	.....	.....	.....	.....	.....	147	65	529	570	9	5
27	.....	.....	.....	.....	.....	.....	178	65	372	300	9	9
28	.....	.....	.....	.....	.....	.....	147	65	335	206	9	7
29	.....	.....	.....	.....	.....	.....	165	57	825	178	9	5
30	.....	.....	.....	.....	.....	.....	165	49	1,510	152	9	5
31	.....	.....	.....	.....	.....	.....	.....	49	.....	104	5	.....
Accuracy							C	A	B	A	B	B

Note.—*Maximum observed gage height 13.2 ft.

DAILY DISCHARGE, IN SECOND-FEET, OF HEART RIVER NEAR SUNNY, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1925

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	5	42	.....	.....	.....	9	611	65	30	152	2	3
2	5	42	.....	.....	.....	49	489	65	36	104	2	5
3	5	42	.....	.....	.....	41	410	65	49	65	2	2
4	5	36	.....	.....	.....	33	300	65	825	49	2	2
5	9	36	.....	.....	.....	25	236	57	489	49	2	2
6	7	25	.....	.....	.....	20	236	57	611	42	2	2
7	5	25	.....	.....	.....	16	206	49	372	36	2	2
8	10	25	.....	.....	.....	32	206	49	449	49	2	3
9	16	25	.....	.....	.....	49	178	49	570	49	2	5
10	12	36	.....	.....	.....	76	152	49	410	65	2	5
11	16	36	.....	.....	.....	104	152	49	267	83	2	5
12	25	36	.....	.....	.....	97	152	42	236	83	2	5
13	25	36	.....	.....	.....	90	152	36	221	65	3	2
14	20	36	.....	.....	.....	83	127	36	206	49	5	2
15	16	36	.....	.....	.....	65	127	36	192	36	5	3
16	25	36	.....	.....	.....	70	127	36	206	30	5	5
17	37	30	.....	.....	.....	83	104	36	236	25	3	5
18	49	30	.....	.....	.....	104	104	36	300	20	3	5
19	300	36	.....	.....	.....	178	104	30	236	20	2	5
20	236	36	.....	.....	.....	104	104	30	236	16	2	3
21	206	36	.....	.....	.....	65	127	25	206	16	2	2
22	178	30	.....	.....	.....	127	152	25	165	16	2	2
23	104	28	.....	.....	.....	236	127	25	236	14	2	2
24	94	25	.....	.....	.....	570	104	25	695	12	2	2
25	83	.....	.....	.....	.....	962*	83	25	439	9	3	2
26	65	.....	.....	.....	.....	962	83	36	335	9	5	2
27	65	25	.....	.....	.....	781	83	36	300	9	5	2
28	49	.....	.....	.....	.....	870	83	30	300	7	5	2
29	49	25	.....	.....	.....	916	65	25	236	5	5	2
30	49	.....	.....	.....	.....	825	65	25	206	5	5	2
31	49	.....	.....	.....	.....	738	.....	25	.....	3	5	.....
Accuracy	B	C	E	E	E	D	A	A	A	B	C	C

Note.—*Gage height 10.8 ft. Stout correction for ice applied Nov. 11 to March 25.

