PUBLIC DOCUMENT No. 15

THIRD BIENNIAL REPORT

OF THE

State Engineer

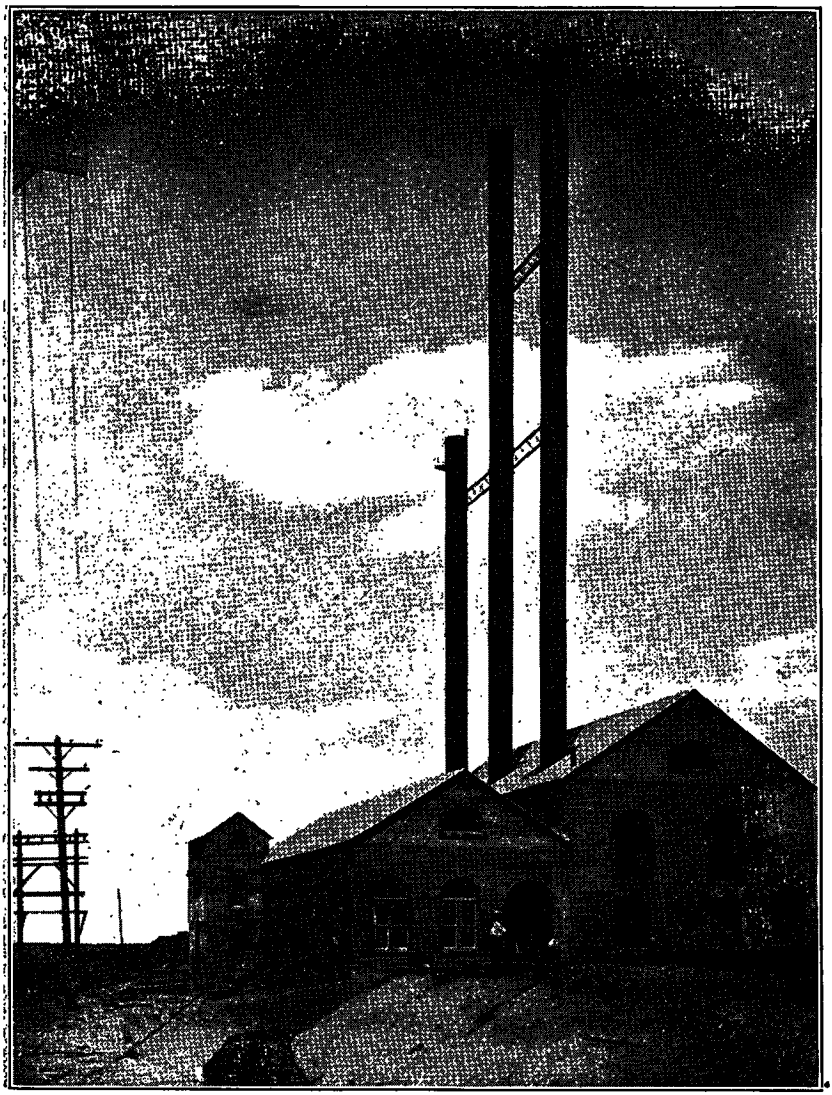
TO THE

GOVERNOR OF NORTH DAKOTA

FOR THE

Years 1907 and 1908

BISMARCK, N. D.
TRIBUNE, STATE PRINTERS AND BINDERS
1908



POWER HOUSE FOR WILLISTON AND BUFORD-TRENTON PROJECTS.

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LETTER OF TRANSMITTAL

Bismarck, North Dakota, September 30, 1908.

Honorable John Burke, Governor of North Dakota:

SIR: In accordance with State Irrigation Code I have the honor to transmit herewith report of the transactions of the department of the state engineer, from September 30, 1906 to September 30, 1908.

Very respectfully,

T. R. ATKINSON,
State Engineer.

FINANCIAL STATEMENT

WARRANT ACCOUNT FOR PROMOTION OF IRRIGATION AND DRAINAGE FROM OCTOBER 14, 1906, TO NOVEMBER 1, 1908.

No.	Date	To Whom Issued	Amount
66833	11- 1-1906	A. G. Patterson, P. M	$ 10.00
66837	11- 1-1906	A. L. Fellows	208.33
66838	11- 1-1906	T. R. Atkinson	150.00
66839	11- 1-1906	Laura Connor	75.00
66888	11-15-1906	Laura Connor	37.50
66892	11-15-1906	W. U. Tel. Co.	.25
66984	11-21-1906	O. F. Jones	112.50
66985	11-21-1906	H. V. Ausburn	68.80
66986	11-21-1906	R. L. Jackson	50.25
66987	11-21-1906	Asa Gardner	19.49
66988	11-21-1906	T. R. Atkinson	18.73
66989	11-21-1906	A. L. Fellows	13.25
66990	11-21-1908	Thorn Dickinson	9.25
67034	11-30-1906	A. L. Fellows	208.33
67035	11-30-1906	T. R. Atkinson	150.00
67355	12-20-1906	A. L. Fellows	208.33
67356	12-20-1906	T. R. Atkinson	150.00
67579	1- 7-1907	A. L. Fellows	86.70
67869	1-26-1907	A. L. Fellows	208.33
68078	2- 1-1907	T. R. Atkinson	150.00
68132	2- 4-1907	A. L. Fellows	6.37
68133	2- 4-1907	Bismarck Tribune Co	11.25
68568	2-18-1907	A. G. Patterson, P. M.	40.00
68588	2-27-1907	A. L. Fellows	208.33
68589	2-27-1907	T. R. Atkinson	150.00
68662	3- 2-1907	Northern Express Co.	1.25
69070	3-20-1907	T. R. Atkinson	150.00
69201	3-30-1907	A. L. Fellows	208.33
69237	4-11-1907	Northern Express Co.	.75
69350	4-30-1907	A. L. Fellows	208.33
69351	4-30-1907	T. R. Atkinson	150.00
69591	5- 3-1907	N. D. Book & Sty. Co.	10.50
69592	5- 3-1907	G. H. Merrifield	5.40
69653	5- 6-1907	A. L. Fellows	18.94
69654	5- 6-1907	T. R. Atkinson	32.70
69670	5- 6-1907	Northern Express Co.	.60
69942	5-28-1907	T. R. Atkinson	150.00
70102	6- 1-1907	A. L. Fellows	208.33
70300	6-15-1907	T. R. Atkinson	150.00
70389	6-24-1907	A. L. Fellows	208.33
70500	7- 1-1907	Wm. F. Harris	13.50
70510	7- 1-1907	A. L. Fellows	8.75
70511	7- 1-1907	Wm. F. Harris	8.50

FINANCIAL STATEMENT—Continued.

No.	Date	To Whom Issued	Amount
70509	7- 1-1907	T. R. Atkinson	30.65
70600	7- 9-1907	Northern Express Co.	8.35
70637	7- 9-1907	T. R. Atkinson	208.33
70687	7-11-1907	Western Union Tel. Co.	.20
70799	7-30-1907	H. E. Michelson	9.00
70935	8- 1-1907	T. R. Atkinson	26.17
70936	8- 1-1907	T. R. Atkinson	15.70
71011	8- 3-1907	Bismarck Implement Co.	55.00
71012	8- 3-1907	Frank J. Fox	225.00
71013	8- 3-1907	A. L. Fellows	21.75
71037	8- 5-1907	Grambs & Wolbert	56.21
71070	8- 7-1907	Northern Express Co.	.85
71073	8- 7-1907	Western Union Tel. Co.	1.29
70940	8-22-1907	T. R. Atkinson	208.33
71178	8-24-1907	V. H. Aiken	55.10
71179	8-24-1907	V. H. Aiken	75.00
71399	8-31-1907	A. G. Patterson, P. M.	10.00
71399	8-31-1907	A. G. Patterson, p. m.	10.00
71405	8-31-1907	T. R. Atkinson	208.33
71406	8-31-1907	Ara Waggoner	75.00
71461	9- 4-1907	Northern Express Co.	1.15
71472	9-10-1907	T. R. Atkinson	26.91
71625	9-28-1907	V. H. Aiken	12.10
71662	9-30-1907	T. R. Atkinson	208.33
71663	9-30-1907	Ara E. Waggoner	75.00
71916	10-19-1907	Ara E. Waggoner	50.00
72085	11- 2-1907	T. R. Atkinson	208.33
72089	11- 2-1907	T. R. Atkinson	19.20
72100	11- 7-1907	Western Union Tel. Co.	.80
72108	11- 7-1907	Northern Express Co.	2.20
72146	11-25-1907	H. D. Warner	16.55
72229	11-30-1907	V. H. Aiken	75.00
72244	12- 4-1907	T. R. Atkinson	208.33
72255	12- 7-1907	V. H. Aiken	53.23
72259	12- 7-1907	Northern Express Co.	1.55
72292	12-12-1907	V. H. Aiken	40.35
72293	12-12-1907	T. R. Atkinson	131.80
72294	12-12-1907	W .D. Warner	25.00
72295	12-12-1907	W. D. Warner	24.20
72380	12-14-1907	Western Express Co.	1.25
72581	12-23-1907	V. H. Aiken	75.00
72582	12-23-1907	T. P. O'Connor	20.00
72618	1- 4-1908	T. R. Atkinson	208.33
72629	1- 8-1907	Northern Express Co.	1.50
72642	1-11-1908	A. G. Patterson, P. M.	12.72
72686	1-21-1908	T. R. Atkinson	22.65
72737	1-21-1908	G. W. Wolbert Hdwe. Co.	4.70
72805	1-24-1908	Western Union Tel. Co.	.49
72840	1-30-1908	V. H. Aiken	75.00
72937	2- 1-1907	A. G. Patterson, P. M.	10.00
73213	2-17-1907	V. H. Aiken	5.65
73214	2-17-1908	Melvin G. Hagen	3.00
73215	2-17-1908	Brummond & Vesperman	9.00
73216	2-17-1908	Noyes Bros. & Cutler	5.75

FINANCIAL STATEMENT—Continued.

No.	Date	To Whom Issued	Amount
73217	2-17-1907	E. F. Chandler	18.00
73289	2-25-1908	T. R. Atkinson	208.33
73384	2-28-1908	V. H. Aiken	75.00
73399	3- 2-1908	T. R. Atkinson	47.45
73400	3- 2-1908	T. R. Atkinson	26.60
73670	3-17-1908	Western Union Tel. Co.	3.03
73685	3-18-1908	Joseph E. Brown	8.00
73810	3-28-1908	T. R. Atkinson	208.33
73866	3-26-1908	H. J. Fritz	7.70
73933	3-31-1908	V. H. Aiken	75.00
73934	3-31-1908	Paul N. Ford	50.00
73935	3-31-1908	J. M. Hansen	40.00
73946	3-31-1908	R. H. Garrett	30.00
74016	4- 3-1908	V. H. Aiken	35.85
74092	4- 6-1908	J. W. Bliss	37.55
74093	4- 6-1908	J. M. Hansen	16.00
74272	4- 8-1908	G. W. Wolbert Hdwe. Co.	11.33
74300	4- 9-1908	T. R. Atkinson	208.33
74316	4-15-1908	A. G. Patterson, P. M.	10.00
74520	4-29-1908	V. H. Aiken	12.50
74521	4-29-1908	F. B. Starkenberg	15.00
74522	4-29-1908	John M. Hansen	20.00
74523	4-29-1908	I. E. Schneider	60.00
74524	4-29-1908	D. B. Spaulding	70.00
74525	4-29-1908	Paul N. Ford	100.00
74604	5- 4-1908	T. R. Atkinson	18.37
74605	5- 4-1908	T. R. Atkinson	29.60
74606	5- 5-1908	J. W. Bliss	53.45
74675	5- 5-1908	T. R. Atkinson	208.33
74680	5- 6-1908	Western Union Tel. Co.	.65
74827	5-11-1908	G. W. Wolbert Hdwe. Co.	3.65
74242	4- 8-1908	J. W. Bliss	50.00
75050	6- 1-1908	V. H. Aiken	41.94
75051	6- 1-1908	F. B. Starkenberg	30.64
75052	6- 1-1908	J. M. Hansen	20.00
75053	6- 1-1908	I. E. Schneider	60.00
75054	6- 1-1908	Paul N. Ford	100.00
75138	6- 6-1908	O. J. Rued	27.71
75139	6- 6-1908	T. R. Atkinson	208.33
75141	6- 6-1908	Western Union Tel. Co.	4.91
75279	6-10-1908	Power & Ward	8.00
75280	6-10-1908	J. W. Bliss	23.33
75281	6-10-1908	Henry R. Evans	78.00
75282	6-10-1908	Eugene Dietzgen Co.	156.14
75284	6-11-1908	Northern Pacific Ry. Co.	4.74
75444	6-30-1908	Paul N. Ford	100.00
75445	6-30-1908	I. E. Schneider	60.00
75446	6-30-1908	J. W. Bliss	33.33
75464	6-30-1908	A. G. Patterson, P. M.	10.00
75470	7- 3-1908	T. R. Atkinson	208.33
75471	7- 3-1908	V. H. Aiken	100.00
75472	7- 3-1908	F. B. Starkenberg	50.00
75473	7- 3-1908	John M. Hansen	40.00
75474	7- 3-1908	Thorn Dickinson	42.50

FINANCIAL STATEMENT—Continued.

No.	Date	To Whom Issued	Amount
75475	7- 3-1908	Ralph Brown	29.33
75494	7- 7-1908	Northern Express Co.	3.00
75526	7-15-1908	Western Union Tel. Co.	1.40
75531	7-15-1908	Paul N. Ford	50.00
75533	7-15-1908	V. H. Aiken	40.95
75547	7-24-1908	T. R. Atkinson	174.70
75592	7-29-1908	J. W. Bliss	100.00
75616	7-31-1908	V. H. Aiken	100.00
75617	7-31-1908	Thorn Dickinson	85.00
75618	7-31-1908	I. E. Schneider	60.00
75619	7-31-1908	F. B. Starkenberg	50.00
75620	7-31-1908	J. M. Hansen	40.00
75621	7-31-1908	Ralph Brown	40.00
75643	8- 1-1908	A. G. Patterson, P. M.	28.00
75649	8- 1-1908	Northern Express Co.	3.50
75652	8- 3-1908	T. R. Atkinson	208.33
75811	8-10-1908	Western Union Tel. Co.	.33
75812	8-10-1908	Northern Express Co.	.65
75813	8-10-1908	N. D. Ind. Telephone Co.	.75
75814	8-10-1908	N. D. Ind. Telephone Co.	1.25
75815	8-10-1908	A. W. Lucas Co.	3.30
75816	8-10-1908	A. W. Lucas Co.	5.25
75817	8-10-1908	Baird Halberstadt	15.00
75818	8-10-1908	G. W. Wolbert, Hdwe. Co.	19.45
75819	8-10-1908	Ole J. Rued	32.65
75820	8-10-1908	Henry R. Evans	66.00
75821	8-10-1908	V. H. Aiken	90.43
75822	8-10-1908	Henry R. Evans	96.00
75823	8-10-1908	Wm. Black	120.00
75824	8-10-1908	T. R. Atkinson	136.91
76134	8-26-1908	N. W. Telephone Exch. Co.	.50
76139	8-26-1908	Western Union Tel. Co.	1.52
76159	8-26-1908	Democratic Printing Co.	7.10
76160	8-26-1908	C. A. Huntley	12.50
76161	8-26-1908	J. B. Fleming	15.00
76162	8-26-1908	Eugene Dietzgen Co.	29.17
76163	8-26-1908	V. H. Aiken	29.15
76247	8-31-1908	V. H. Aiken	50.00
76252	8-31-1908	Jay W. Bliss	100.00
76253	8-31-1908	J. M. Hansen	29.03
76254	8-31-1908	A. B. Falconer	8.00
76255	8-31-1908	I. E. Schneider	75.00
76271	8-31-1908	Alice G. Olson	3.00
76279	9- 2-1908	R. W. Brown	40.00
76280	9- 2-1908	F. B. Starkenberg	50.00
76301	9- 2-1908	Northern Express Co.	2.00
76382	9- 4-1908	T. R. Atkinson	208.33
76383	9- 4-1908	J. M. Hansen	6.67
76446	9-11-1908	Thorn Dickinson	60.32
76480	9-25-1908	I. E. Schneider	75.00
76579	9-29-1908	Jay W. Bliss	100.00
76598	10- 1-1908	A. G. Patterson, P. M.	10.00
76609	10- 1-1908	Western Union Tel. Co.	2.16
76620	10- 3-1908	Thorn Dickinson	11.95

FINANCIAL STATEMENT—Continued.

No.	Date	To Whom Issued	Amount
76621	10- 3-1908	T. R. Atkinson	45.05
76623	10- 6-1908	T. R. Atkinson	208.33
76626	10- 8-1908	Northern Pacific Ry. Co.	1.23
76771	10-13-1908	Bismarck Tribune Co.	6.75
76895	10-14-1908	Western Union Tel. Co.	1.20
76896	10-14-1908	N. D. Ind. Telephone Co.	1.30
76897	10-14-1908	Buff & Buff Mfg. Co.	2.29
76898	10-14-1908	Hans Holten & Sons	4.15
76899	10-14-1908	Dacotah Lumber Co.	4.35
76900	10-14-1908	Washburn Livery	6.00
76901	10-14-1908	Thos. Thompson Hdwe. Co.	6.50
76902	10-14-1908	Mrs. Martha Lorentzen	6.95
76903	10-14-1908	Stanthey & Bagnell	8.40
76904	10-14-1908	Jay W. Bliss	8.65
76905	10-14-1908	Eugene Dietzgen Co.	12.05
76906	10-14-1908	Theo. J. Haugeberg	14.30
76907	10-14-1908	Jay W. Bliss	52.39
76908	10-14-1908	Henry R. Evans	78.00
76909	10-14-1908	G. W. Wolbert Hdwe. Co.	91.03
77030	10-28-1908	T. R. Atkinson	21.85
77100	10-30-1908	I. E. Schenider	75.00
		Total	$ 13,160.83

Amount expended as per list	$ 13,160.83	
Balance October 14, 1906		$ 2,397.50
Appropriation — Biennial		12,000.00
Balance, November 1, 1908	1,236.67	
	$ 14,397.50	$ 14,397.50

RECEIPTS OF STATE ENGINEERS OFFICE

FROM OCTOBER 1, 1906 TO NOVEMBER 1, 1908.

1906.

October 11—Recording fees No. 8	$ 1.75
October 11—Recording fees No. 9	1.75
October 16—Filing fees No. 10	5.00

1907.