DAILY DISCHARGE, IN SECOND-FEET, OF HEART RIVER NEAR SUNNY, N. DAK. FOR THE YEAR ENDING SEPTEMBER 30, 1926

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	2	.....	.....	10	7	25	36	20	9	16	83	5
2	2	9	.....	10	7	25	36	20	9	16	65	9
3	2	.....	.....	.....	.....	25	25	20	49	11	49	25
4	2	.....	9	.....	.....	36	65	20	36	9	36	104
5	2	.....	.....	.....	.....	30	65	20	36	9	36	127
6	2	.....	.....	.....	9	25	57	20	36	7	16	83
7	4	9	9	.....	.....	25	57	20	25	7	9	65
8	5	9	.....	.....	.....	36	49	20	25	5	9	36
9	5	9	.....	7	12	42	49	20	16	5	9	16
10	7	.....	.....	.....	.....	49	49	25	16	5	7	9
11	7	16	16	.....	.....	49	49	36	9	5	5	9
12	7	.....	.....	.....	12	49	42	30	9	4	5	9
13	5	.....	.....	.....	.....	49	42	25	9	2	2	7
14	5	9	.....	.....	.....	49	42	25	9	2	2	5
15	5	.....	.....	.....	.....	42	36	25	16	2	2	5
16	5	9	.....	.....	.....	42	36	25	65	1	2	4
17	5	.....	.....	.....	.....	49	36	25	65	1	5	2
18	5	.....	.....	.....	.....	65	36	25	49	1	36	2
19	7	.....	.....	.....	.....	104	36	25	42	1	36	2
20	7	.....	.....	.....	.....	140	36	20	65	1	36	2
21	9	9	12	.....	.....	236*	36	20	127	1	65	9
22	7	.....	.....	.....	12	204	36	20	127	1	65	5
23	5	.....	.....	.....	.....	178	36	25	104	36	65	2
24	5	.....	.....	.....	.....	152	36	20	65	4	49	2
25	5	.....	.....	.....	.....	152	25	20	49	4	49	1
26	7	.....	12	.....	.....	127	25	16	42	4	36	1
27	7	.....	.....	.....	16	127	25	16	36	5	25	1
28	9	.....	.....	.....	20	104	25	12	25	36	16	2
29	9	.....	.....	.....	.....	83	25	12	25	49	16	2
30	9	9	.....	.....	.....	65	20	9	16	49	9	1
31	9	.....	.....	.....	.....	49	.....	9	.....	104	5	.....
Accuracy	C	C	D	D	D	D	B	C	C	C	C	C

Note.—*Gage-height 8.8 ft. Stout correction applied to gage-heights Nov. 6 to March 22, for effect of ice.

DAILY DISCHARGE, IN SECOND-FEET, OF HEART RIVER NEAR SUNNY, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1927.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	.....	2	.....	.....	.....	25	104	36	300	236	49	9
2	.....	.....	.....	.....	.....	25	127	36	257	127	36	7
3	2	.....	2	.....	2	25	127	30	257	127	25	5
4	.....	2	.....	.....	.....	16	116	30	300	127	20	5
5	.....	1	.....	.....	.....	16	104	25	257	104	16	5
6	.....	1	.....	.....	.....	25	104	25	236	104	16	5
7	.....	2	.....	.....	.....	16	104	30	206	104	16	7
8	2	.....	2	.....	2	65	104	83	206	83	16	9
9	.....	2	.....	.....	.....	206	116	1,510	192	65	16	9
10	.....	.....	.....	.....	.....	267	116	4,710*	152	57	12	12
11	.....	.....	.....	.....	.....	178	104	3,170	127	49	12	12
12	.....	.....	.....	.....	.....	152	104	1,940	104	49	9	12
13	2	2	2	.....	2	127	116	1,200	104	42	9	16
14	.....	2	.....	.....	.....	206	116	1,300	83	36	9	127
15	.....	3	.....	.....	2	335	104	2,720	83	36	9	236
16	.....	.....	.....	.....	2	489	104	2,350	74	49	16	152
17	.....	.....	.....	.....	2	267	104	1,510	74	49	20	104
18	2	3	2	.....	2	781	94	825	65	65	16	83
19	.....	.....	.....	.....	2	570	83	570	65	65	12	65
20	.....	3	.....	.....	2	1,720	65	449	335	65	9	57
21	.....	3	.....	.....	5	1,780	65	410	206	49	16	49
22	.....	2	.....	.....	25	570	65	449	178	42	25	49
23	2	.....	2	.....	36	372	65	962	1,610	36	30	42
24	.....	.....	.....	.....	83	335	65	2,720	781	36	25	36
25	.....	.....	.....	.....	236	267	57	2,230	570	104	25	30
26	.....	.....	.....	.....	267	267	49	1,250	449	83	25	25
27	.....	2	.....	.....	65	178	49	570	335	152	65	16
28	2	.....	2	.....	65	127	42	410	221	104	36	16
29	.....	2	.....	.....	.....	127	36	335	152	83	25	16
30	.....	.....	.....	.....	.....	178	36	300	178	65	20	12
31	2	.....	2	.....	.....	104	.....	300	.....	65	16	.....
Accuracy	D	D	E	E	D	C	B	B	B	C	C	C

Note—*Gage height 16.4 ft. Stout correction applied to gage-heights Nov. 9 to March 15, for effect of ice.

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

Month	Discharge in second-feet			Run-off in acre-feet
	Maximum	Minimum	Mean	
1923-1924				
October	.....	.....	.....	.....
November	.....	.....	.....	.....
December	.....	.....	.....	.....
January	.....	.....	.....	.....
February	.....	.....	.....	.....
March	.....	.....	.....	.....
April	2,060	50	474	28,200
May	293	49	131	8,030
June	2,530	36	586	34,900
July	1,200	104	275	16,900
August	104	5	35	2,140
September	9	2	5	303
The Period	2,530	2	251	90,400
1924-1925				
October	300	5	59	3,610
November	42	25	32	1,890
December	.....	.....	20	1,230
January	.....	.....	15	922
February	.....	.....	20	1,110
March	962	9	270	16,600
April	611	65	175	10,400
May	65	25	40	2,460
June	825	30	312	18,500
July	152	3	38	2,360
August	5	2	3	184
September	5	2	3	180
The year	962	2	82	59,500
1925-1926				
October	9	2	6	340
November	16	9	10	570
December	16	9	12	730
January	10	7	7	450
February	20	7	12	650
March	236	25	78	4,830
April	65	20	39	2,310
May	36	9	21	1,280
June	127	9	40	2,400
July	104	1	13	800
August	83	2	27	1,690
September	127	1	18	1,090
The year	236	1	24	17,140
1926-1927				
October	2	2	2	120
November	3	1	2	130
December	2	2	2	120
January	.....	.....	2	120
February	267	2	29	1,630
March	1,780	16	317	19,500
April	127	36	88	5,250
May	4,710	25	1,048	64,400
June	1,610	65	272	16,200
July	236	36	79	4,860
August	65	9	21	1,290
September	236	5	41	2,440
The year	4,710	1	160	116,100

CANNONBALL RIVER NEAR STEVENSON, N. DAK.

LOCATION.—In NW.¼ sec. 21, T. 133 N., R. 82 W., at boundary of standing Rock Indian Reservation, 5 miles east of present location of Stevenson post office, Morton County, 4 miles above mouth of Dogtooth Creek, and 4 miles southeast of Timmer.

DRAINAGE AREA.—3,650 square miles.

RECORDS AVAILABLE.—June 10, 1903, to November 30, 1908; August 9, 1911, to September 30, 1918; October 1, 1921, to September 30, 1927.

GAGE.—Chain gage on left bank. Datum of gage the same as the datum of the gage maintained at same point from 1903 to 1910 and 1915 to date, read by F. S. Bingenheimer.

DISCHARGE MEASUREMENTS.—Made by wading and from cable 20 rods above gage.

CHANNEL AND CONTROL.—Bed of stream composed of sand, gravel, and stones, covered in places by silt to a depth of a foot. Control composed of stones and small boulders, at riffle 20 rods below gage; shifts slightly.

EXTREMES OF DISCHARGE.—1903-1908; 1911-1918; 1921-1927: Maximum stage recorded, 21.05 feet April 2, 1912 (discharge, 6,360 second-feet); no flow during periods each year 1904-1908 and 1913.

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

DIVERSIONS.—None.

REGULATION.—No dams that appreciably affect the flow.

ACCURACY.—Stage-discharge relation permanent except as affected by ice. Rating curve fairly well defined between 2 and 4,000 second-feet. Gage read to half-tenths once daily; occasionally to hundredths. Daily discharge ascertained by applying daily gage height to rating table. Records for open-water periods, fair; for periods of ice effect, poor.