January 12—Making map No. 10	5.00
February 6—Filing fees, U. S. Reclamation Service	1.00
June 15—Filing fees U. S. Reclamation Service, No. 11	5.00
June 15—Survey and plat No. 11	25.00
June 19—Filing fees No. 12	5.00
June 29—Filing fees No. 13	5.00
June 29—Proof of publication No. 13	1.00
July 31—Proof of publication No. 12	1.00
August 21—Proof of publication No. 11	1.00
August 21—Fuller's Lake Drainage District, Steele county	480.35

1908.

May 13—Filing fees No. 14	5.00
May 26—Filing fees No. 15	5.00
May 26—Filing fees No. 16	5.00
July 15—Recording fees No. 11	1.75
July 15—Proof of publication No. 14	1.00
August 24—Recording fees N. 14	1.75
August 24—Filing Fees No. 17	5.00
August 24—Filing fees No. 18	5.00
August 28—Filing fees No. 19	5.00
August 28—Filing fees No. 20	5.00
August 28—Copies of field notes	3.40
August 28—Copies of field notes	1.40
August 28—Copies of field notes	10.80
September 8—Proof of publication Nos. 15 and 16	2.00
October 6—Proof of publication No. 17	1.00
October 19—Proof of publication Nos. 19 and 20	2.00
October 19—Fuller's Lake Drainage District	88.00
October 20—Copies of field notes	5.10
October 20—Copies of field notes and plat	12.90
Deposited with state treasurer	703.95
November 1—Due from counties of Cavalier, McHenry and Bottineau, account of drainage work	998.50
Total	$1,702.45

INTRODUCTION

The present state engineer was promoted from the position of assistant state engineer to state engineer July 1, 1907, to fill the vacancy caused by the resignation of A. L. Fellows, who had held the position since the passage and approval of the Irrigation Code, March 1, 1905. The first two years having been mostly spent in organizing the office and becoming acquainted with the water resources and the irrigable lands of the state, the last year has been one of great activity on the part of the state engineer's office.

While the experience of the past ten years in North Dakota has proven that with a normal rainfall and its proper distribution during the growing season a crop failure in the western half of the state is not possible, yet experience has also taught us that with a supply of water at hand which can be applied intelligently at the proper time a crop exceeding that grown by dry farming methods from two hundred to three hundred per cent will be obtained.

A peculiar condition arising from the location and topography of our state is such that the eastern part is benefited by drainage while the western part is benefited by irrigation. On account of the necessity for drainage in the eastern part of the state, the irrigation code contains the following provision:

"Whenever requested so to do by any of the boards of commissioners of any of the counties of the state, it is hereby made the duty of the state engineer, either by himself or by any authorized assistant engineer, to co-operate with said county commisioners in the engineering work required to lay out, establish and construct any drain to be used by any county or counties of portions of the same for the purpose of diverting flood water, lakes, water courses and in general to aid and assist the counties of this state in making preliminary surveys and establishing systems of drainage." (Sec. 7666, Rev. Statutes, 1905.)

This office has been called upon by the counties of Steele, Cavalier, McHenry, and Bottineau during the past year and has done the engineering work and made the plans for the construction of drains in each of the above named counties. The contract for the construction of one of these drains was let August 20th, and it is expected that contracts for the construction of two others will be let this fall.

Chapter 52 of the session laws of 1907 provide that the state engineer shall be ex-officio state coal mine inspector and whenever

called upon to do so by the board of university and school lands, shall make examination of state lands and report to the board whether or not they are coal bearing within the meaning of the constitution. Many of the mines of the state have been visited by an assistant from this office during the past year and nearly one hundred sections of state land have been examined to determine whether they are coal bearing.

In addition to the work above outlined, this office has done the engineering work connected with the construction of a new sewer at the state penitentiary and has been called upon on several different occasions to settle disputes over section line boundaries.

This office has also furnished the services of an assistant to aid the farmers under the Williston irrigation project in the laying out and construction of their lateral ditches.

It has been a duty as well a pleasure for this office to co-operate with the engineers of the United States Reclamation Service in the examination of proposed irrigation projects and with the Division of Irrigation and Drainage Investigations, Office of Experiment Stations, United States Department of Agriculture, in investigating drainage problems in the state and with the Bureau of Forestry in the promotion of a forest reserve in the badlands.

PERMANENT BENCH MARKS IN RED RIVER VALLEY.

In June and July, 1907, in co-operation with C. G. Elliot, Chief of Drainage Investigations, Office of Experiment Stations, United States Department of Agriculture, permanant bench marks were set in the Red River Valley for the convenience of the county surveyors and others having to do with the drainage or other engineering work in this part of the state. These bench marks, furnished by the above named office of the U. S. Department of Agriculture, are made of three inch wrought iron pipes surmounted by a bronze cap on which the name, "U. S. Department of Agriculture, Office of Experiment Stations," appears and the elevation above sea level to the nearest foot is stamped thereon. Following is the location, description and elevation of these bench marks:

Location	Description.	Elevation
Fargo	In court house yard twenty-two feet east of front entrance to the court house, and eleven feet south of walk leading to front entrance	905.34
Davenport	In school house yard, on Channing avenue and Winslow street, thirty-eight feet southeast of southeast corner of building	921.44
Mapleton	In school house yard, 109 feet north of northwest corner of building	907.90
Grandin	In school house yard, 126 feet northeast of northeast corner of building	895.41
Hillsboro	In court house yard, ninety-seven feet east of northeast corner of building	906.58
Reynolds	In school house yard, eighty-one feet northwest of northwest corner of building	910.70
Grand Forks	In court house yard, 104 feet southeast of southeast corner of building	832.47
Ardock	In school house yard thirty-nine feet southwest of southwest corner of building	828.24
Grafton	In court house yard, forty-five feet west of northwest corner of building	829.91
Pembina	In court house yard, fifteen feet southeast of southeast corner of building	791.78
Walhalla	In school house yard, thirty-two feet southeast of southeast corner of building	981.04
St. Thomas	In school house yard, thirty-six feet northwest of northwest corner of building	841.91
Mekinock	In school house yard, seventy feet southwest of southwest corner of building	864.71

IRRIGATION FILINGS.

To some land owners who desire to make applications for water rights the method of procedure to obtain a right seems to be cumbersome and expensive. Especially does this appear to be the case while such a small percentage of our water has been appropriated. The years of expensive litigation over water rights which our older western states have passed through are an example to us to make sure our water rights are carefully appropriated and legally used in order that we may avoid such endless litigation. And the methods of securing water rights under our irrigation code while seeming to be expensive, will I am sure, in later years, prove to have been carefully and wisely planned. The irrigation code provides for the recording in this office of all claims for water filed with the county officers prior to the passage of this act as well as the recording of those filings made subsequent to the passage of the act. With one exception all counties having such records of filings have forwarded copies to this office and such filings were published in the second biennial report of this office.

The filing in Williams county prior to the passage of the irrigation code are as follows:

LIST OF FILINGS IN WILLIAMS COUNTY.

No.	Name of Applicant	Description of Land	Source of Supply	Amount of Water Claimed	Date of Claim
1	Thos. J. Freeman, Jr., Rose Freeman and Tena Freeman	NW¼ and NE¼ Sec. 11 and NW¼ Sec. 12, T. 158 N., R. 100 W	Pat's Coulee	5000 inches	1901 Apr. 26
2	Edwin Jack	Desert land entry on Fort Buford military reservation (unsurveyed)	Eight Mile Creek	1000 inches	May 2
3	Thomas Ward	SE¼ Sec. 20 and W½ SW¼ and W½ NW¼, Sec. 21, T. 154 N., R. 95 W	Beaver Creek	5000 inches	May 6
4	Ellen Adams	W½ SE¼ and SW¼ Sec. 28 and SE¼ SE¼ Sec. 29 and NE¼ NE¼ Sec. 32, T. 155 N., R. 98 W	Adams Coulee	All	May 7
5	Ellen Adams	W½ SE¼ and SW¼ Sec. 28 and SE¼ SE¼ Sec. 29 and NE¼ NE¼ Sec. 32, T. 155 N., R. 98 W	Lone Tree Creek	All	May 7
6	Ellen Adams	W½ SE¼ and SW¼ Sec. 28 and SE¼ SE¼ Sec. 29 and NE¼ NE¼ Sec. 32, T. 155 N., R. 98 W	Twelve Mile Coulee	All	May 7
7	Nels J. Kemp and Gust J. Bjorkland	Lands in Secs. 3 and 10, T. 154 N., R. 96 W.	Beaver Creek	3000 inches	May 27
8	Alfred Larson	Lands in Secs. 28 and 33, T. 155 N., R. 96 W.	Beaver Creek	1200 inches	June 18
9	Carl J. Johnson	E½ of Sec. 2, Twp. 154 N., R. 97 W	Half Breed Coulee	1728 inches	June 19
10	Ernest F. Nelson	E½ of NW¼ of Sec. 1, T. 154 N., R. 97 W	Nelson Creek	2000 inches	June 19
11	Herman A. Nelson	Lands in Secs. 1 and 12, T. 154 N., R. 97 W.	Nelson Creek	3000 inches	June 19
12	Halvor Thorson	Lands in Sec. 31, T. 155 N., R. 96 W	Thorsen Creek	2000 inches	June 19
13	Geo. R. Littlefield	Lands in Secs. 17 and 8, T. 155 N., R. 96 W.	Beaver Creek	2000 inches	June 24
14	William Tancre	W½ of Sec. 15, T. 154 N., R. 96 W	Thorson Creek	2000 inches	July 11
15	Alfred Hanson	SW¼ of Sec. 34, T. 155 N., R. 95 W	West Branch Alkali Creek	1000 inches	July 15
16	John F. Rogers	Lands on east side of Creek and on south side of G. N. R. R. track	Four Mile Creek	2000 inches	July 24
17	Joseph Langford	Lands in Secs. 22, 27 and 28, T. 157 N., R. 100 W	Triple Lakes	1728 inches	July 26
18	Manley Anderson and Charles Wallander	Lands in Secs. 31 and 36, T. 155 N., R. 96 and Sec. 2, T. 154 N., R. 96 W	Dry Fork Creek	3500 inches	Aug. 13
19	Charles Baldwin	Lands in Sec. 15, T. 154 N., R. 97 W	Tobacco Garden Creek	1000 inches	Aug. 20
20	A. H. Brown	Lands in Secs. 5 and 6 of T. 157 N., R. 100 W.	Little Muddy Creek	700 inches	Sept. 13
21	Oliver Anderson Hans Barstead, Joel Walstead, William Anderson, Gilbert Ytredahl and Hans Rasmussen	Their Desert and Homestead Claims	Dry Fork or Beaver Creek	1000 inches	Nov. 8
22	*John M. Elliot*	Lands in Secs. 11 and 12, T. 155 N., R. 68 W.	Stony Creek	1000 inches	May 29
23	Katharine C. Smith	Lands in Sec. 31, T. 156 N., R. 100 W	Cow Creek	5000 inches	Mar. 26
24	Edgar A. Sharp	Lands in Sec. 16, T. 154 N., R. 100 W	Stony Creek	5060 inches	Apr. 13
25	F. S. Rounsavelle and N. Bellinger	Lands in Townships 154 and 155, R. 100	Little Muddy Creek	3456 inches	Apr. 15

LIST OF FILINGS IN WILLIAMS COUNTY.—(Continued.)

No.	Name of Applicant	Description of Land	Source of Supply	Amount of Water Claimed	Date of Claim
26	John Bruegger and George Bruegger	Lands in Secs. 20 and 17, T. 154, R. 100	Stony Creek		1901
27	Herman A. Nelson	SE¼ Sec. 36, T. 155 N., R. 97 W	Nelson Creek	1000 inches	Apr. 17
28	George Marelius, Louisa Marelius, W. S. E. Marmon and Florence Marmon	Lands described in plat accompanying notice	Black Tail Creek	3000 inches	Aug. 24
29	Arthur Burke	Lands in Sec. 5, T. 152 N., R. 104 W	Garden Coulee		Sept. 13
30	Joseph E. Clifford	Lands in Secs. 8 and 17, T. 151 N., R. 104 W	Four Mile Creek	1293 inches	1902
31	John Fagan and Patrick Fagan	Lands in Sec. 23, T. 155, R. 102 W	Sand Creek	2000 inches	Jan. 7
32	Rudolph Reider	Lands in Secs. 9 and 10, T. 155 N., R. 101 W	North Fork of Camp Creek	1000 inches	Jan. 13
33	John Noel	Lands in Sec. 12, T. 156 N., R. 101 W	Ottertail Creek	750 inches	Jan. 22
34	H. V. Smith	Lands in Secs. 33 and 32, T. 156 N., R. 100 W.	Palmer Spring	1000 inches	Jan. 24
35	John C. Dwyer	NE¼ of Sec. 5, T. 155 N., R. 100 W	Palmer Spring	100 inches	Jan. 26
36	Lottie Rosencrans	Lands in Secs. 22 and 27	Unnamed Coulee	600 inches	Feb. 4
37	M. M. Stacy	Lands in Secs. 23 and 24, T. 154 N., R. 95 W	Alkali Creek	700 inches	Feb. 4
38	Rollo A. Jones	Lands in Secs. 11 and 14, T. 152 N., R. 104 W.	Jones Coulee	7000 inches	Feb. 15
39	Joseph Langford, William Langford and Ffank Newville	Lands in Secs. 15, 22, 27, 28 and 34, T. 157 N., R. 100 W	Little Muddy Creek	4000 inches	Feb. 27
40	O. Jones and E. E. Jones	Lands in Secs. 10, 16 and 9, T. 152 N., R. 104 W	Buford Coulee	1500 inches	Feb. 27
41	Alexander Reinville	W½ NE¼ Sec. 12, T. 154, R. 104 W	Four Mile Creek	2880 inches	Mar. 10
42	Patrick Dogherty	Lands in Secs. 11 and 12, T. 158 N., R. 101 W.	Pat's Coulee	700 inches	Mar. 20
43	G. S. Fee	Lands in Secs. 1 T. 152 N., R. 104 W. and Secs. 6 and 7, T. 152 N., R. 103 W	Four Mile Creek	750 inches	Mar. 31
44	Michael Strangeland	NW¼ of Sec. 21, T. 155 N., R. 95 W	Dry Fork	1200 inches	Apr. 7
45	W. C. and F. A. Jones	Lands in Secs. 10 and 15, T. 152 N., R. 104 W.	Buford Coulee	1500 inches	Apr. 9
46	John U. Silker	Lands in Secs. 17 and 20, T. 157 N., R. 100 W.	North Bend Coulee	1000 inches	Apr. 10
47	Frederich R. Zahl and Mary E. Zahl	Lands in Secs. 23, 24 and 26, T. 159 N., R. 101 W	Scoria Coulee	900 inches	Apr. 17
48	M. A. Hewitt	Lands in Sec. 12, T. 152 N., R. 104 W	Four Mile Creek	5000 inches	Apr. 19
49	Frank Hankey	Lands in Sec. 14, T. 158 N., R. 96 W	Unnamed Coulee	500 inches	Apr. 26
50	R. C. Matthews	Lands in Sec. 30, T. 154 N., R. 100 W	Stony Creek	2000 inches	May 17
51	Wm. M. Anderson, Oliver Hendrickson, H. W. Barstad	Lands in Secs 24 and 19, T. 154 N., R. 96 W.	Dry Fork Creek	1296 inches	June 9
52	Acey Weeks	W½ NE¼ and E½ NW¼ Sec. 8, T. 156 N., R. 100 W	East Fork of Little Muddy Creek	2000 inches	June 19
53	Charles Lawrence	Lands in Sec. 4, T. 152 N., R. 104 W	Garden Coulee	900 inches	June 23
54	Peter C. Hanson	Lands in Secs. 5 and 6, T. 154 N., R. 95 W	Dry Fork Creek	1728 inches	June 28
55	Chas. N. Smith	Lands in Sec. 15, T. 153 N., R. 103 W	West Fork of Eight Mile Creek	1000 inches	July 2
56	Ole Thorson	Land described in Notice of Appropriation	Thorson Creek	2000 inches	July 15
57	Emil Gable	Lands in Sec. 28, T. 156 N., R. 100 W	Dry Coulee	2204 inches	July 24
				All	Aug. 24 Sept. 3

58	H. A. Carey	Lands in Sec. 24, T. 154 N., R. 96 W.	Beaver Creek	5000 inches	Sept. 9
59	George W. Rist	SE¼ of Sec. 8, T. 154 N., R. 98 W.	Nelson Creek	1000 inches	Sept. 27
60	Thomas J. Freeman	Desert claims in Secs. 7 and 8, T. 158 N., R. 100 W	Sandy Creek	6000 inches	Oct. 13
61	Hezekiah Matthews	Desert claims of Hezekiah Mattews	East Fork	1000 inches	Oct. 18
62	Charlotte C. Freeman	Lands in Secs. 7 and 8, T. 158 N., R. 100 W.	Sandy Creek	1000 inches	Oct. 18
63	Rose A. Freeman	Lands in Secs, 17 and 18, T. 158 N., R. 100 W.	Little Muddy Creek	1000 inches	Oct. 18
64	Philander Brown	Lands in Sec. 32, T. 158 N., R. 100 W. and Secs. 5 and 6, T. 157 N., R. 100 W.	Little Muddy Creek	1000 inches	Oct. 18
65	John Wesley Raber	Lands in Sec. 6, T. 157 N., R. 100 W.	Ollie Coulee	750 inches	Oct. 22
66	Howard B. Lampman	Lands in Secs. 21, 22, 27, T. 156 N., R. 101 W.	Cow Creek	750 inches	Oct. 31
67	Bert Johnson	Lands in Sec. 6, T. 154 N., R. 96 W.	Manley Coulee		Nov. 3
68	Charles Schafer	Lands in Secs. 23, 26 and 25, T. 150 N., R. 98 W	Beaver Creek	1000 inches	Nov. 7
69	C. A. Wittmeier, Ed. Jack, G. L. Conley and Charles Schumacher	Desert land entries as described on plate filed with notice	Eight Mile Creek	3000 inches	Nov. 14
70	Charles Bramer	Desert land entry			Nov. 18
71	David Pomerlean	Desert land entry	Box Spring Creek	750 inches	Nov. 18
72	Gustav Jacobson and Olaf Nelson	Desert land entries	X Coulee	1250 inches	Nov. 18
73	Carl A. Brolin	Desert land entre			Nov. 18
74	Carl A. Brolin	Desert land entry	Burnt Mine Creek	1000 inches	Nov. 18
75	Hilda Jacobson Julius Jacobson, Nels Wal strom and A. Enquist	Desert land entries	Dry Fork Creek	1000 inches	Nov. 18
76	Leonard Logan	Desert land entry	Dry Coulee	750 inches	Nov. 20
77	Gilbert T. Narveson	Lands in Secs. 1 and 2, T. 158 N., R. 101 W.	Red Butte Coulee	4000 inches	Nov. 20
78	Charles C. Kemper	Lands in Sec. 6 T. 154 N , R. 103 W.	Tributary of Painted Woods Creek.	75 second feet	Nov. 21
79	Lewis and Fred Paulson	Desert land entries	West Fork Timber Creek	1000 inches	Nov. 29
80	Halvor Solem, Anna H. Melland and Olaf Knutson				
81	William M. Sherland	Lands in Secs. 17 and 20, T. 156 N., R. 101 W.	Cow Creek	1000 inches	Dec. 8
82	David C. Wartenbee	Lands in Secs. 31, T. 155 N., R. 94 W., T. 154 N., R. 94 W.	Branch of Alkali Coulee	1000 inches	Dec. 8
83	Francis Hendrickson and Mamie Hendrickson	Desert land entries	1st big coulee on south side of West Camp Creek from head	800 inches	Dec. 10
84	Francis Hendrickson and James G. Hendrickson	Desert land entries	2nd Coulee on south side West Camp Creek	800 inches	Dec. 10
85	James G. Hendrickson and Adeline Hendrickson	Desert land entries	3rd Coulee on south side West Camp Creek	800 inches	Dec. 10
86	Benton Van Immans	Lands in Secs. 8 and 9, T. 155 N., R. 104 W.	Gardon Coulee	1080 incher	Dec. 30 1903
87	F. J. Brunt	Lands in Sec. 22, T. 154 N., R. 95 W.	Dry Fork and Ewen's Irrigation Ditch	2000 inches	Jan. 9
88	Lewis Forslund	Lands in Sec. 1?, T. 154 N., R. 96 W.	Unnamed Coulee	1200 inches	Mar. 5
89	Louis Forslund	Lands in Sec. 13, T. 154 N., R. 96 W.	Brush Coulee	1000 inches	Mar. 5

LIST OF FILINGS IN WILLIAMS COUNTY.—(Continued.)

No.	Name of Applicant	Description of Lands	Source of Supply	Amount of Water Claimed	Date of Claim
90	Wm. W. Barstad	Lands in Secs. 2 and 3, T. 154 N.. R. 96 W.	Dry Fork Coulee	3000 inches	June 18
91	Andrew Moliné	Lands in Secs. 13, T. 156 N.. R. 101 W., and Sec. 18, T. 156 N., R. 100 W.	Unnamed Coulee	576 inches	June 18
92	John M. Symanske	Lands in Sec. 4, T. 155 N., R. 100 W.	Spring Coulee	500 inches	June 26
93	Leonard Logan	Lands in Secs. 9 and 4, T. 154 N., R. 102 W.	East Fork of Ranch Coulee	576 inches	July 14
94	Leonard Logan	Lands in Secs. 4, 9 and 10, T. 154 N., R. 102 W.	Ranch Coulee	576 inches	July 14
95	Forrest M. Morrill, Rosetta M. Morrill and Della R. Gill	Desert land and homestead entries snd the land in Secs. 19, 29 and 30, T. 150 N., R. 104 W.	Yellowstone River	1000 inches	July 18
96	Wm. and Amos T. Pickrell	Lands in Sec. 13, T. 157 N., R. 101 W.	Unnamed Coulee	800 inches	July 20
97	George W. Millhouse	Lands in Sec. 22, T. 152 N., R. 103 W.	Millhouse Coulee	2880 inches	July 21
98	Fred A. Kellogg	Lands in Secs. 21 and 28, T. 152 N., R. 103 W.	Coyote Coulee	2880 inches	July 21
99	Mary A. Scott	Lands in Secs. 7 and 8, T. 158 N., R 99 W.	Little Muddy Creek	1000 inches	July 23
100	Martin Egan	Lands in Secs. 10 and 15, T. 154 N., R. 104 W.	Horse Creek	50 inches	July 29
101	Fred R. Estes	Lands in Secs. 5 and 6, T. 149 N., R. 104 W., and Sec. 32, T. 150 N., R 104 W.	Merrill Coulee	2880 inches	July 31
102	George W. Noble	Lands in Secs- 18 and 19, T, 150 N., R. 102 W.	Charbonneau Creek	4000 inches	Aug. 1
103	Astoria A. Austill	Lands in Secs. 30 and 31, T. 151 N., R. 102 W.	Charbonneau Creek	2000 inches	Aug. 1
104	Fred Feigley	Lands in Sec. 12, T. 150 N., R. 103 W.	Charbonneau Creek	2000 inches	Aug. 3
105	George M. Holland	Lands in Sec. 35, T. 155 N., R. 101 W.	Unnamed Spring	100 inches	Aug. 8
106	Clara Penson and Mary B. Calderwood	Lands in Secs. 14, 15 and 22, T. 151 N., R. 102 W.	Northwest Coulee	1000 inches	Aug. 12
107	P. F. McAnneny	Lands in Secs. 7 and 8, T. 155 N., R. 99 W.	Unnamed Coulee	All	Aug. 17
108	Thomas Freeman	Lands in Sec 31, T. 158 N., R. 100 W.	Ollie Freeman Coulee	1000 inches	Aug. 17
109	Thos. and Lena Norby	Lands in Secs. 20 and 29, T. 155 N., R. 95 W.	Unnamed Coulee	900 inches	Aug. 19
110	Alex Mathews	Lands in Sec. 4, T. 156 N.; R. 100 W.	East Fork of Little Muddy River	300 inches	Oct. 6
111	Lillie A. Merrill	Lands in Sec. 3, T 155 N., R. 99 W.	Unnamed Coulee	3456 inches	Oct. 9
112	Lillie A. Merrill	Lands in Sec. 3, T. 155 N., R. 99 W.	Unnamed Coulee	3456 inches	Oct. 9
113	Harmon J. Finney	Lands in Sec. 29 T. 158 N., R. 97 W.	Dry Coulee	3000 inches	Oct. 29
114	Nannie J. Stiehl	Lands in T. 154 N., R. 104 W.	Lake Coulee	480 inches	Dec. 10
115	Mary L. Powell	Desert land entries.	Spring Creek	3000 inches	Dec. 15
116	Dilno A. Powell	Desert land entry	East Fork Charoonneau Creek		Dec 15
117	Ray M. Powell	Desert land entry	East Fork of Charbonneau Creek	2000 inches	Dec. 15
118	Robert W. Stroud	Lands in Secs. 26 and 27, T. 151 N., R. 103 W.	Stroud Coulee	2000 inches	Dec. 31 1904
119	Terrence E. Reilly	Lands in Sec. 35, T. 155 N., R. 100 W.	Stony Creek	36 inches	Feb. 23
120	William D. Potter	Lands in Sec. 34, T. 155 N., R. 101 W.	Unnamed Coulee	720 inches	Mar. 7
121	William D. Potter	Lands in Sec. 34, T. 155 N., R. 101 W.	Stump Creek	1500 inches	Mar. 7
122	John C. Bain	Desert land entry	Little Muddy Creek	17280 inches	Mar. 9
123	John M. Elliot	Desert land entries	Stony Creek	1000 inches	Mar. 10
124	R. R. Stoner	Lands in T. 154 N., R. 104 W.	Little Muddy Creek	15000 inches	June 15

125	R. R. Stoner	Lands in T. 154 N., R. 104 W	Horse Tied Creek	1000 inches	June 15
126	G. H. Hyde and A. L. Slaytor	Lands in Secs. 35 and 36, T. 153 N., R. 102 W.	Herman's Coulee	All remaining	July 5
127	Central Security Co	Lands in T. 27 and 28 N., R. 59 E., M. M.	Horse Tied Creek	2000 inches	July 26
1 8	Thomas Ward	Lands in Secs. 20 and 21, T. 154 N., R. 95. W.	Lampman Coulee	300 inches	Sept. 15
129	Thomas Ward	Lands in Sec. 20, T. 154 N., R. 95 W	Dead Horse Coulee	300 inches	Sept. 15
130	Thomas Ward	Lands in Secs. 20 and 21, T. 154 N., R. 95 W.	Butte Coulee	300 inches	Sept. 15
131	William Freeman and Celestia M. Freeman	Lands in Secs. 17, 18, 19 and 20, T. 158 N., R. 100 W. and Secs 19. 20 and 30, T. 158 N., R. 100 W	Woolley's Coulee	1500 inches	Oct. 11
132	Lillie A. Merrill	Lands in Sec. 3, T. 155 N., R. 89 W	Dolby's Coulee	4032 inches	Oct. 19
133	Asbyon Olson	Lands in Sec. 32, T. 155 N., R. 95 W	Dry Fork Creek	1000 inches	Nov. 5
134	Albert D. Tice	Lands in Sec. 3, T. 152 N., R. 104 W	Buford Coulee	1728 inches	Dec. 6
135	Herman A. Nelson	Lands in T. 155, R. 96 and T. 154 N., R. 96-7	Nelson Creek	5000 inches	Dec. 21
136	William S. Marmon and George Marelius	Lands as described on plat accompanying this notice of appropriation	Black Tail Creek	3000 inches	Dec. 24 1905
137	Thomas H. Conroy	Lands in Secs. 14 and 15, T. 159 N., R. 102 W.	Brush Coulee	All	Mar. 15
138	Thomas H Conroy	Lands in Secs. 14 and 15, T. 159 N., R. 102 W.	Sun Coulee	All	Mar. 15
139	Benjamin Thoeng	Lands in Sec. 35, T. 158 N., R. 101 W	Cut Bank Coulee	All	Mar. 15
140	Joseph Plummer	Lands in Sec. 32 T. 156 N., R. 100 W	Palmer Springs	720 inches	Apr. 3
141	John Johnson	Lands in Sec. 11, T. 158 N., R. 101 W	Pat's Coulee	720 inches	Aug. 8 1907
142	L. L. Lampman	Lands in Sec. 20, T. 156 N., R. 101 W	South Fork of Cow Creek	500 inches	July 13

FILINGS MADE IN ACCORDANCE WITH THE IRRIGATION CODE SINCE THE LAST BIENNIAL REPORT.

No.	Name of Applicant	Lands to be Irrigated	Source of Supply	Amount of Water Claimed	Date of Claim
10	D. N. McPhee	320 acres in Secs. 21, 28 and 29, T. 130 N., R. 101 W	Spring Creek	Second Feet 4	1906 Oct. 16 1907
11	C. A. Patterson	80 acres in Sec. 7, T. 132 N., R. 101 W	Spring Creek	1	June 7
12	Thomas, John, Robert and Joseph Fisher	320 acres in Secs. 4, 5, and 9, T. 140 N., R. 96 W	Green River	4	June 17
13	Forstein Hallin	120 acres in Secs. 7 and 18, T. 150 N., R. 95 W.	Hallin Creek	2	July 1 1908
14	Wakefield Brothers	170 acres in Sec. 6, T. 133 N., R. 92 W	Cannon Ball River	2½	May 12
15	J. T. Ashbury	480 acres in Sec. 27, T. 133 N., R. 104 W	Bacon Creek	6	May 26
16	J. T. Ashbury	260 acres in Sec 15, T. 132 N., R. 103 W	Deep Creek	3¼	May 26
17	J. P. Larson	200 acres in Sec. 17, T. 134 N., R. 94 W	Spring Creek	2½	Aug. 12
18	Eli Segnel	126 acres in Secs. 8 and 17, T. 151 N., R. 98 W.	Line Camp Draw	1½	July 28
19	James P. Steadman and Dakota Land & Cattle Company	850 acres in Secs. 19, 20, 21, 29, T. 145 N., R. 95 W	Spring Creek	10⅝	Aug. 29
20	Dakota Land & Cattle Company	100 acres in Sec. 35, T. 143 N., R. 96 W	Crooked Creek	1¼	Aug. 29

INVESTIGATIONS OF STATE LANDS.

At the request of the Board of University and School Lands the state engineer in July and August, 1907, made examinations of nearly three hundred tracts of state land to determine whether they were coal bearing. Below is given his report to the board:

Bismarck, N. D., August 26, 1907.

To the Honorable Board of University and School Lands of North Dakota, Bismarck, North Dakota:

GENTLEMEN: Pursuant to your request I have examined the lands described in the attached schedule in Morton, Hettinger, Adams, Bowman, and Billings counties, and beg to submit the following report:

Section 7608 of the Revised Codes of 1905, as amended in 1907, makes it the duty of the state engineer upon request of the board of university and school lands to investigate any particular piece of state land for the purpose of determining whether or not it is coal bearing within the meaning of the constitution. Section 155 of the constitution reads as follows: "The coal lands of the state shall never be sold, but the legislative assembly may by general laws provide for leasing the same. The words 'coal lands' shall include lands bearing lignite coal." The United States Geological Survey classify lands which upon superficial examination show no signs of coal, as agricultural lands, i. e., unless coal outcrops along ravines or the surface indications lead their geologists to the conclusion that coal is beneath.

The United States land office now have a party of geologists in the western part of the state examining government lands in North Dakota and Montana, and this method of superficial examination is their way of determining what are coal lands. This party of government geologists are in charge of Dr. Leonard, our state geologist, and I have conferred with him on two different occasions concerning the lands referred to in this report. This method was the one used by Dr. Leonard in his examination of school lands in McLean county in 1906. This also is the method used by me in making my examination of the lands covered by this report. The question arises, however, as to the definition of "coal lands" as used in that clause of the constitution. Much of the land in the western part of the state has an underlying seam of coal, varying in thickness. At the present time men engaged in the business of mining lignite coal in North Dakota do not consider it profitable to work a seam of less than six feet in thickness. The settlers, however, are working lignite for local use where the seam is not over two feet thick. If the clause in the constitution shall be construed to mean that all state lands containing lignite seams of whatever thickness and

whatever depth below the surface, then but a small proportion of state lands could be sold. For the purpose of this report I have construed the clause to mean lands on which the coal seams are too thin to permit of profitable mining at the present value of lignite coal.

However, the method used for determining what are coal lands, as I have designated, is not a satisfactory one, and I would recommend that all future investigations be made by drilling at least one hole on each quarter section of land, wherever there is a possibility of coal being present. No fund has as yet been provided for such investigations, but the probably increase in the value of our lignite coal makes it highly important that such a fund be provided and all future investigations made as suggested above.

Respectfully submitted,

T. R. ATKINSON,
State Engineer.

MORTON COUNTY.

Description	Sec.	Twp.	Rge.	
NE¼	16	134	83	Not coal land
NW¼	16	134	83	Not coal land
SE¼	16	134	83	Not coal land
SW¼	16	134	83	Not coal land
NE¼	16	134	83	Not coal land
NW¼	16	134	88	Not coal land
SW¼	16	134	88	Not coal land
NE¼	36	134	88	Coal land
NW¼	36	134	88	Coal land
SE¼	36	134	88	Coal land
SW¼	36	134	88	Coal land
NE¼	16	134	89	Not coal land
NW¼	16	134	89	Not coal land
SE¼	16	134	89	Not coal land
SW¼	16	134	89	Not coal land
NE¼	36	134	89	Not coal land
NW¼	36	134	89	Not coal land
SE¼	36	134	89	Not coal land
SW¼	36	134	89	Not coal land
NE¼	36	134	90	Not coal land
NW¼	36	134	90	Not coal land
SE¼	36	134	90	Not coal land
SW¼	36	134	90	Not coal land
NE¼	16	135	80	Not coal land
NW¼	16	135	80	Not coal land
SE¼	16	135	80	Not coal land
SW¼	16	135	80	Not coal land
NW¼	36	135	80	Not coal land
SW¼	36	135	80	Not coal land
SE¼	36	135	80	Not coal land
W½ of NE¼	36	135	80	Not coal land
E½ of NE¼	36	135	80	Not coal land
NE¼	16	135	81	Coal land

MORTON COUNTY—Continued.

Description	Sec.	Twp.	Rge.	
NW¼	16	135	81	Coal land
SE¼	16	135	81	Coal land
SW¼	16	135	81	Coal land
NE¼	36	135	81	Not coal land
NW¼	36	135	81	Not coal land
SE¼	36	135	81	Not coal land
SW¼	36	135	81	Not coal land
NE¼	16	135	82	Not coal land
NW¼	16	135	82	Not coal land
SE¼	16	135	82	Not coal land
SW¼	16	135	82	Not coal land
NE¼	36	135	82	Coal land
NW¼	36	135	82	Coal land
SE¼	36	135	82	Coal land
SW¼	36	135	82	Coal land
NE¼	16	135	83	Not coal land
NW¼	16	135	83	Not coal land
SE¼	16	135	83	Not coal land
SW¼	16	135	83	Not coal land
NE¼	36	135	83	Not coal land
NW¼	36	135	83	Not coal land
SE¼	36	135	83	Not coal land
SW¼	36	135	83	Not coal land
NE¼	16	135	84	Not coal land
NW¼	16	135	84	Not coal land
SE¼	16	135	84	Not coal land
SW¼	16	135	84	Not coal land
NE¼	36	135	84	Not coal land
NW¼	36	135	84	Not coal land
SE¼	36	135	84	Not coal land
SW¼	36	135	84	Not coal land
NE¼	16	135	85	Not coal land
NW¼	16	135	85	Not coal land
SE¼	16	135	85	Not coal land
SW¼	16	135	85	Not coal land
NE¼	36	135	85	Not coal land
NW¼	36	135	85	Not coal land
SE¼	36	135	85	Not coal land
SW¼	36	135	85	Not coal land
NE¼	16	135	88	Not coal land
NW¼	16	135	88	Not coal land
SE¼	16	135	88	Not coal land
SW¼	16	135	88	Not coal land
NE¼	36	135	88	Not coal land
NW¼	36	135	88	Not coal land
SE¼	36	135	88	Not coal land
SW¼	36	135	88	Not coal land
NW¼	16	136	80	Not coal land
SW¼	16	136	80	Not coal land
Lot 5	16	136	80	Not coal land
Lot 6	16	136	80	Not coal land
Lot 7	16	136	80	Not coal land
Lot 8	16	136	80	Not coal land

MORTON COUNTY—Continued.