DAILY DISCHARGE, IN SECOND-FEET, OF CANNON BALL RIVER NEAR STEVENSON, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1923

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	6	10	.....	.....	126	3,140	.....	280	62	622	325	80
2	6	10	.....	.....	102	6,900†	.....	280	62	650	325	80
3	6	17	.....	.....	54	6,600	.....	205	62	932	280	47
4	6	26	.....	.....	.....	.....	.....	147	62	680	280	23
5	6	59	.....	.....	.....	.....	.....	147	62	965	280	8
6	6	67	.....	.....	.....	.....	.....	147	80	998	770	147
7	6	86	.....	.....	.....	.....	.....	147	80	1,060	650	122
8	6	59	.....	.....	20	.....	.....	147	80	740	535	71
9	6	50	.....	.....	.....	.....	.....	147	80	535	425	62
10	6	50	.....	.....	.....	.....	.....	147	80	480	375	47
11	6	44	.....	.....	.....	.....	.....	122	80	425	325	47
12	6	44	.....	.....	.....	.....	.....	122	80	280	325	47
13	6	44	.....	.....	.....	.....	.....	122	80	240	325	47
14	6	50	.....	.....	.....	.....	.....	122	80	205	325	47
15	6	67	.....	.....	.....	.....	.....	122	80	205	480	34
16	6	86	.....	.....	.....	.....	.....	122	80	205	325	34
17	6	86	.....	.....	.....	.....	.....	122	80	205	325	62
18	6	107	.....	.....	.....	.....	.....	100	62	175	280	62
19	6	86	.....	.....	.....	.....	.....	100	62	175	280	62
20	6	.....	.....	.....	.....	.....	.....	100	80	1,450	280	62
21	6	.....	.....	.....	.....	.....	.....	100	80	1,450	325	47
22	6	.....	.....	.....	.....	.....	.....	80	80	770	325	47
23	6	.....	.....	.....	.....	.....	.....	80	80	650	325	47
24	7	.....	.....	.....	.....	.....	.....	80	80	535	280	47
25	7	.....	.....	.....	.....	.....	.....	80	80	425	280	80
26	7	.....	.....	.....	.....	.....	.....	80	122	425	280	868
27	10	.....	.....	.....	.....	.....	.....	80	1,800*	425	240	680
28	10	.....	.....	.....	.....	.....	.....	80	1,450	375	205	835
29	10	.....	.....	102	.....	.....	.....	80	802	375	175	900
30	10	.....	.....	180	.....	.....	.....	80	480	325	122	770
31	10	.....	.....	152	.....	.....	.....	62	.....	325	100	.....
Accuracy	C	D	E	E	E	E	E	D	D	D	D	D

Note—*Observed maximum gage height 7.6 ft. at 4 P. M. June 27. †Uncertain.