Description	Sec.	Twp.	Rge.	
NE¼	36	136	80	Not coal land
NE¼	16	136	81	Not coal land
SE¼	16	136	81	Not coal land
NE¼	36	136	81	Not coal land
NW¼	36	136	81	Not coal land
SE¼	36	136	81	Not coal land
SW¼	36	136	81	Not coal land
NE¼	16	136	82	Not coal land
NW¼	16	136	82	Not coal land
SE¼	16	136	82	Not coal land
SW¼	16	136	82	Not coal land
NE¼	36	136	82	Not coal land
NW¼	36	136	82	Not coal land
SE¼	36	136	82	Not coal land
SW¼	36	136	82	Not coal land
NE¼	16	136	83	Not coal land
NW¼	16	136	83	Not coal land
SE¼	16	136	83	Not coal land
SW¼	16	136	83	Not coal land
NE¼	36	136	84	Not coal land
NW¼	36	136	84	Not coal land
SE¼	36	136	84	Not coal land
SW¼	36	136	84	Not coal land
NE¼	16	137	81	Not coal land
NW¼	16	137	81	Not coal land
SE¼	16	137	81	Not coal land
SW¼	16	137	81	Not coal land
NE¼	36	137	81	Coal land
NW¼	36	137	81	Coal land
SE¼	36	137	81	Coal land
SW¼	36	137	81	Coal land
NE¼	16	137	82	Not coal land
NW¼	16	137	82	Not coal land
SE¼	16	137	82	Not coal land
SW¼	16	137	82	Not coal land
NW¼	36	137	82	Not coal land
SE¼	36	137	82	Not coal land
SW¼	36	137	82	Not coal land
NE¼	16	138	81	Not coal land
NW¼	16	138	81	Not coal land
SE¼	16	138	81	Not coal land
SW¼	16	138	81	Not coal land
NE¼	36	138	81	Coal land
NW¼	36	138	81	Coal land
SW¼	36	138	81	Coal land
NE¼	36	138	82	Not coal land
NW¼	36	138	82	Not coal land
SE¼	36	138	82	Not coal land
SW¼	36	138	82	Not coal land
NE¼	16	138	84	Not coal land
NW¼	16	138	84	Not coal land
SE¼	16	138	84	Not coal land
SW¼	16	138	84	Not coal land

MORTON COUNTY—Continued.

Description	Sec.	Twp.	Rge.	
NE¼	36	138	88	Coal land
NW¼	36	138	88	Coal land
SE¼	36	138	88	Coal land
SW¼	36	138	88	Coal land
NE¼	16	138	90	Coal land
NW¼	16	138	90	Coal land
SE¼	16	138	90	Coal land
SW¼	16	138	90	Coal land
NE¼	36	138	90	Coal land
NW¼	36	138	90	Coal land
SE¼	36	138	90	Coal land
SW¼	36	138	90	Coal land
NE¼	16	139	81	Not coal land
NW¼	16	139	81	Not coal land
SE¼	16	139	81	Not coal land
SW¼	16	139	81	Not coal land
NE¼	16	139	83	Not coal land
NW¼	16	139	83	Not coal land
SE¼	16	139	83	Not coal land
SW¼	16	139	83	Not coal land
NE¼	16	139	85	Not coal land
NW¼	16	139	85	Not coal land
SE¼	16	139	85	Not coal land
SW¼	16	139	85	Not coal land
NE¼	16	139	88	Not coal land
NW¼	16	139	88	Not coal land
SE¼	16	139	88	Not coal land
SW¼	16	139	88	Not coal land
NE¼	36	139	89	Not coal land
NW¼	36	139	89	Not coal land
SE¼	36	139	89	Not coal land
SW¼	36	139	89	Not coal land
NE¼	36	140	83	Not coal land
NW¼	36	140	83	Not coal land
SE¼	36	140	83	Not coal land
SW¼	36	140	83	Not coal land
NE¼	16	140	84	Coal land
NW¼	16	140	84	Coal land
SE¼	16	140	84	Coal land
SW¼	16	140	84	Coal land
NE¼	36	140	85	Coal land
NW¼	36	140	85	Coal land
SE¼	36	140	85	Coal land
SW¼	36	140	85	Coal land

HETTINGER COUNTY.

N½	36	133	93	Coal land
S½	36	133	93	Coal land
N½	16	132	92	Not coal land
S½	16	132	92	Not coal land

HETTINGER COUNTY—Continued.

Description	Sec.	Twp.	Rge.	
N½	16	134	92	Not coal land
S½	16	134	92	Not coal land
N½	36	134	92	Coal land
S½	36	134	92	Coal land
E½	36	134	93	Not coal land
W½	36	134	93	Not coal land
N½	16	134	94	Coal land
S½	16	134	94	Coal land
N½	36	134	94	Not coal land
S½	36	134	94	Not coal land
N½	16	135	92	Coal land
S½	16	135	92	Coal land
E½	36	135	92	Not coal land
W½	36	135	92	Not coal land
N½	16	135	93	Not coal land
S½	16	135	93	Not coal land
E½	36	135	93	Not coal land
W½	36	135	93	Not coal land
N½	16	135	95	Not coal land
S½	16	135	95	Not coal land
N½	36	135	95	Not coal land
S½	36	135	95	Not coal land
NE¼	18	134	91	Not coal land
S½	22	134	91	Not coal land
W½	32	134	93	Not coal land
N½	8	134	94	Coal land
S½	8	134	94	Coal land
N½	18	134	94	Coal land
S½	18	134	94	Coal land
N½	22	134	94	Coal land
SW¼	22	134	94	Coal land
N½	26	134	94	Not coal land
SE¼	20	134	95	Not coal land
N½	8	133	91	Coal land
S½	8	133	91	Coal land
N½	12	133	91	Not coal land
S½	12	133	91	Not coal land
N½	4	133	92	Coal land
S½	4	133	92	Coal land
Lots 1-2-3-4	6	133	92	Not coal land
N½	10	133	92	Not coal land
S½	10	133	92	Not coal land

ADAMS COUNTY.

N½	16	129	91	Not coal land
S½	16	129	91	Not coal land
Lots 1-2-3-4 & W½ NE¼	36	129	91	Not coal land
W½ SE¼	36	129	91	Not coal land
W½	36	129	91	Not coal land
N½	16	129	92	Not coal land

HETTINGER COUNTY—Continued.

Description	Sec.	Twp.	Rge.	
S½	16	129	92	Not coal land
N½	36	129	92	Not coal land
S½	36	129	92	Not coal land
N½	16	129	93	Not coal land
S½	16	129	93	Not coal land
N½	36	129	93	Not coal land
S½	36	129	93	Not coal land
N½	16	129	94	Not coal land
S½	16	129	94	Not coal land
N½	36	129	94	Not coal land
S½	36	129	94	Not coal land
N½	16	129	95	Not coal land
S½	16	129	95	Not coal land
N½	36	129	95	Not coal land
S½	36	129	95	Not coal land
N½	16	129	96	Not coal land
S½	16	129	96	Not coal land
N½	36	129	96	Not coal land
S½	36	129	96	Not coal land
N½	16	130	95	Not coal land
S½	16	130	95	Not coal land
N½	36	130	95	Not coal land
S½	36	130	95	Not coal land
N½	16	130	97	Not coal land
S½	16	130	97	Not coal land
N½	36	130	97	Not coal land
S½	36	130	97	Not coal land
N½	16	130	98	Coal land
S½	16	130	98	Coal land
N½	36	130	98	Not coal land
S½	36	130	98	Not coal land

BILLINGS COUNTY.

N½	16	133	105	Coal land
S½	16	133	105	Coal land
N½	36	133	105	Not coal land
S½	36	133	105	Not coal land
N½	36	133	106	Not coal land
S½	36	133	106	Not coal land

BOWMAN COUNTY.

N½	16	131	99	Not coal land
S½	16	131	99	Not coal land
N½	36	131	99	Coal land
S½	36	131	99	Coal land
N½	16	131	100	Coal land
S½	16	131	100	Coal land

BOWMAN COUNTY—Continued.

Description	Sec.	Twp.	Rge.	
N½	36	131	100	Not coal land
SE¼	36	131	100	Not coal land
SW¼	36	131	100	Not coal land
N½	16	131	101	Not coal land
S½	16	131	100	Not coal land
N½	36	131	101	Not coal land
S½	36	131	101	Not coal land
N½	16	131	102	Not coal land
S½	16	131	102	Not coal land
N½	16	132	103	Coal land
S½	16	132	103	Coal land
N½	36	132	103	Coal land
S½	36	132	103	Coal land
N½	16	132	104	Not coal land
S½	16	132	104	Not coal land

The following report was made on section 16, township 142, range 81, in response to the request of the Board of University and School Lands that an estimate be made of the amount of standing timber on said section.

September 18, 1907.

To the Honorable Board of University and School Lands, Bismarck, North Dakota:

DEAR SIRS: As per your request I have examined the timber standing on section 16, township 142, range 81, and beg to submit the following estimate of this timber:

	Board Measure Feet
W½ of NW¼	55,000
NE¼ of SW¼	60,000
NW¼ of SW¼	25,000
SW¼ of SW¼	50,000
SE¼ of SW¼	60,000
Lot 4	40,000
Total	290,000

Respectfully submitted,

DRAINAGE.

Fuller's Lake Drain Number One, in Steele county, to which reference was made in the second biennial report was held up by litigation until the summer of 1908. New plans and specifications

having been made by this office the work was let on Augnst 20, 1908, to John Kohler, of Frazee, Minnesota, at a price of 13.49 cents per cubic yard. The work is to be done with a steam dredge and to be completed August 1, 1909. This drain is seven miles long, has 86,000 cubic yards of earth excavation, reclaiming 35,772 acres of slough land at an average cost per acre of $3.80.

At the request of the board of drainage commissioners of Cavalier county the state engineer during August, 1908, made surveys of plans and profiles for the drainage of Roseau Lake in township 161, ranges 58 and 59. The length of the main drain is five and one-third miles, the number of acres reclaimed being 1,849 at an estimated cost of $2.57 per acre. Report on this project to the board of drain commissioners of Cavalier county is as follows:

Bismarck, N. D., September 8, 1908.

To the Honorable Board of Drain Commissioners, Cavalier County, Langdon, N. D.:

GENTLEMEN: Pursuant to your request of July 2, 1908, I have made surveys of Roseau Lake drain and attach herewith plan, profile and description of the center line of said drain.

In order to determine the best location for this drain, levels were run east along the section lines from the south one-quarter corner of section 20, township 161, north, range 58 west, to the Tongue river in section 23, said township. While the grade line via this route was better than on any other route surveyed the earth excavation would have been considerable more than via the route finally determined upon as the best, the course of the Tongue river. Levels were also run north one and one-fourth miles from the center of section 7, township 161 north, range 58 west, and found that the water from the Roseau lake drain could be carried north into a coule which drains into the Little Pembina river, but as it was found that this was not the natural outlet of Roseau lake it was thought best not to locate the drain in his direction. The natural outlet having been found to be through Tongue river, the location was therefore made in that direction and is shown in red ink on the plan herewith attached. I have sub-divided the sections on the plan into forty acre tracts and have shown on each tract the number of acres of low land in that tract. The total length of the main drain is five and one-third miles and the length of the "West Branch" is one an three-one-hundredths miles. I have divided the drain into four divisions as shown on the plan and profile.

Division No. 1 includes that part of the main drain lying between station 0 and station 24. It has a grade line of one foot per mile, a bottom width of one and one-half feet, side slopes one to one and requires the excavation of 6,857 cubic yards of earth.

Division No. 2 includes the "West Branch." It has a grade line of one and one-half feet per mile, a bottom width of one and one-

half feet, side slopes one to one and requires the excavation of 1,766 cubic yards of earth.

Division No. 3 includes that part of the main drain lying between the center of section 19, township 161, north, range 58, west, and the south line of section 20, said township. It has a grade line of one and one-half feet per mile, a bottom width of four feet, side slopes one to one and requires the excavation of 6,757 cubic yards of earth.

Division No. 4 includes that part of the main drain lying between the south line of section 20, township 161, north, range 58, west, and the end of the drain in the northeast quarter of section 33, said township. It has a grade line of one and one-half feet per mile, a bottom width of four feet, side slopes one to one and requires the excavation of 8,500 cubic yards of earth.

The total number of acres of low land that will be drained by this ditch is 1,849. Division Nos. 1 and 2 could best be constructed by the use of a "Plow-ditching" machine and with the supposition that one of these will be used on these divisions I would estimate the total cost of the work as follows:

1,017 rods "plow-ditching' work, at $1.00	$ 1,017.00
15,257 cubic yards earth excavation, at 18c	2,746.26
Engineering and legal expenses, (including commissioners)	700.00
Land damages	300.00
Total cost	$ 4,763.26

Hearing of the petition for this ditch was held on October 7, 1908, and the hearing on the assessment was held on October 22d and the assessment confirmed and the contract for the construction let on the last named date.

MOUSE RIVER DRAINAGE PROJECT.

At the request of R. H. Minkel of Deep, N. D., representing a number of farmers along the Mouse river in McHenry and Bottineau counties, the state engineer met with these farmers on August 12 and 13, 1907, and considered with them the drainage of the meadow lines along this river from section 20, township 159, range 77, to the international boundary. Arrangements were entered into whereby the state engineer agreed to make detailed surveys of the river and the bottom lands adjacent which would be benefited by the improvement of the river, the interested parties paying the cost of the field work except for the time of the state engineer which was given. Surveys were commenced on September 15, 1907, and completed on Ooctoer 12, 1907. Plans and profiles were made and a report rendered to the landowners' committee. Meetings were held to discuss the problem at Upham and

at Russell during January and February, 1908, which the state engineer attended and gave his advice. It having been determined to go ahead with the work of improving the river, petitions were presented to the drainage boards of Bottineau and McHenry counties to establish a drain along the river. A report was rendered the joint boards on June 8, 1908, showing the cost to be $142,773, and the acres benefited 22,251. Hearing on the petition was heard at Russell, N. D., July 9, 1908. No serious opposition appearing at this meeting of the joint drainage boards the drain was declared necessary and the work of assessing the benefits was immediately undertaken.

Owing to the magnitude of the undertaking and the high cost per acre to the land benefited it was the policy of the drainage board to give careful attention to this part of their work. The land benefited in the project was shown on the plats made by the state engineer, in forty acre tracts, and each of these tracts were viewed by the drainage board and the benefits that each tract would receive and the percentage of the cost were determined.

Hearings on the assessment were held at Bottineau on October 13, 1908 and at Towner on October 16th. Very little opposition to the assessment having appeared it was voted to have the state engineer prepare specifications for construction. Contract for the construction of the work will be let in November. It has been the policy of the joint drainage board and the state engineer as well to give all possible publicity to the land owners of the proceedings of the board an to give each one an opportunity to be heard. It is due to this fact that so little opposition to the work has appeared.

PRELIMINARY SURVEYS OF IRRIGATION PROJECTS

FORT BERTHOLD INDIAN RESERVATION.

Fort Berthold Indian reservation, containing 1,000,000 acres and lying between 47 degrees and 30 minutes and 48 degrees north latitude, is divided into nearly equal parts by the Missouri river which flows through it from the northwest to the southeast corner.

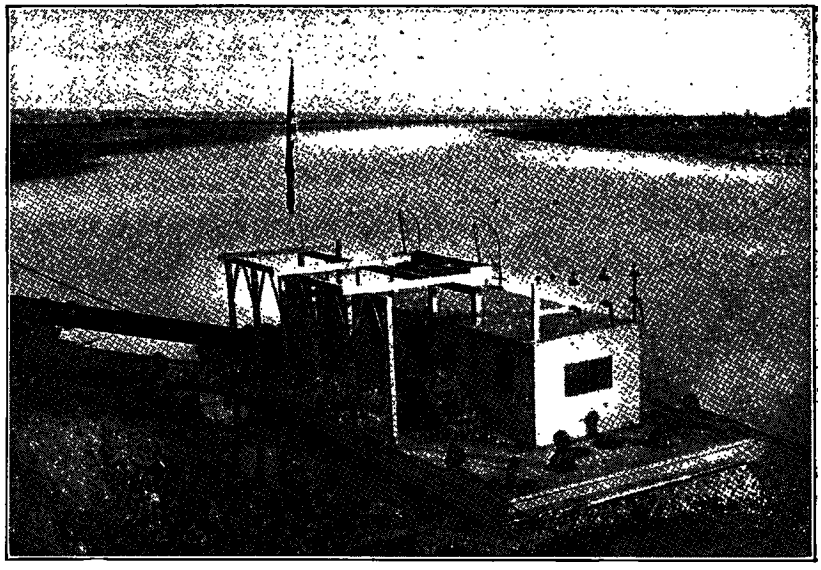
Only nine townships of this reservation have as yet been surveyed by the general land office, and these for the purpose of making allotments to the Indians. Along the river through the reservation are several fine bottoms and adjoining bench lands which can be irrigated by pumping from the river.

Realizing that it will only be a matter of a few years when this reservation will be opened to settlement the state engineer has recently made preliminary surveys of the larger tracts in order that irrigation systems could be constructed prior to the opening of these lands. Lignite coal in abundance is found along the whole course of the river through the reservation and a party from the United States geological survey are making examinations for the purpose of determining the thickness of the veins and the quality of this coal which is in close proximity to the several projects. A branch of the Northern Pacific has been located on the right of way purchased for a line north from Mandan following closely the left bank until the Yellowstone is reached and up the right bank of the Yellowstone to a junction with the main line at Glendive. This line will undoubtedly be in operation within two years and will make more valuable the projects on the west side of the river through the reservation.

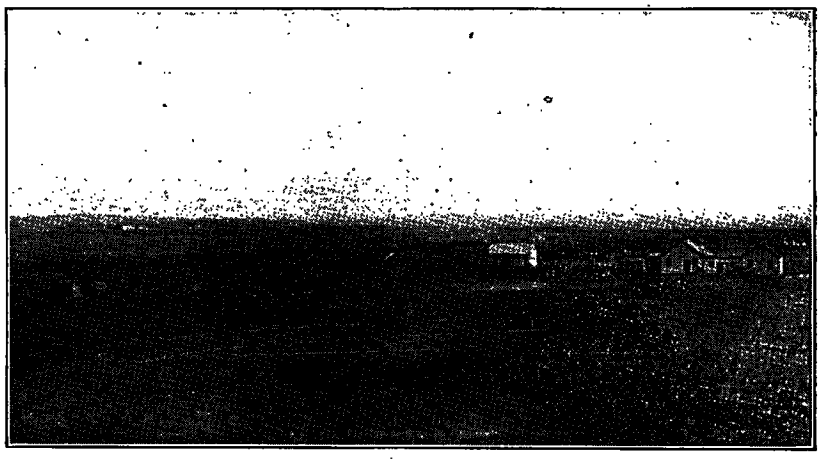
SHELL CREEK PROJECT.

The Shell Creek project, preliminary surveys of which were made by the state engineer in October and November, 1907, is situated on the north side of the Missouri river in township 150, ranges 91 and 92, and in townships 151, ranges 91 and 92, on the Fort Berthold Indian reservation. This project comprirses 18,000 to 20,000 acres of irrigable land at a maximum elevation not to exceed 100 feet above low water in the Missouri river.

Shell Creek, which drains an area of 175,000 acres, runs through the center of this project and the flow can be stored and utilized on



BARGE ON WHICH PUMPING PLANT OF WILLISTON PROJECT IS LOCATED.



SHELL CREEK PROJECT.

several thousand acres. The soil is mostly sandy loam. Only small areas have been cultivated by the Indians, but when the rainfall is sufficient, the soil has shown wonderful fertility. The presence of lignite coal in large quantities is shown by out-crops. Under date of December 17, 1907, the state engineer made a report on this project to the reclamation service and it is expected that the construction of the project will be undertaken within a few years.

INDEPENDENCE PROJECT.

Directly south of the Shell Creek project, on the right bank of the river lies the Independence project. The soil is a sandy loam on the bottoms and clayey loam on the first bench. There are 2,600 acres of grass land and 2,700 acres of brush land in this project. The maximum pumping left to cover this amount of land will not exceed 80 feet. Independence Indian village lies on the eastern edge of this tract.

ELBOWOODS PROJECT.

Commencing near the north line of township 149, range 90, on the left bank of the Missouri river are a series of bottoms and benches extending down the river eighteen miles, consisting of 8,000 acres of grass land and 5,000 acres of timber and brush land which can be reached by a maximum lift of not to exceed 100 feet. Elbowoods post-office and Fort Berthold Indian agency are situated at the extreme southeastern edge of this project. Rising Water Creek which empties into the river in section 18, township 149, range 90, has a drainage area of about 50,000 acres. The soil is sandy loam on the brush covered bottoms and sandy loam and clayey loam on the benches.

FORT BERTHOLD PROJECT.

In this project is situated the original government military post called Fort Berthold. The project lies in townships 147, ranges 87 and 88 and contains about 10,000 acres of irrigable land, 3,500 acres of which are in brush and timber. The range line between ranges 87 and 88 is the east boundary line of the FortBerthold reservation. The soil is a sandy loam on the brush covered bottoms and clayey loam on the benches. The maximum lift will be 90 feet, and lignite coal is found in close proximity to the proposed location of the main pumping plant.

STEVENSON PROJECT.

Old Fort Stevenson military reservation, which was sold to private purchasers in 1901 and has since that time been acquired by settlers, includes lands lying on both sides of the Missouri river and is located in township 147, ranges 85 and 86. Of the land in these two townships, about 20,000 acres can be irrigated by a maximum

pumping lift of ninety feet, 16,000 acres of which lies on the north side of the river and 4,000 acres on the south side. Of the total amount of irrigable land in this tract 4,000 acres is now in brush and timber. Lignite coal in abundance is found on each side of the river convenient for use in a pumping plant. The land owners under this project are very anxious to have the reclamation service undertake construction on this project and it is expected that the initial steps necessary for the accomplishment will be commenced this fall.

HANCOCK PROJECT.

On the east side of the Missouri river in townships 145 and 146, range 84, lies the Hancock bottoms comprising about 7,000 acres of land which lies well for irrigating by pumping, the maximum lift being eighty feet. These bottoms have been settled for about thirty years yet a very small portion of the tract has been broken, and settlers having confined their efforts to ranging live stock, but now that their range country is being fast settled the land owners in the bottoms desire irrigation in order to assist them in their agricultural efforts. Lignite coal is convenient for fuel and the construction of this project will probably go forward within a very few years.

HYROGRAPHY

One of the most important duties of the state engineer is to make hydrographic surveys of the streams in the state for the purpose of obtaining data for the determination, development and adjudication of the water supply of the state. Since April, 1907, the state engineer has co-operated with the water resources branch of the United States Geological Survey in the work of gaging the streams west of the Missouri river. The following tables of run-off from the various streams of the state and the discussion are furnished by Professor E. F. Chandler of University, North Dakota, who has charge of the stream gaging throughout the state for the United States geological survey.

RED RIVER AT GRAND FORKS, N. D.

Gagings of the flow of the Red river at Grand Forks were begun by the United States geological survey in 1901, but a gage height record was kept by the United States engineers (war department) for a long succession of years previously. The gaging station is located below the confluence of the Red and Red Lake rivers. The total drainage area is 25,000 square miles of which 13,400 is in Minnesota.

The tables of discharge are based on the measurements in the list below and on thirty-three measurements made during the six preceding years, and are well checked and accurate for all stages during the open season. During the frozen season fewer measurements have been made, and abnormal conditions are sometimes caused for a few days by the ice, so that the summaries are occasionally based on estimates; but it may be assumed that no errors amounting to ten per cent have been entered anywhere.

DISCHARGE MEASURMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
12-21-1906	Chandler and Clark	8.59*	1,698
1-28-1907	Chandler and Clark	8.07*	1,177
3- 4-1907	W. H. Clark	8.18*	1,216
4- 8-1907	W. H. Clark	39.25	29,400
4-22-1907	E. F. Chandler	19.37	8,740
11-11-1907	E. F. Chandler	6.81	1,670
1-20-7908	E. F. Chandler	6.76*	912
3- 9-1908	E. F. Chandler	7.76*	924
3-28-1908	E. F. Chandler	14.16*	3,680
4-13-1908	E. F. Chandler	31.10	18,760
5- 1-1908	E. F. Chandler	13.16	4,990
6-29-1908	E. F. Chandler	13.85	5,260
7-29-1908	E. F. Chandler	8.62	2,610

*Frozen. Mean thickness of ice from 0.9 to 1.9 feet.

MONTHLY DISCHARGE OF RED RIVER AT GRAND FORKS, N. D.

	Maximum	Minimum	Mean
1906—			
November	2,480	*1,730	2,100
December	.....	.....	1,820
1907—			
January	.....	.....	1,400
February	.....	.....	1,090
March	.....	.....	3,070
April	29,400	7,320	14,870
May	6,790	3,850	4,930
June	11,240	3,330	6,440
July	5,020	2,450	3,560
August	2,430	1,640	2,120
September	3,420	1,470	2,090
October	2,860	1,670	2,090
November	1,780	*1,330	1,540
December	*1,500	*1,100	1,200
1908—			
January	.....	.....	890
February	.....	.....	796
March	*3,980	*850	1,960
April	*22,500	*4,000	10,500
May	10,130	3,660	6,220
June	9,280	5,800	7,660
July	5,580	2,480	3,550
August	2,700	1,760	2,090
September	3,850	1,430	1,550

*Estimated.

River closed November 18, 1906; opened April 8, 1907; closed November 11, 1907; opened April 12, 1908.

Maximum gage heights, 39.95 feet, April 7, 1907; 20.4 feet, June 18, 1907; 32.8 feet, April 11, 1908; 19.1 feet, May 25, 1908.

Minimum gage heights, 7.2 feet, November 17, 1906; 9.9 feet, June 10, 1907; 6.1 feet, November 15, 1907; 10.4 feet, May 13, 1908; 6.9 feet, August 31, 1908.

RED RIVER AT FARGO, NORTH DAKOTA.

The gaging station on the Red river at Fargo was established May 27, 1901. The drainage area above this point is 6,020 square miles of which 1,750 square miles is in North Dakota, 500 square miles in South Dakota, and 3,770 square miles in Minnesota.

The tables of discharge are based on the measurements in the list below and on thirty-three measurements made during the six preceding years, due allowance being made for the gradual slight changes in the river channel.

DISCHARGE MEASURMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
4–5 1907	E. F. Chandler	*24.99	5,720
4–8–1907	E. F. Chandler	*20.34	3,360
4–15–1907	E. F. Chandler	13.80	2,390
4–15–1907	E. F. Chandler	13.79	2,140
6–17–1907	E. F. Chandler	19.28	4,360
6–17–1907	E. F. Chandler	19.26	4,500
9–13–1907	E. F. Chandler	7.79	389
6–27–1908	E. F. Chandler	12.81	1,930
8–29–1908	E. F. Chandler	8.57	516

*Partial ice conditions.

MONTHLY DISCHARGE OF RED RIVER AT FARGO, N. D.

	Maximum	Minimum	Mean
1906—			
November	1,150	*650	910
December	.....	.....	*600
1907—			
January	.....	.....	*500
February	.....	.....	*360
March	*5,820	*350	*1540
April	5,980	1,640	2,920
May	1,640	1,220	1,380
June	4,420	1,180	2,210
July	1,380	716	1,030
August	716	450	593
September	541	386	454
October	541	428	481

Monthly Discharge of Red River—Continued.

	Maximum	Minimum	Mean
November	495	250	426
December	.....	.....	*310
1908—			
January	.....	.....	*200
February	.....	.....	*130
March	*1,500	*130	*493
April	1,190	589	1,100
May	1,030	589	718
June	2,600	911	1,785
July	1,850	970	1,276
August	970	540	722
September	565	428	487

*Estimated.

River closed November 21, 1906; opened about March 30, 1907; closed about December 1, 1907; opened March 29, 1908.

Maximum gage heights, 29.8 feet, March 31, 1907; 19.3 feet, June 17, 1907; 13.0 feet, April 6, 1908; 14.7 feet, June 13, 1908.

Minimum gage heights, 8.8 feet, November 25, 1906; 10.8 feet, May 25, 1907; 7.0 feet, November 14, 1907; 8.6 feet, April 23, 1908; 8.4 feet, August 27, 1908.

OTTERTAIL RIVER, NEAR FERGUS FALLS, MINN.

The gaging station on the Ottertail (or Red) river near Fergus Falls, Minnesota, was established May 9, 1904, and is located about three miles northeast of Fergus Falls. The drainage area above this point is 1,310 square miles.

The tables of discharge are based upon the measurements in the list below and thirteen previous measurements, and are accurate for all stages.

DISCHARGE MEASURMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
7–19–1907	E. F. Chandler	3.51	603
8– 1–1907	Follansbee and Chandler	3.26	427
6–26–1908	E. F. Chandler	4.05	894

MONTHLY DISCHARGE OF OTTERTAIL RIVER, NEAR FERGUS FALLS, MINN.

	Maximum	Minimum	Mean
1906—			
November	....	....	681
1907—			
April	790	582	655
May	730	670	713
June	760	640	696
July	670	449	567
August	425	315	359
September	336	276	303
October	357	315	334
November	357	315	336
December	.....	.....	*350
1908—			
January	.....	.....	*325
February	.....	.....	*300
March	.....	.....	*300
April	357	276	317
May	553	357	422
June	910	582	808
July	850	553	689
August	553	380	454
September	380	357	362

*Estimated. Maximum gage heights: 3.9 feet, March 31, 1907; 3.85 feet, June 18, 1907; 3.1 feet, April 6, 1908; 4.1 feet, June 14, 1908. Minimum gage heights: 3.55 feet, April 13, 1907; 2.9 feet, September 8, 1907; 2.9 feet, April 18, 1908; 3.15 feet, August 31, 1908.

PEMBINA RIVER AT NECHE, NORTH DAKOTA.

The gaging station on the Pembina river was established April 29, 1903, and is located at Neche, sixteen miles from the mouth of the river. The drainage area above this point is 2,940 square miles, of which 920 square miles is in North Dakota and 2,020 square miles in Manitoba.

The tables of discharge are based on the measurements in the list below and twenty-one previous measurements, necessary allowance being made for changes that have several times occurred in the channel conditions determining the gage-height at season of lowest flow.

DISCHARGE MEASUREMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
5-13-1907	E. F. Chandler	13.08	1,940
7-13-1907	E. F. Chandler	3.68	159
8- 2-1907	Follansbee and Chandler	2.72	75
9-14-1907	E. F. Chandler	3.46	36
9-14-1907	E. F. Chandler	3.46	37
1-27-1908	E. F. Chandler	2.13	3.8
4- 3-1908	E. F. Chandler	.....	*3
6-24-1908	E. F. Chandler	4.13	191
7-24-1908	E. F. Chandler	3.18	51
7-24-1908	E. F. Chandler	3.18	53

*Estimated.

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

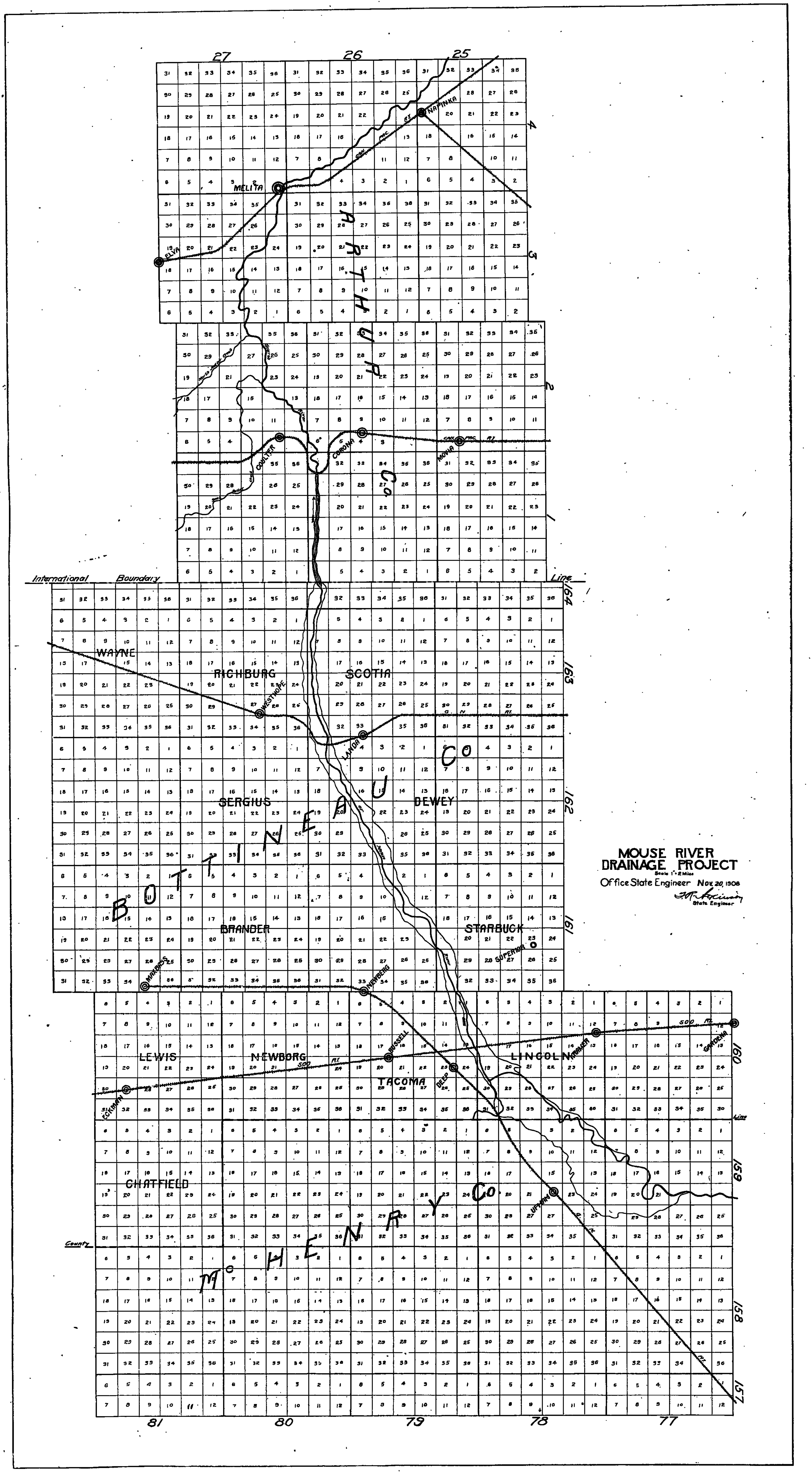
	Maximum	Minimum	Mean
1906—			
November	.....	.....	*110
1907—			
April	1,930	.....	*310
May	2,190	821	1,597
June	800	263	506
July	263	76	156
August	80	23	50
September	47	23	35
October	66	36	55
November	66	*25	*38
December	.....	.....	*19
1908—			
January	.....	.....	*6
February	.....	.....	*3
March	.....	.....	*3
April	927	*3	378
May	591	310	473
June	486	136	232
July	136	36	88
August	66	36	52
September	80	55	63

*Estimated.

River closed, Nov. 1906; opened, about April 29, 1907; closed, Nov. 8, 1907; opened, about April 5, 1908.

Maximum gage heights: 13.6 feet, May 14, 1907; 7.7 feet, April 10, 1908.

Minimum gage heights: 3.0 feet, November 13, 1906; 2.2 feet, August 13, 1907; 2.1 feet, January 19, 1908; 3.0 feet, August 9, 1908.


MOUSE RIVER DRAINAGE PROJECT
Scale 1" = 2 Miles
Office State Engineer Nov. 20, 1908
State Engineer
International Boundary Line
ARTHUR CO.
BOTTINEAU CO.
McHENRY CO.
MELITA
NAPINKA
ELVA
COULTER
CORONA
MOVIA
WAYNE
RICHBURG
SCOTIA
WESTHOPE
LANDA
SERGIUS
DEWEY
BRANDER
STARBUCK
SUPERIOR
MAXBASS
NEWBERG
LEWIS
NEWBORG
LINCOLN
TACOMA
RUSSELL
DEEP
KRAMER
GARDENA
ECKMAN
CHATFIELD
UPHAM
Mouse River
SOO RY.
G. N. RY.
CAN. PAC. RY.
County Line
27
26
25
4
3
2
1
164
163
162
161
160
159
158
157
81
80
79
78
77

RED LAKE RIVER AT CROOKSTON, MINN.

The gaging station at Crookston, Minnesota, was established May 19, 1901. The drainage area above Crookston is 5,525 square miles. Almost the entire discharge of the river is included at this station, there being no considerable tributaries between this point and the mouth of the river at Grand Forks.

The tables of discharge are based on the measurements in the list below and thirty-one measurements made during the previous years and are unusually accurate, the conditions at the station being very favorable at all stages during the open season. During the winter the conditions are not so favorable, and the records are less complete, but it may be assumed that there are no errors greater than ten per cent at any season.

DISCHARGE MEASUREMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
2-11-1907	Chandler and Clark	*5.21	458
3-18-1907	E. F. Chandler	*5.98	648
11-18-1907	E. F. Chandler	4.45	**621
8- 3-1907	Follansbee and Chandler	4.15	612
2-10-1908	E. F. Chandler	*5.99	607
2-24-1908	E. F. Chandler	*5.52	408
6-25-1908	E. F. Chandler	7.50	2,640

*Frozen; thickness of ice, 0.9 to 1.2 feet.
**River beginning to freeze over.