DAILY DISCHARGE, IN SECOND-FEET, OF CANNON BALL RIVER NEAR STEVENSON, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1924.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	485	180s	46	.....	23	15w	40	210	33	81	9	33
2	900	152f	.....	.....	23	23	152	210	33	81	9	33
3	770	152	.....	.....	.....	46	1,450	180	33	62	23	23
4	595	152	.....	.....	.....	15	1,030	152	33	46	23	23
5	650	152	.....	.....	.....	9f	802	152	33	33	81	23
6	540	152	.....	.....	.....	.....	1,030	126	33	33	62	23
7	595	126	.....	23	.....	.....	1,730	126	33	33	46	15
8	595	126	.....	.....	.....	.....	1,880*	102	166	46	33	15
9	540	126	.....	.....	9	.....	1,590	102	166	46	33	23
10	540	126	.....	.....	.....	.....	1,450	102	114	46	23	23
11	595	126	.....	.....	.....	.....	868	81	92	33	15	15
12	540	126	.....	.....	.....	.....	595	81	152	33	15	15
13	485	126	.....	.....	.....	.....	430	81	75	23	15	15
14	485	126	.....	.....	.....	.....	330	81	139	23	15	15
15	540	126	.....	.....	.....	.....	245	81	180	23	15	15
16	430	126	.....	.....	.....	46w	210	81	114	33	15	9
17	330	126	33	23	.....	15	210	62	62	33	15	9
18	285	126	.....	.....	.....	.....	180	62	265	33	307	9
19	285	126	.....	.....	.....	.....	126	62	650	23	595	5
20	285	126	.....	.....	9	.....	126	56	430	81	1,450	5
21	285	116	.....	.....	.....	.....	126	56	180	62	1,590	5
22	285	102	.....	.....	.....	.....	102	56	102	46	180	5
23	285	102	.....	.....	.....	.....	92	56	81	62	102	5
24	245	94	.....	.....	.....	.....	81	56	81	46	81	3
25	245	94	.....	.....	.....	.....	102	46	81	33	62	3
26	245	94	.....	.....	.....	.....	102	46	62	33	46	3
27	210	81	.....	.....	.....	.....	126	46	62	33	33	5
28	210	73	.....	.....	.....	.....	210	41	102	33	33	5
29	180	62	.....	.....	.....	.....	485	41	102	23	46	9
30	180	56	.....	.....	.....	.....	330	41	92	15	46	9
31	180	.....	.....	.....	.....	.....	.....	41	.....	15	33	.....
Accuracy	D	D	E	E	E	E	A	A	A	A	B	B

Note—*Maximum observed. s—frozen margin, f—frozen, w—water running over ice. Stout correction for effect of ice applied Dec. 5 to April 3.

DAILY DISCHARGE, IN SECOND-FEET, OF CANNON BALL RIVER NEAR STEVENSON, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1925.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	5	33	15	.....	5	15	650	33	3	46	3	0.5
2	5	23	15	.....	5	15	568	33	1	126	3	0.5
3	5	23	9	5	46	15	355	23	0	102	3	0.5
4	9	23	9	.....	46	23	245	23	0	81	2	0.5
5	9	23	9	.....	46	46	210	15	0	62	2	0.5
6	5	23	.....	.....	46	102	180	15	0	46	2	0.5
7	5	23	.....	.....	180	285	152	15	540	46	2	0.5
8	23	23	8	5	152	245	152	15	2,870	46	1.5	46
9	102	15	.....	.....	126	180	126	15	1,170	62	1.5	33
10	62	15	.....	.....	126	245	126	15	210	46	1.5	23
11	46	.....	.....	.....	180	152	126	15	126	33	1.5	9
12	46	.....	.....	.....	126	81	102	15	91	23	2	5
13	62	15	10	5	62	180	102	9	62	23	2	5
14	62	.....	.....	.....	33	210	81	9	62	23	2	5
15	46	.....	.....	.....	30	245	81	15	62	62	2	5
16	46	15	.....	.....	.....	285	62	15	114	46	2	3
17	33	15	.....	.....	.....	330	62	15	1,310	33	1.5	3
18	23	15	8	5	20	595	62	9	245	23	1.5	2
19	23	23	.....	.....	.....	770	62	9	102	23	1.5	2
20	15	23	.....	.....	.....	965	62	9	81	15	1.5	2
21	33	15	.....	.....	.....	1,100	62	9	62	15	1.5	1.5
22	33	15	.....	.....	.....	1,380	46	139	1,380	15	1.5	1.5
23	33	15	7	5	20	1,960	46	180	1,240	9	1	1.5
24	46	15	.....	.....	.....	3,800	46	62	540	9	1	1.5
25	62	15	.....	.....	.....	4,400*	62	33	102	9	1	1
26	46	15	.....	.....	15	3,600	62	33	152	5	1	1
27	46	23	.....	.....	15	3,050	62	23	81	5	1	1
28	33	15	6	5	15	1,100	62	15	125	5	1	1.5
29	33	9	.....	.....	.....	1,170	62	15	81	5	1	1.5
30	33	9	.....	.....	.....	965	46	9	62	3	0.5	2
31	33	.....	6	5	.....	802	.....	9	.....	3	0.5	.....
Accuracy	B											

Note—*Gage height 9.4 ft. f—frozen. r—ice running. Stout correction for ice effect applied Nov. 10 to March 22.

DAILY DISCHARGE, IN SECOND-FEET, OF CANNON BALL RIVER NEAR STEVENSON, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1926

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	1	3	.....	.....	.....	62	81	23	46	126	33	33
2	2	5	.....	.....	.....	126	81	33	46	102	33	23
3	2	5	.....	.....	.....	152	62	23	33	102	33	622
4	1	5	.....	.....	.....	152	62	23	33	102	33	430
5	1	4f	.....	.....	3	126	46	23	23	102	62	210
6	1	3	.....	.....	3	152	46	23	23	81	46	126
7	2	3	.....	.....	3	180	46	33	46	81	46	102
8	2	2	.....	.....	5	210	46	33	46	62	46	81
9	2	2	.....	.....	5	81	33	46	33	540	46	62
10	3	2	.....	.....	3	81	33	46	33	166	46	62
11	3	2	.....	.....	46	46	46	46	23	102	46	62
12	3	2	.....	.....	54	33	46	33	23	102	46	62
13	3	2	.....	.....	15	37	33	33	23	81	46	46
14	3	2	.....	.....	10	42	33	33	114	81	46	46
15	3	3	.....	.....	8	46	46	33	81	62	46	650
16	3	2	.....	.....	7	81	46	33	1,450	62	46	81
17	3	2	.....	.....	7	102	33	23	1,590*	46	33	46
18	3	2	.....	.....	6	126	46	23	768	46	102	46
19	3	2	.....	.....	6	126	33	23	650	33	210	33
20	2	3	.....	.....	6	126	33	23	595	33	228	33
21	2	3	.....	.....	6	180	33	23	540	46	102	33
22	2	3	.....	.....	6	126	33	23	485	46	102	23
23	2	3	.....	.....	6	81	46	23	380	46	81	23
24	2	3	.....	.....	6	81	46	23	285	46	81	33
25	2	3	.....	.....	8	62	33	23	245	46	62	33
26	2	3	.....	.....	10	62	33	23	210	46	46	33
27	2	3	.....	.....	15	62	23	15	210	33	33	23
28	2	3	.....	.....	33	81	23	15	180	33	23	23
29	3	3	.....	.....	.....	81	23	33	152	33	81	23
30	3	3	3	3	.....	81	23	62	152	33	62	23
31	3	.....	.....	.....	.....	102	.....	46	.....	33	46	.....
Accuracy	D	D	E	E	E	D	B	C	B	B	B	B

Note—*Gage height 6.2 ft. Stout correction applied for effect of ice, Nov. 20 to March 20. f—channel frozen over.