MONTHLY DISCHARGE OF RED LAXE RIVER AT CROOKSTON, MINN.

	Maximum	Minimum	Mean
1906—			
November	1,110	570	758
December	*1,110	*815	*950
1907—			
January	.....	.....	*650
February	.....	.....	*460
March	.....	.....	*1,270
April	6,160	2,750	4,480
May	2,860	1,650	2,190
June	3,920	1,390	2,290
July	1,890	840	1,260
August	1,110	525	861
September	1,685	615	1,015
October	1,360	815	1,054
November	960	*410	668
December	*870	*375	*632

Monthly Discharge of Red Lake River—Continued.

	Maximum	Minimum	Mean
1908—			
January	*760	*300	*467
February	*730	*300	*508
March	*980	*370	*618
April	10,340	*1,040	4,700
May	6,470	1,950	3,750
June	4,640	1,850	3,080
July	1,820	980	1,340
August	3,330	840	1,190
September	3,450	760	1,180

*Approximate.

Maximum gage heights: 12.0 feet, April 4, 1907; 16.6 feet, April 7, 1908; 12.2 feet, May 23, 1908.

Minimum gage heights: 4.0 feet, November 19, 1906; 3.9 feet, August 26, 1907; 3.8 feet, November 15, 1907; 4.5 feet, August 25, 1908.

RED LAKE RIVER AT EAST GRAND FORKS, MINN.

Occasional measurements as shown in the list below have been made of the Red Lake river at its confluence with the Red river at Grand Forks.

DISCHARGE MEASUREMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
1-28-1907	Chandler and Clark		444
3- 4-1907	W. H. Clark		549
11-11-1907	E. F. Chandler		737
1-20-1908	Chandler and Stee		449
4-13-1908	E. F. Chandler		8,980

SHEYENNE RIVER AT HAGGART, NORTH DAKOTA.

The gaging station on the Sheyenne river at Haggart, N. D., was established March 22, 1902, and was discontinued on account of lack of funds July 1, 1907. It is located six miles west of Fargo, this being thirteen miles above the mouth of the river. The drainage area above this point is 5,400 square miles, this including the entire drainage area of the Sheyenne river except 1,530 square miles which is chiefly tributary to the Maple river, entering the Sheyenne river ten miles above its mouth.

The tables of discharge are based on twenty-four previous measurements and on the following measurements, and are fairly reliable.

DISCHARGE MEASUREMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
4- 8 1907	Chandler and Rodgers	9.31	652

River not entirely clear of ice.

MONTHLY DISCHARGE OF SHEYENNE RIVER AT HAGGART, N. D.

	Maximum	Minimum	Mean
1906—			
November	51	38	46
December	.....	.....	*30
1907—			
April	*1,900	359	605
May	632	281	442
June	320	222	255

*Estimated.

MOUSE RIVER AT MINOT, NORTH DAKOTA.

The gaging station on the Mouse river at Minot was established May 5, 1903. The drainage area above this point is 8,400 square miles, of which three-fourths is in Canada and one-fourth in North Dakota.

The tables of discharge are based on the measurements in the list below and twenty-seven measurements made in previous years, and are accurate for all stages, except during the winter months, when they are merely rough estimates.

DISCHARGE MEASUREMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
5-12-1907	E. F. Chandler	11.23	1,360
5-27-1907	E. F. Chandler	15.88	2,170
7- 1-1907	E. F. Chandler	6.61	672
8- 6-1907	E. F. Chandler	4.50	149
12-21-1907	E. F. Chandler	3.80	9.6
5-30-1908	E. F. Chandler	4.67	172
5-30-1908	E. F. Chandler	4.67	156

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

	Maximum	Minimum	Mean
1906—			
November	20	*16	18
December	.....	.....	*15
1907—			
January	.....	.....	*14
February	.....	.....	*12
March	.....	.....	*15
April	548	35	172
May	2,660	636	1,820
June	2,590	262	926
July	878	240	436
August	218	52	104
September	52	20	36
October	.....	.....	*20
November	.....	.....	*16
December	.....	.....	*11
1908—			
January	.....	.....	*8
February	.....	.....	*6
March	.....	.....	*12
April	644	89	293
May	163	109	135
June	407	163	244
July	174	99	127
August	119	79	94
September	89	27	63

*Estimated.

Maximum gage heights :16.0 feet, May 29, 1907; 6.5 feet, April 13, 1908.

Minimum gage heights: 3.9 feet, Nov. 1, 1906; 3.8 feet, Dec. 21, 1907.

LITTLE MUDDY RIVER NEAR WILLISTON, N. D.

The gaging station on the Little Muddy river was established February 4, 1904, and is located in section 19, township 155, north range 100 west, about seven miles north of Williston and the mouth of the river. The drainage area above this point may be considered as about 800 square miles.

The tables of discharge are based on the measurements in the list below and twenty-two measurements in previous years, and are fairly accurate for all stages herein included.

DISCHARGE MEASUREMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
5- 7-1907	J. H. Turner	3.30	60
7-12-1907	J. H. Turner	2.57	8.9
8- 5-1907	Chandler and Follansbee	2.44	7.3
5-24-1908	G. H. Ellis	3.5	96
5-26-1908	G. H. Ellis	3.6	103
6- 5-1908	G. H. Ellis	4.6	*144
8-30-1908	G. H. Ellis	2.2	6
9- 9-1908	G. H. Ellis	2.2	5.3
9-13-1908	G. H. Ellis	2.2	5.2

*Made under unusual conditions of flow.

MONTHLY DISCHARGE OF THE LITTLE MUDDY RIVER NEAR WILLISTON, N. D.

	Maximum	Minimum	Mean
1906—			
November	14	9	10
1907—			
April	1,110	93	725
May	135	36	64
June	36	18	26
July	23	6	12
August	9	4	4.7
September	13	6	8.2
October	.....	.....	9
November	.....	.....	9
1908—			
March	.....	.....	*10
April	1,560	16	212
May	170	16	48
June	391	21	76
July	21	6	8
August	6	5	5
September	7	5	5

*Estimated

Maximum gage heights: 6.0 feet, April 18, 1907; 6.8 feet, April 5, 1908.

Minimum gage heights: 2.3 feet, Aug. 16, 1907; 2.2 feet, Aug. 20, 1908.

CANNON BALL RIVER AT STEVENSON, N. D.

The gaging station on the Cannon Ball river was established June 10, 1903, near the postoffice of Stevenson, which is about forty miles south of Mandan, and about thirty miles from the mouth of the river. The drainage area above this point is 3,650 square miles.

The tables of discharge are based upon the measurements in the list below and twenty-two measurements in the previous years, and are fairly accurate, except the figures from March to July, 1908 which on account of an injury to the gage are merely estimates.

DISCHARGE MEASUREMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
4-22-1907	T. R. Atkinson	3.46	84
6- 1-1907	T. R. Atkinson	3.16	78
7-23-1907	Chandler and Hoskins	4.62	532
7-23-1907	E. F. Chandler	4.77	631
7-24-1907	E. F. Chandler	4.47	467
7-24-1907	E. F. Chandler	4.33	416
7-25-1907	E. F. Chandler	4.16	335
7-30-1907	Follansbee and Chandler	3.35	128
7-30-1907	Follansbee and Chandler	3.54	129
8- 5-1908	E. F. Chandler	2.73	8.6
8- 6-1908	E. F. Chandler	2.71	9

MONTHLY DISCHARGE OF THE CANNON BALL RIVER AT STEVENSON, N. D.

	Maximum	Minimum	Mean
1906—			
November	.....	.....	5
December	.....	.....	*5
1907—			
January	.....	.....	*5
February	.....	.....	*100
March	*2,400	.....	*490
April	1,200	33	265
May	693	24	124
June	3,340	44	612
July	1,130	44	263
August	58	1	13
September	3	0	*0.5
October	3	0	*0.5
November	4	0	*1.4
December	.....	.....	*3
1908—			
January	.....	.....	*3
February	.....	.....	*5
March	*3,800	.....	*810
April	*1,060	*120	*370
May	*1,900	*120	*570
June	*2,620	*33	*1,210
July	*638	*3	*143
August	33	0	5

*Estimated.

Maximum gage heights: 9.8 feet, February 20, 1907; 8.4 feet, June 8, 1907; about 9.0 feet, March 20, 1908; about 7.5 feet, June 3, 1908.
Minimum gage heights: 1.8 feet, November 9, 1906; 1.4 feet, October 23, 1907; 2.0 feet, August 28, 1908.

HEART RIVER, NEAR RICHARDTON, NORTH DAKOTA.

The gaging station on the Heart river was established May 18, 1903, and is located at the iron highway bridge ten miles south of Richardton. The drainage area above this point is 1,250 square miles.

The tables of discharge are based upon the measurements in the list below and nineteen measurements made in previous years. Only one measurement above medium stage has ever been obtained, hence the figures above 800 second feet are subject to later revision but for medium and low stages the tables are accurate.

DISCHARGE MEASUREMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
5-29-1907	T. R. Atkinson	4.83	48
7-28-1907	Atkinson and Chandler	5.04	49
7-28-1907	Chandler and Atkinson	5.03	53
5- 7-1908	P. N. Ford	4.50	18
5-29-1908	P. N. Ford	6.24	177
8-11-1908	E. F. Chandler	4.10	1.8

MONTHLY DISCHARGE OF THE HEART RIVER NEAR RICHARDTON, N. D.

	Maximum	Minimum	Mean
1906—			
November	.....	.....	*8
December	.....	.....	*5
1907—			
January	.....	.....	*3
February	.....	.....	*64
March	*2,350	.....	*490
April	245	22	91
May	37	11	16
June	200	11	22
July	643	2	161
August	37	2	10
September	4	1	3
October	7	4	4
November	.....	.....	*4
December	.....	.....	*3
1908—			
March	*370	.....	*125
April	260	22	106
May	1,130	11	160

Monthly Discharge of the Heart River—Continued.

	Maximum	Minimum	Mean
June	439	29	123
July	56	7	15
August	22	1	4

*Estimated.

Maximum gage heights: 14.2 feet, March 22, 1907; 8.6 feet, July 23, 1907; 10.5 feet, May 24, 1908.
Minimum gage heights: 4.3 feet, Nov. 6, 1906; 4.0 feet, Sept. 15, 1907; 4.0 feet, August 25, 1908.

HEART RIVER, AT MANDAN, NORTH DAKOTA.

No regular record has been maintained of the flow of the river at its mouth, near Mandan, but some occasional measurements have been made, as shown in the list below and ten meaesurements in previous years. The drainage area above this point is 3,360 square miles.

DISCHARGE MEASUREMENTS.

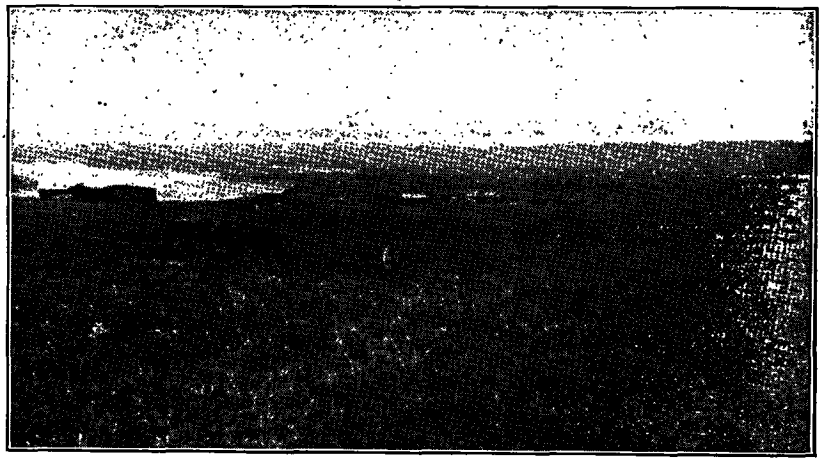
Date	Name of Hydrographer	Gage Height	Discharge
7–21–1907	E. F. Chandler	.....	205
7–25–1907	Atkinson and Chandler	.....	534
8– 9–1908	E. F. Chandler	.....	26

KNIFE RIVER, NEAR BRONCHO, NORTH DAKOTA.

The gaging station on the Knife river is north of Hebron, in section 4, township 142 north, range 90 west, being near Broncho postoffice. A station was first established on the river in this immediate vicinity May 29, 1903. The drainage area above this point is 1,260 square miles.

The tables of discharge are based upon the measurements in the list below, in conjunction with the results of twenty-one measurements made in previous years at the same or neighboring points, and are fairly accurate for all stages herein contained.

ONE OF THE MANY IRRIGABLE TRACTS ALONG THE KNIFE RIVER.



INDEPENDENCE PROJECT.

DISCHARGE MEASUREMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
4-13-1907	T. R. Atkinson	4.40	51
5-30-1907	T. R. Atkinson	3.80	19
7-27-1907	Atkinson and Chandler	4.04	30
5-30-1908	P. N. Ford	4.30	61
8-10-1908	E. F. Chandler	3.34	2.1

MONTHLY DISCHARGE OF THE KNIFE RIVER NEAR BRONCHO, N. D.

	Maximum	Minimum	Mean
1906—			
November	.....	.....	10
1907—			
April	389	33	110
May	33	18	24
June	285	18	40
July	44	4	12
August	44	4	8
September	10	2	4
October	7	2	4
November	.....	.....	7
1908—			
March	560	.....	190
April	585	18	113
May	595	10	116
June	864	18	159
July	18	4	9
August	7	4	5

Maximum gage heights: 6.3 feet, April 4, 1907; 7.7 feet, March 14, 1908; 8.9 feet, June 4, 1908.

Minimum gage heights: 3.6 feet, Nov. 15, 1906; 3.3 feet, Sept. 18, 1907; 3.3 feet, August 10, 1908.

LITTLE MISSOURI RIVER, AT MEDORA, N. D.

The gaging station on the Little Missouri river at Medora was established May 12, 1903. From such maps as were formerly available the drainage area was considered as 5,785 square miles; but more detailed maps recently published will make the area nearly or quite 6,000 square miles.

The tables of discharge are based upon the measurements in the list below, taken in conjunction with thirty measurements made in previous years. But the conditions at the station are not favorable to accurate records, as the channel is continually scouring, silting, and changing, and the relation between gage height and discharge

can be definitely known for only a few days or weeks after a discharge measurement. Hence, the need of records of this stream not seeming great enough to justify the expenditure necessary to make the very frequent discharge measurements by which accurate summaries could be secured. The following tables of monthly discharge can be considered as a series of rough estimates, which is likely to be at some periods as much as twenty-five per cent in error for medium stages, and possibly as much as fifty per cent at extreme low stages.

DISCHARGE MEASUREMENTS.

Date	Name of Hydrographer	Gage Height	Discharge
5-29-1907	T. R. Atkinson	12.08	13,960
7-28-1907	Atkinson and Chandler	4.79	1,020
5-15-1908	P. N. Ford	3.74	366
5-27-1908	P. N. Ford	7.13	3,890
8-14-1908	E. F. Chandler	3.46	70
8-15-1908	E. F. Chandler	3.50	81
8-16-1908	E. F. Chandler	4.28	267

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

	Maximum	Minimum	Mean
1906—			
November	.....	.....	64
December	.....	.....	50
1907—			
January	.....	.....	40
February	8,100	.....	1,650
March	1,810	490	1,190
April	490	150	290
May	15,500	105	2,570
June	19,000	970	4,140
July	6,460	820	1,780
August	1,050	40	280
September	680	20	110
October	70	6	25
November	.....	.....	6
1908—			
March	1,610	.....	600
April	1,140	10	340
May	4,140	70	1,340
June	10,200	610	3,330
July	1,710	80	470
August	640	33	100

Maximum gage heights: 9.3 feet, Feb. 19, 1907; 12.8 feet, May 30, 1907; 16.0 feet, June 24, 1907; 10.3 feet, June 6, 1908.

Minimum gage heights: 3.3 feet Nov. 1, 1906; 3.3 feet, May 18, 1907; 2.7 feet, Dec. 2, 1907; 2.9 feet, April 26, 1908.

MISSOURI RIVER, AT WILLISTON, NORTH DAKOTA.

Gage height records of the Missouri river has been kept by the United States reclamation service at Williston, N. D. The zero of the gage is 1,800 feet above sea level, and the highest recorded stage during 1908 was fifty-one and three-tenths feet above the gage zero, on June 16; this was the crest of the greatest flood of which there is a definite record on the Missouri river in this region, although the water is said to have sometimes risen to greater heights for a few hours on account of early spring ice jams, causing backwater. The minimum stage recorded in the spring was at gage reading thirty-one and one-tenth feet, April 10, this very low reading probably having been caused by stoppage of the water by an ice jam above. The ordinary low water stage of thirty-three and five-tenths feet would approximately correspond to the low water stage of four feet at the gage formerly maintained at Baker's Ferry, eleven miles below Williston.

On account of unfavorable channel conditions of this river in North Dakota, it has not been possible at reasonable expense to secure reliable discharge records. On June 20, 1908, an approximate measurement of discharge was made at Baker's Ferry by E. F. Chandler, the reading of the gage at that point being about nineteen and forty-nine one-hundredths feet. The great surface velocity found in mid channel at the point of measurement was slightly less than seven and one-half miles per hour, and the mean velocity was seven and forty-three one-hundredths feet per second, or about five miles per hour. The width of the channel was 885 feet; accurate soundings in mid-channel were not possible at this time, but from previous work the maximum depth was assumed to be thirty-seven feet, and the mean depth about twenty-one feet, giving a total cross-section of 18,300 square feet, and a discharge of 136,000 second feet. This result is likely to be in error as much or more than ten per cent, but can be hardly as much as twenty per cent in error.

From this measurement and six measurements made at low and medium stages in 1905, the following approximate estimates of discharge for the season of 1908 have been prepared; these estimates are not of the usual standard of accuracy, and are likely to contain errors as great as twenty per cent in some of the figures, but are of interest as showing roughly the amount and distribution of one of the largest and greatest floods that has ever been seen on this river.

ESTIMATED APPROXIMATE MONTHLY DISCHARGE OF MISSOURI RIVER AT WILLISTON, NORTH DAKOTA.

1908	Maximum	Minimum	Mean
April	15,000	4,000	10,000
May	52,000	11,000	28,000
June	173,000	54,000	119,000
July	99,000	36,000	71,000
August	35,000	13,000	18,000

THE RELATION BETWEEN RAINFALL AND STREAMFLOW IN NORTH DAKOTA

BY E. F. CHANDLER.

The essentials of the discussion for any purpose of the surface water-supply, whether drainage, water-power, irrigation or other use, be in consideration, can usually be briefly summed up in the answers to two questions. First, what is the total annual run-off per square miles from that region? Seconds, how is the run-off distributed through the year?

Neither of these questions can be satisfactorily answered unless there are available reasonable accurate records of stream-flow for the region under discussion; furthermore, in order to avoid false conclusions these records must have extended through a considerable term of years, since there are great differences in quantity of stream flow from year to year, and any single year may have been so much out of the ordinary that on it, taken alone, no generalizations can be properly based.

The second question is the simpler one on which the express an opinion. There is no one who has lived for several years on the banks of a stream but can tell in what portions of the season the floods and the low stages usually occur, although no numerical estimates of comparative quantities may be ventured.

The usual seasonal distribution of flow in the ordinary prairie streams of North Dakota is this: Through the winter the flow is steady, but very small, reaching a minimum in February or thereabouts; the ice covering is from one to three feet in thickness, and the smaller streams are often said to be "frozen to the bottom," by which is meant that on cutting through the ice no flow is found underneath at most of the points across the widths of the channel, the flow having diminished until a small fraction of the channel width is ample to carry it. In March or early April, from the melting snow in the valleys and the early spring rains every coulee and ravine is filled, the larger streams are raised, and the ice breaks up and melts; at this time if the ice lodges or jams it sometimes happens that the river rises for a few days to a height disproportionate to the actual quantity of water discharged by the stream, and floods the valley to a great width on each side, making flood records. Later may be expected the June rains, which may or may not be heavy enough to again cause noticeable rise in the rivers, but which not infrequently brings as great flow as in the early spring. Following this, unless floods are caused by violent storms, the

rivers sink lower and lower through the summer, usually reaching in August or September the lowest stage of the year. With the cool weather of the fall, evaporation becomes less and there is some increase in flow; the streams remain at a rather low stage until the cold of winter, closing the small tributaries, cuts off the supply so that the river shrinks again to the winter minimum.

Such streams in North Dakota depend almost wholly on the flow from the surface of the ground that follows rain or melting snow, and receives but little from the small springs or seepage. Hence in dry seasons the flow, even of rivers that drain several thousand square miles, shrinks astonishingly, and the minimum may be only a hundredth or thousandth as great as the maximum.

The regimen of a stream fed by a country of a different nature, is quite unlike this. A stream which comes from the mountain snow fields reaches its maximum at the time of most rapid melting of the snows by the heat of June; for this reason the June flood of the Missouri river, which reaches North Dakota in the latter half of June, may be expected to far surpass the spring rise both in height and duration. The Little Missoui river comes from the high country of northeastern Wyoming, and has frequent short violent floods in the summer. The Red river, except in early spring, receives the greater portion of its water from Minnesota, where there are many lakes in which the water accummulates gradually, so that the flow is more steady and is apt to increase gradually through the entire spring.

Before taking up the question concerning the measured quantity of water which actually flows down the stream in a year it is proper to introduce here a short discussion of the relation between rainfall, evaporation and run-off.

The water which falls, in the form of rain or snow, in a day longer period on any section of the country ultimately leaves that section again by one of the following methods. First, it may run immediately off from the surface into the water-courses and be carried away. Second, it may remain standing in drops and puddles where it falls, or in pools and sloughs in the immediate vicinity, and finally be evaporated by the wind and sun and disappear. Third, it may soak into the ground but before reaching a great depth be brought again to the surface by the capillarity of the soil and evaporated at the surface as the soil drys. Fourth, it may be brought up by the roots of vegetation and transpired from the foliage into the atmosphere. Fifth, the water may sink into the ground until it reaches the level, called the "ground water level," below which the soil is completely saturated with water, the level at which water stands in ordinary wells; since this underground reservoir cannot receive additions indefinitely without change, its level is gradually raised by the percolations from above until the water is slowly forced horizontally through the strata on whichever

side there is the easiest exit, and in the low ground or valleys and ravines escapes as seepage or springs into streams and flows away.

It is thus seen that (with some exceptions so very small, in North Dakota, as to be unnecessary to specify) every drop of the rainfall ultimately disappears either in the first or fifth manner, becoming part of the "run-off," or else in the second, the third or the fourth manner, becoming part of the "evaporation." The evaporation and the run-off together are precisely equal to the rainfall; it is the ratio between them which we wish to determine.

(It may be mentioned parenthetically that the water reaching the streams as run-off ultimately reaches the ocean, from which it is of course again evaporated sooner or later; but that is foreign to the present discussion, which is concerned merely with these relations for a limited land area.)

The ratio between evaporation and run-off depends in each locality upon a great number of topographic and meteorologic conditions, of which the more important will be mentioned here. The nature and condition of the soil determine whether the rain falling upon it shall be immediately absorbed or remain on the surface. Clean sand, or any soil deeply and thoroughly cultivated so as to be loose and open, will when dry absorb every drop of rain until enough has been received to soak it completely. On the other hand, a bare rock surface, if not broken by fissures and crevices, will absorb practically nothing, or in winter and early spring the frozen ground may have a similar impervious condition. Between these two extremes there are all grades.

The longer the water remains on the surface, the greater the opportunity for absorbtion. The percentage of run-off is therefore much less in level country than in a country of steep slopes. Likewise the percentage of run-off is less or greater according as the rain falls slowly or rapidly; if an inch of water falls in a gentle rain lasting through several days, the flow in the streams will scarcely be perceptibly affected unless the soil of the valley had already been water-soaked to overflowing by heavy previous rains; but if the same quantity of water had fallen in an hour, all the ditches and water courses would have been brimming quickly.

Whether the water shall pass rapidly through the soil or very slowly depends also on the character of the soil. A bed of pebbles or coarse sand carries away the water as fast as it comes. But a soil may be packed and settled into such an impervious mass that it will take up the water so slowly that during heavy rainfalls nearly all the water must flow off over the surface.

It should be noted here that, because the surface of the ground is ordinarily nowhere perfectly smooth and even, every little hollow retains a pool or puddle which never becomes a part of the measured run-off, since it either soaks in or evaporates before the next shower.

A portion of the rainfall having now passed away into the streams, let us trace the course of that portion which has entered the soil.

The quantity of water that can be held by the soil is large; in ordinary soil the pores or openings between the soil grains may be assumed to be from twenty to forty-five per cent of the whole volume; in other words, if the soil were absolutely dry, a rainfall of twenty inches would be sufficient to entirely soak the soil only to a depth of four, six, or nine feet from the surface. These few upper feet of the ground are, so to speak, a reservoir which is being continuously replenished or depleted. The depletion may occur by flow downwards and away through the soil or subterranean strata, by absorption by the roots of vegetation, or by evaporation from the ground surface.

This last loss may be very large if the soil is closely settled so that the capillary pores extend without break from considerable depths to the surface, but it can be largely prevented by cultivation, for the surface soil thus becomes a fine, loose mulch that is not closely enough attached to the soil below to draw water from it but protects it from the sun's heat and drying winds. The evaporation from a standing water-surface or reservoir in North Dakota has been found from several years' records to be between thirty and thirty-six inches in a year, which is an average of nearly a tenth of an inch per day; it is often as much as or even more than a quarter of an inch in a single day, when the temperature is high and there are strong winds, and of course is very small or nothing on very damp, cold, quiet days. From a soil surface kept continuously damp the total evaporation would presumably be about the same.

Next to be considered is that portion of the available water that is taken up by the roots of vegetation. Pause should be made to call attention to the fact that herein is the source of North Dakota's wealth. Water is absolutely essential to agriculture, the main resource of our population; but there is little opportunity to use it here either for power-development, for navigation, or for any other purpose; hence the more completely it can be turned into the first use, the sustaining of the field crops, the better for all. The water which is taken up by the roots of vegetation passes upwards into the foliage and is transpired into the air; without a supply of water continuously within reach at its roots the plant becomes parched and brown. The "hot winds" of midsummer need not be feared when the soil is well soaked; but if the ground is nearly dry when the winds arise the supply of water will be unequal to the demands made by every plant, and the grain-field will soon be ruined.

The figures stating the quantity of water thus used during plant-growth at first sight seem incredible. For the ordinary field crops and forest growths, during the growth of *each pound* of the de-

sired product there has been drawn up from the ground by the plant and passed into the atmosphere between 500 and 4000 pounds of water. To illustrate; in the growth of a grain crop of twenty bushels per acre it may be estimated that during the growing season there has been evaporated from the vegetation a total of 2,000,000 pounds of water per acre, more or less; this would amount to a total depth of about nine inches over the whole field.

The amount of this evaporation, it must be understood, not only varies from day to day through the season, varying with the temperature, wind, and humidity, but depends on the character of the herbage. Land covered with a rank, luxuriant growth loses more water than that possessed only of sparse and scanty covering. Some species of plants require so much water that they can grow only in a very humid climate; the cactus in the desert continues to exist because by the adaptation of nature the evaporation from it is so small that it is able to live where other plants would die of thirst; even the cactus must have water, but a little is sufficient.

Without water, no crop. Therefore it is indeed fortunate that the storage capacity of the soil is so considerable, and that from the soil storage the needed water will be supplied to plants between times of rain provided the drought be not so long extended as to exhaust the reservoir.

The evaporation from the surface and the amount taken up by and evaporated from the plant covering are found to be easily able to aggregagte twenty inches or more in a year, an amount somewhat greater than the usual total rainfall of the year in North Dakota. If, however, the rains are sufficiently abundant and frequent so that more water than this is taken up by the soil and it is filled completely and becomes water logged, or if the strata are too open in texture to hold the water and it soaks downward out of reach, the level of the standing water in the ground (the ground-water level) is ultimately raised until the water overflows or is forced out at the edges of the strata into every valley and ravine in springs. This portion of the water, as has been shown, is as a rule that which, having soaked into the ground after its fall, has not been evaporated from the surface, has escaped the grasp of plant roots, and has not been used to replenish ground-storage depleted by these two needs; in other words, it is the unused surplus of water still remaining after all demands have been supplied.

In North Dakota, speaking in general terms, there is no surplus water. The average annual supply, which fortunately falls usually in the portion of the year when most needed, is almost precisely equal to the demand. In this state, there are no springs (if it be permitted again to speak in general terms.) Of course there are inumerable low places and valleys or ravines where the water seeps slowly out affording an abundance of good water for domestic use and for stock; but genuine gushers, such as occur in every square

mile of some eastern states, are here almost unknown. The total amount of water flowing from springs in North Dakota is so small that it may safely be estimated as far less than one per cent of the total rainfall, being almost certainly less than one-fifth of one per cent, and perhaps less than one tenth of one per cent.

There are some regions of the United States where the conditions are such that the water finds easy and rapid passage in large quantities for long distances underground, either in underground caverns or in artesian basins; in such case the water may disappear from sight and reappear in the run-off of a far distant territory. In North Dakota this is not to be expected; there is some artesian flow, supplied presumably from the foot hills of the mountains in Montana, but its aggregate quantity is so comparatively small that it need not be considered in this discussion.

If therefore the total amount of stream-flow entering the state be measured, and the total amount leaving the state be measured,, the difference between them will be the aggregate of the streams having their origin within the state. And if this aggregate be subtracted from the total rainfall there will be known with a fair degree of precision what part of the rainfall should be classed as having entered the evaporation.

It has been stated above that for different river basins the percentage of run-off varies with the steepness of the slopes, the amount and character of the vegetation, the soil depth and its condition and the geologic structure; that in the same locality in different years the run-off varies with the climatic influences, such as the amount of rainfall, the rate of its fall, the temperature of air and earth, and the wind velocity; furthermore, that in North Dakota the run-off is but a small portion of the rainfall, so that small variations in the antecedent conditions will produce variations in the run-off which will be very large fractions of the whole. The run-off in this region therefore seems to be very erratic in its quantity; it is proportionately far more regular than the seasonal rainfall, and is equally difficult to predict specifically through any long period in advance.

If these facts be clearly understood and remembered in order to shun misleading conclusions, some very interesting and valuable results may be secured from a study of the records of stream-flow for this region. Brief summaries of the detailed records for the past two seasons of the more important streams, as prepared for this purpose by the resident hydrographer of the United States geological survey, are found in another portion of this report. It is from such records that the following tables have been prepared.

The above monthly summaries show the mean flow of the stream at the point of measurement or gaging station in "second-feet" i. e. cubic feet of water flowing past in one second. From this, the total quantity discharge in a year can be found; and then, by division

by the total number of square miles drained by the river above the point of measurement, the average quantity of water that flowed during the year from each square mile of the drainage area is found.

Each drainage-area, (as that term is used in these summaries), is considered to be the entire area of the river valley from one side to the other, being bounded by the divides or watersheds which separate that valley from the adjoining valleys. In other words, every square mile of North Dakota is considered as a portion of some one of the drainage-areas or river-valleys. It is true that this state in detail is so uneven and yet in the large or in general is so level that many hundred square miles is in a sense undrained, the water merely collecting in pools or sloughs that have no outlet but dry up during each summer without ever having filled far enough to overflow. But it is practically impossible to fix the limits of or to measure such sections, and if the rainfall were sufficient no such undrained sections would exist. Hence, with the exception of a few very large districts, such as the Devils Lake drainage-area, the whole state has been considered as apportioned among its various river valleys.

When the total annual run-off from each square mile has been computed we have the necessary and indispensable basis for many plans concerning the use of water at any point the area of the country tributary to which is known; for example, the dimensions of a reservoir that will be great enough to store the whole flow, the quantity of water obtainable for irrigation by means of a diversion dam there, or the quantity available for water-power at that point. Definite knowledge of the mean flow will be the first essential. For the complete development of plans there will probably also be needed data concerning the variation of the flow in different years, its distribution through the season, the ordinary medium discharge, and the severity of the floods that should be expected occasionally. If the records are complete and cover a satisfactorily long term of years, these data are also obtainable.

For the comparisons between rainfall and run-off which are being made in this paper, it is more convenient to express the run-off as the total number of inches depth from the drainage area in a year; a flow of one-second foot will cover one square mile to a depth of thirteen and fifty-seven one-hundredths inches in a year.

The following are figures secured at the more reliable of the gaging stations. The number of years included in the mean is also stated in order to show whether the mean can be deemed well-founded. The streams are arranged according to their location, beginning at the western side of the state.

MEAN ANNUAL RUN-OFF, EXPRESSED IN INCHES.

Name of River and Point of Measurement.	Years Included in Record	Annual Run-off (No. of Inches).
Little Missouri, Medora, N. D.	1903–8	1.4
Little Missouri, Camp Crook, S. D.	1903–6	1.6
Litle Muddy, Williston, N. D.	1903–8	1.0
Mouse, Minot, N. D.	1903–8	0.5
Knife, Broncho, N. D.	1903–8	0.7
Heart, Richardton, N. D.	1903–8	0.8
Gannon Ball, Stevenson, N. D.	1903–8	0.7
Grand, Seim, S. D.	1905–6	0.7
Sheyenne, Haggart, N. D.	1902–6	0.5
Pembina, Neche, N. D.	1903–8	1.1
Red (inc. Red Lake), Grand Forks, N. D.	1900–8	1.9
Red, Fargo, N. D.	1901–8	1.6
Ottertail, Fergus Falls, Minn.	1904–8	5.2
Red Lake, Crookston, Minn.	1901–8	4.5

At the western side of North Dakota the mean annual rainfall is about fifteen inches; at the eastern side about twenty inches; nearly the whole of this goes into the evaporation, for the average run-off is hardly as much as an inch. When the eastern side of the Red River valley in Minnesota is reached, the mean annual rainfall is found to be about twenty-five inches; in this latitude and climate, evaporation can hardly take so large an amount as this, therefore the remainder reaching the rivers is much greater, as is shown by the records of the Ottertail and Red Lake rivers.

West of North Dakota, many of the neighboring Montana streams resemble our own, and have a small run-off. As the streams of the higher lands and mountains of central and western Montana are reached the run-off is found to be much greater, first because of the greater altitudes a greater rainfall usually occurs, and second, because over steeper slopes more of the rainfall escapes quickly to the streams without being caught and absorbed by the ground. (It is for similar reasons that the Little Missouri river, part of whose drainage area is in the Wyoming highlands, shows a greater run-off than that of the adjoining North Dakota streams.)

Going east from North Dakota, into a region of greater rainfall, a correspondingly greater run-off is seen. The run-off of the Mississippi river at St. Paul, (including the Minnesota river) is not quite three inches, the rainfall over its basin being from 25 to 30 inches. Still further east, the Muskingum river, in Ohio, from a mean annual rainfall of about 40 inches, receives an annual run-off of 13 inches; the Croton river, in New York, from a rainfall of 49 inches receives 23 inches run-off; the Connecticut river receives from a rainfall of 43 inches, a run-off of 22 inches.

We thus conclude that in this latitude, under ordinary conditions of drainage area, if abundant water is supplied, evaporation will re-

move twenty inches or somewhat more. It may fairly be assumed that if in North Dakota the annual rainfall came entirely in frequent light rains, the streams and rivers would be nearly or quite dry through the whole year, being scarcely more than feeble rivulets. The presence of a considerable stream-flow in this region is due to the fact that the rainfall is not evenly distributed through the year, but often falls so rapidly and in such quanities that some of it is able to flow off over the surface without being absorbed; the steepness of the slopes, the impervious or open condition of the soil, and other facts of course are also pertinent.

The normal distribution of the total annual flow among the months of the year is illustrated by the following typical streams.

MEAN MONTHLY RUN-OFF, EXPRESSED IN INCHES.

Month	Mouse River at Minot	Cannon Ball River at Stevenson	Red River at Grand Forks	Red Lake River at Crookston
January	.01	.00	.05	.17
February	.01	.01	.04	.14
March	.01	.10	.09	.25
April	.16	.11	.54	.90
May	.16	.12	.34	.77
June	.06	.26	.21	.57
July	.03	.04	.16	.41
August	.01	.02	.11	.29
September	.02	.01	.10	.30
October	.01	.00	.10	.29
November	.01	.00	.09	.21
December	.01	.00	.07	.21
Total	.50	.68	1.90	4.51

These figures give an idea of the to-be-expected distribution of water through the season, but must not be taken as certain or definite for each future year; they are merely the averages from the records of several years. Undue trust must not be placed in averages, for it may sometimes happen that the total flow of a stream in a single month of one year is twenty times as great as the flow of the stream through the same month of another year. Such an extreme statement could not be made of the stream in all parts of the United States, but it is true of streams which have so small a mean flow as some of ours; for on such a stream the flood caused by unusual storm or other exceptional condition will be a considerable portion of the total discharge for the entire year. On the Little Missouri river, for example, it not infrequently happens that the flow increases fifty-fold in a single day.