DAILY DISCHARGE, IN SECOND-FEET, OF CANNON BALL RIVER NEAR STEVENSON, N. DAK., FOR THE YEAR ENDING SEPTEMBER 30, 1927

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	33	18	.....	.....	.....	81	210	81	330	485	62	46
2	33	.....	.....	.....	.....	46	180	81	330	210	62	33
3	23	.....	.....	.....	.....	23	180	81	330	180	62	33
4	23	.....	.....	33	.....	46	152	81	285	152	62	33
5	23	.....	.....	.....	5	46	152	81	245	152	46	33
6	23	33	.....	9	.....	72r	152	81	285	126	46	33
7	33	.....	.....	.....	.....	126	152	152	245	102	46	33
8	33	.....	.....	9	.....	152	152	1,450	245	102	46	23
9	33	.....	.....	.....	.....	102	152	3,230*	245	81	33	23
10	23	.....	.....	.....	.....	285	152	1,100	210	81	33	23
11	33	.....	.....	.....	.....	900	152	1,380	210	81	33	23
12	33	.....	.....	.....	.....	1,100	126	2,600	180	81	33	23
13	23	23	.....	.....	.....	1,240	126	1,960	180	81	23	15
14	23	22	.....	.....	.....	710	126	1,650	152	81	23	15
15	23	20f	.....	.....	.....	380	152	1,800	152	62	23	15
16	23	.....	15	.....	.....	210	210	2,040	152	868	430	15
17	23	.....	.....	.....	.....	710	210	1,450	152	595	152	15
18	23	.....	.....	.....	.....	1,240	180	770	152	180	102	15
19	23	.....	.....	.....	.....	265	152	965	180	152	81	15
20	23	.....	.....	.....	.....	1,100r	126	650	330	102	62	15
21	15	.....	.....	.....	28	1,240	126	1,660	210	81	62	15
22	15	.....	.....	.....	46	1,170	126	770	180	81	62	15
23	15	.....	.....	.....	46	900	126	2,200	180	81	62	15
24	15	.....	.....	.....	126	802	126	1,030	152	62	62	15
25	15	.....	.....	.....	152	680	126	965	152	62	62	9
26	15	.....	.....	.....	102	568	126	710	126	81	46	9
27	23	.....	.....	.....	152	485	102	540	126	81	46	9
28	23	.....	.....	.....	102	458	102	380	102	81	46	9
29	23	.....	.....	23w	.....	458	102	330	102	62	46	9
30	15	.....	.....	.....	.....	380	102	430	835	62	46	9
31	15	.....	.....	.....	.....	330	.....	380	.....	62	46	.....

Accuracy

Note—*Observed maximum gage height 8.4 ft. at 5 P. M. f—frozen. r—ice or slush running. w—water flowing over ice. Stout correction applied for effect of ice. Nov. 15 to March 21.

MONTHLY DISCHARGE OF CANNON BALL RIVER NEAR STEVENSON N. DAK.

Month	Discharge in second-feet			Run-off in acre-feet
	Maximum	Minimum	Mean	
1922-1923				
October	10	6	7	420
November	107	10	53	3,150
December	35	20	26	1,580
January	180	15	27	1,650
February	126	15	26	1,460
March	6,900	40	1,208	74,300
April	.....	.....	1,000	59,400
May	280	62	123	7,600
June	1,800	62	218	13,000
July	1,450	175	557	34,300
August	770	100	328	20,200
September	900	8	184	10,900
The year	1,800	6	314	228,000
1923-1924				
October	900	180	420	25,800
November	180	56	119	7,100
December	46	30	35	2,170
January	25	23	23	1,430
February	23	9	11	659
March	46	9	13	820
April	1,880	40	541	32,200
May	210	41	88	5,380
June	650	33	126	7,500
July	81	15	40	2,470
August	1,590	9	163	10,000
September	33	3	13	789
The year	1,880	3	133	96,400
1924-1925				
October	102	5	34	2,110
November	33	9	18	1,060
December	15	6	8	512
January	5	5	5	306
February	180	5	52	2,880
March	4,400	15	913	56,200
April	650	46	137	8,170
May	180	9	27	1,680
June	2,870	0	362	21,500
July	126	3	34	2,080
August	3	0	2	99
September	46	0	5	317
The year	4,400	0	133	96,900
1925-1926				
October	3	1	2	140
November	5	2	3	170
December	3	3	4	250
January	3	3	3	180
February	54	3	10	570
March	210	33	100	6,120
April	81	23	42	2,470
May	62	15	30	1,820
June	1,590	23	284	16,900
July	540	33	82	5,060
August	228	23	64	3,950
September	650	23	104	6,200
The year	1,590	1	61	43,800
1926-1927				
October	33	15	23	1,430
November	33	16	22	1,310
December	15	13	15	910
January	33	8	11	670
February	152	5	31	1,700
March	1,240	23	550	33,800
April	210	102	145	8,640
May	3,230	81	1,003	61,700
June	835	102	225	13,400
July	868	62	153	9,420
August	430	23	66	4,060
September	46	9	20	1,180
The year	3,230	5	189	138,200