In this district it is therefore a perplexing matter to make many weeks in advance any qualitative predictions concerning the behavior of a stream; and accurate quantitative predictions are out of the question. Yet if use is to be made of a stream some basis for plans must be obtained, and (if there is nothing better) data which permit mere rough estimates of future flow are of great value. The seasonal flow varies relatively much more than the total annual flow; but the variations in this from year to year are also very capricious as is seen from the following summary for a few of the streams:

TOTAL RUN-OFF, EXPRESSED IN INCHES.

Year	1900	1901	1902	1903	1904	1905	1906	1907	1908
Little Missouri river, Medora..	....	....	....	1.4	0.7	1.4	1.3	2.4	1.2
Mouse river, Minot	....	....	....	0.4	1.6	0.1	0.2	0.5	0.2
Heart river, Richardton	....	....	....	0.6	1.2	0.3	1.5	0.8	0.5
Cannon Ball river, Stevenson..	....	....	....	0.6	0.6	0.6	1.1	0.6	0.9
Pembina river, Neche	....	....	....	0.4	3.0	0.9	0.7	0.6	1.1
Red river, Grand Forks.....	1.2	1.8	1.7	1.6	2.7	2.0	2.5	2.0	1.8
Red Lake river, Crookston.....	....	4.9	4.6	3.7	5.0	4.8	5.3	3.4	4.1

In regions having a greater rainfall than North Dakota, the differences in stream-flow are larger in actual number of inches, but are comparatively much smaller than here; that is, the percentage variations are not so great because on the streams in such regions the smallest minimum run-off is several inches.

Such variations in stream flow as shown above must be expected for the rainfall is much greater in some years than in others, and a considerable part of the excess rainfall must reach the streams, a much greater part of the excess than of the normal rainfall. A difference of ten inches between the rainfall of consecutive years at the same point is not infrequently seen in North Dakota, and although the ground storage will hold a part of the excess until the dry year, the streams will largely be affected.

The mistaken idea is sometimes disseminated that the climate is changing, that with cultivation the rainfall increases and the "rain-belt moves westward;" elaborate but ill-founded arguments are put forward in defense of the proposition. Sometimes it is similarly argued that if the waters of North Dakota's streams were saved at flood, stored in reservoirs, and spread over the land in irrigation, instead of being permitted to run needlessly to the ocean, on account of the increased evaporation rainfall would be increased and the climate changed. But in the light of our present records it is evident how small an effect this could produce; for if, in the ordinary year, all except a half inch of North Dakota's rainfall is already evaporated within the state, it could hardly be expected

that the evaporation of the remaining half-inch would produce a very marked effect upon the climate.

Even if all the arguments that a change of climate ought to result from cultivation should be admitted to the extent of conceding the *tendency* toward a change, we need not expect to notice or be conscious of any change; for any possible artificially-caused change of such sort would be so small as to be entirely imperceptible among the great natural variations from year to year in quantity of rain, in temperature, etc. As a matter of fact, the officials of the Weather Bureau state that if periods of only a few years be considered the mean rainfall or temperature may appear to have changed considerably (this being the effect of a single abnormal year included in the period, if short;) but that if long periods be considered, ten to twenty years or longer, there is no portion of the country where the records show any permanent change in the climate, the temperature or rainfall, ever to have taken place.

This need be no cause for distress; it is not necessary that the climate should change before a good crop can be grown in North Dakota. The change in soil condition effected by proper cultivation, by breaking up the capillary passages so that the water in the soil will not escape by useless evaporation at the soil surface, but only by evaporation from the vegetation after it has come up through the roots, this is a change that brings more direct returns to the farmer than would be brought by climatic change that doubled the rainfall.

This suggests a last question. If during a rain the surface-flow over unbroken prairie sod is greater than that over a plowed and deeply cultivated field, will not the continual increase in cultivated area in every county and township of the state cut off the supply from the rivers and cause them to shrink even smaller?

There are no records which will give an unhesitating answer to this question either positive or negative. Tme will tell, but there can be no immediate reply. On the other hand, it appears that there may be causes working toward that result; but there seems to be also sufficient basis for venturing the statement that even if such a change should gradually take place, there need be no fear that it will be great enough to interfere appreciably with any advantageous use of the streams that may be developed before that time. For, on the other hand, to counterbalance any possible loss of run-off on account of the cultivation of the land, there will be a gain in inflow into the streams from the numberless marshes, meadows, sloughs, etc., which will be each year more fully drained as the country is developed.

It should be recognized that in hardly any other portion of America is the drainage less developed by nature than in most of North Dakota; this lack of development is in general explicable from two causes, first, the small run-off per square mile, and second,

the small fall of the streams. The run-off per square mile is so very small that the water must be followed a long distance, even miles, from the point where it first reaches the earth, before it become a part of a stream or rivulet large enough to do effective work in washing out a channel for itself; or perhaps it reaches a hollow, and thus evaporates from a standing pool which never receives enough water to be filled to overflowing, but which if it had ever been sufficiently supplied to reach the overflow point would soon have washed a deep channel in the restraining ridge and would have drained itself; furthermore, on account of our northern situation the ground is so deeply frozen that a great portion of the spring flood may have passed before the soil had been loosened from the frost, and hence erosion was prevented. Secondly, this is a prairie state; the fall of the streams is very slight, from a fraction of a foot per mile for streams like the Red, the Missouri, the Mouse and the James, to only two or three or five feet per mile as a maximum for most of the principal streams; and the slopes of the small tributaries, and of the land-surface from the watersheds toward the streams, are as a rule correspondingly small. Therefore the water flowing over the land surface each year is not only small in amount, but also because it has so small a fall is without effectiveness for erosion, and does not acquire suficient velocity to scour out for itself channels across the prairie; being thus delayed on the way for lack of water courses to carry it to the streams, it loses the more by evaporation.

Nature is working very slowly in the completion of Dakota's drainage systems, and in the extending of all the minute ramifications leading from every acre to the main stream; as agricultural development goes on, nature will be assisted, drainage channels completed, and much low-lying waste land reclaimed; the tendency of this will of course be to increase the run-off in the main streams; though no one may venture in advance a precise estimate of the amount of the increase nor any whether it will be imperceptible or a considerable fraction of an inch. But this result is indisputable as regards its quality or direction, and so it may be set off against the effect of cultivation in diminishing the run-off.

An interesting exemplification of the rainfall evaporation run-off ratio is offered by Devils Lake, concerning which the following extract from an article recently prepared by the writer for a forthcoming government report may be in place.

"Devils Lake has no outlet; its surface elevation depends entirely upon the ratio between the evaporation from its surface and the rainfall upon it and inflow from the surrounding country.

"On the south the lake is bordered by hills of one to two hundred feet in height, and it is not far to the divide between the Devils Lake drainage area and the valley of the Sheyenne river, which flows nearly parallel to the lake on the south at a distance of six

to twelve miles. On the north the land is a gently rolling prairie, rising but slowly; and on the northwest no other drainage area is reached for a distance of more than fifty miles. The total Devils Lake drainage area is theoretically somewhat more than 1,900 square miles.

"This area is all included within the region covered by glacial drift, and is thickly scattered with small lakes, hollows, and pools. The fall is slight, nearly the whole area being included between the elevations of 1,440 and 1,600 feet above sea-level. The rainfall is but slightly more than the evaporation, the total run-off for the entire year as found at stations in this state being rarely more than two inches, and often only a fraction of one inch, as computed from the theoretical drainage areas.

"Within so small a run-off and so small fall, the drainage channels and river systems are therefore very imperfectly developed as yet. Much water that runs into the small lakes or coulees is held there until it evaporates, and there are large portions of the total drainage area from which no water ever reaches Devils Lake unless in years of exceptionally great or sudden rainfall. The area which actually drains into Devils Lake in ordinary years is quite probable not more than a third or a half of the theoretical 1,900 square miles above mentioned.

"When the settlement of the region took place, about twenty-five years ago, the surveys showed the total length of Devils Lake to be thirty-five miles, with a width of from one to fifteen miles; and an area approximately 120 miles; on account of its many bays and slender arms, the total shore line was more than 200 miles. With settlement and the conversion into farms of the prairies formerly tenanted by vast herds of buffalo, the sod was broken, the soil cultivated, and the flow of rainfall from its surface retarded. The lake thus lost a large portion of its annual supply, and the level was continuously lowered by evaporation, until the reduction in surface area had rendered the evaporation to equality with the inflow. The present area of the lake is not precisely known, but is estimated as not more than a half of 120 miles formerly to be seen; the lake seems to be now approximately in a condition of equilibrium, which ought to continue unless some change in the extent or methods of agriculture should use still more fully the water than otherwise would run into the lake from the surrounding country.

"It is a shallow lake, the greatest depth found at present stage being said to be only about thirty feet. Many old beaches are seen surrounding the lake at elevations of from fifteen to thirty feet above the present surface; at a still further elevation of a few feet it is said that the lake would overflow the rim of its basin at the eastern end and find outlet into Stump lake or the Sheyenne river.

"It is certain that the lake had an outlet in some direction in quite recent geologic times, for the waters, though quite saline or

brackish, have as yet small, solid contents compared with many such lakes; the water contains slightly more than one per cent by weight of the salts of sodium, calcium, and magnesium, which is only about one-third as much as ordinary sea-water."

The normal annual rainfall in the Devils Lake drainage area is between fifteen and eighteen inches. The evaporation from the surface of the lake is between thirty and thirty-six inches each year, or about double the rainfall. Therefore, when the overflow in the lake has been insufficient, the lake surface has been lowered. In 1867 the level of the water was about sixteen feet above its present elevation, in 1879, about twelve feet above its present elevation, the fall of four feet being said to have followed several unusually dry years. The surounding country was rapidly settled after this time, the lake fell rapidly, and in 1896 it was only about two feet above its present elevation. Since 1896 the level has remained nearly constant up to the present, merely making small oscillations up and down, and the total range between highest and lowest during the twelve years has been only about three feet; since 1905 the lake has been gradually faling, so that the present stage is the lowest recorded, but it is not yet possible to state whether this is a permanent change, or merely a temporary change to be followed by another small rise.

The conclusions expressed in the foregoing paper as being founded on a sufficient basis of accurate record or ascertained fact, may be summarized thus:

1. The mean annual rainfall of North Dakota varies (speaking in round numbers) from fifteen inches on the western side to twenty inches on the eastern side; but rainfall is not the same every year, the years of maximum rainfall having from one and one-half times to twice as much water as the years of minimum rainfall.

2. If the rainfall were evenly distributed in small amounts through the entire year (except less in winter), it would approximately all pass into the evaporation, and the run-off would be approximately nothing.

3. As a matter of fact, the mean annual run-off in North Dakota is between 0.5 and 1.2 inches, in different river valleys.

4. The annual run-off varies greatly from year to year, and it should be expected that in extreme wet years the total annual run-off will be from two to four times the mean annual run-off, and in extreme dry years from one-half to one-fourth of the mean.

5. Under normal conditions, from half to three-fourths of the total annual stream-flow passes during the three months of April, May and June.

6. The hypothesis is advanced for corroboration or disproof by further observation, that the run-off will be somewhat diminished by cultivation; but that as a general rule this effect will be largely balanced, or may sometimes be more than counterbalanced, by the increase in the run-off resulting from drainage development.

IRRIGATION ENTERPRISES

All of the irrigation projects in North Dakota of any magnitude that have been undertaken are being constructed by the United States Reclamation Service.

LOWER YELLOWSTONE PROJECT.

This project includes about 60,000 acres along the left side of the Yellowstone river 20,000 acres of which are situated in McKenzie county, North Dakota. Water for this project is obtained from the Yellowstone river by means of a diversion dam located twenty miles below Glendive, Montana. The Northern Pacific Railway have located a line from Mandan, North Dakota, up the Missouri river to the mouth of the Yellowstone and thence up the Yellowstone on the irrigated side. It is expected that this line will be constructed in 1909. Water will be supplied to all the land under this project during the crop season of 1909.

BUFORD-TRENTON PROJECT.

One of the first projects to be undertaken by the Reclamation Service was the Buford-Trenton project, situated on the north bank of the Missouri river in Williams county. This project includes the bench and bottom lands extending eastward along the left bank of the Missouri river, about fifteen miles from the state line between North Dakota and Montana. The Great Northern Railway skirts the northern limits. It comprises two distinct areas, the western called the Buford flat, containing about 12,500 acres of irrigable lands, and the eastern called the Trenton flat, containing about 3,000 acres of irrigable land. No work has been done on the latter. On the former canals and structures have been completed on the first unit of 4,333 acres, and pumping machinery purchased and installed sufficient to supply water to 12,000 acres.

The water supply is from the Missouri river being lifted thirty feet by centrifugal pumps located on a floating barge and a further lift of fifty feet by centrifugal pumps located on the main canal. Power is supplied from the power plant at Williston, being transmitted by electricity twenty-five miles.

Under date of April 8, 1908, the secretary of the interior approved the public notice opening the first unit of the Buford-Trenton project, containing the following irrigable acreage:

Farm units	555 acres
Private dams, subscribed	2,773 acres
Private lands, not subscribed	649 acres
State school lands	171 acres
Government reservations	185 acres
Total	4,333 acres

The charges on each irrigable acre are divided into (1) a building charge of $38, payable in not less than five nor more than ten annual installments, each not less than $3.80 per acre; (2) a fixed annual operation and maintenance charge of 70 cents per acre, whether water is used or not; and (3) an additional charge for operation and maintenance of fifty cents per acre-foot for water actually pumped and delivered for irrigation in any year. The amount of water to be furnished is two acre feet per acre per annum. The size of the farm units on this project is one hundred and sixty acres.

Practically none of the farmers on the Buford bench have ever had experience with irrigation, and the necessity of having an experienced irrigation farmer was so strongly impressed upon the Water Users' Association that on April 10, 1908, they secured the services of an expert to asist them in running out farm laterals and preparing and irrigating their land. The rainfall during May and June totalled nine inches and all crops were in fine condition. Early in July, however, the hot winds came and the rainfall virtually ceased, making irrigation absolutely necessary to complete the growth and fill out the kernels of all the grain crops.

During May and the early part of June considerable difficulty was experienced by the irigation farmer in getting any of the farmers to prepare for irrigation by building the farm laterals required to properly distribute the water. With a very few exceptions, the farmers did not apply for water until late in the season and then wanted it at a rate in excess of what the plant was designed to deliver to each water user. As a result of this excessive demand for power for pumping, the Williston power plant was overloaded and water could not be pumped fast enough to prevent crops from suffering. A comparison of the yields of the various crops on irrigated and unirrigated lands show that irrigation has more than doubled the crop. The best crop at Buford averaged 29 1-2 bushels No. 1 wheat on 43 acres. Practically all the farmers who have used water this season are now thoroughly convinced of the great benefits to be derived from irrigation and intend to place their land in better shape to receive water in the season of 1909. Many of the farmers who have heretofore been opposed to irrigation are now convinced that if they would make the most of farming in western North Dakota, they must have water.

WILLISTON PROJECT.

The Williston project is located in Williams county on the left bank of the Missouri river. The portion of this project selected for initial development includes about 12,000 acres of irrigable land situated north, east and west of the city of Williston. The water supply is pumped from the Missouri river, power being furnished by electric transmission lines from the power house, four miles up the Little Muddy Creek from the river, and delivered to centrifugal pumps situated on a floating barge. The fuel used is the lignite coal mined by the Reclamation Service on Government land. This power plant also furnishes power for the Buford-Trenton project.

About 8,500 acres lying north of the Great Northern Railway tracks and extending up the valley of the Little Muddy about ten miles are covered by the canal system now built. The remainder is situated in the river bottoms, which are now largely covered with brush and timber. No construction work on the canal system for the bottom lands has yet been started.

Formal opening of the first unit of the project was made by public notice dated April 27, 1908. The approved farm unit plats cover 7,943 acres of private lands, 180 acres of farm units open for entry, and 389 acres of government reserves and school lands. The private lands covered by stock subscriptions in the Williston Water Users' Association amount to 6,101 acres, mostly in 160 acre tracts. The charges for construction, maintenance and operation are the same as on the Buford-Trenton project. The pumping machinery and canal system was designed on the basis of being able to deliver, under conditions of maximum demand for water, at the rate of one cubic foot per second for each acre of irrigable land included in the project; this would result in delivering one acre-foot of water over the entire irrigable area in forty days.

The estimated amount of water required during an irrigation season, namely, two acre-feet per acre, represents the total possible outputs of the pumps and the carrying capacity of the main canals during eighty days continuous running. It was not anticipated however, that the irrigation season would be confined to eighty days operation at the full capacity of the system. On the other hand it is expected that the irrigating season will extend from about May 20 to September 20. During these four months of operation, it is probable that the full output of the pumping system will not be required continuously for longer than about six weeks at the height of the season; during which period about one acre-foot per acre for the entire irrigable acreage would be delivered. During the remaining eleven weeks, the rate of delivery would be less, tapering off at each end of the season, so that the average rate of delivery would be from one-third to two-thirds the maximum rate possible.

Consequently, it is necessary that the farmers so select and diversify their crops, and so apply for and use the irrigation water that not over one acre-foot per acre for their entire holdings shall be required within any six weeks period. So long as practically the whole irrigable area is devoted to grain, as it is at present, it will be impossible for the farmers to get all the water they require at all times, for the reason that the pumping and canal systems have not been designed to supply an acre-foot of water per acre for all the lands in a period of two or three weeks, as has been demanded during the season of 1908.

NESSON PROJECT.

The area covered by the Nesson project consists of bench land situated about thirty miles east of Williston, the larger part being on the north side of the Missouri river. This major part is in two benches, both of which are fairly smooth and have good drainage toward the river.

A few creeks run into or through this territory. The lower bench covers about 6,500 acres and the upper bench about 12,000; the bench on the south side of the river covers about 4,000 acres. On the lower benches, on both sides, there is some brush and timber land which may possibly be excluded from the project. The rest is fine grass land, except where cultivated.

As in the other projects, it was contemplated to use the run-off of the various creeks adjacent to the land, but that idea has been abandoned, owing to the small amount of water which can be obtained from this source and the supply will be pumped frm the Missouri river. The main pumping and power plant will be located on the western edge of the area and water delivered from here to the low-line canal, and probably to the two high-line canals. about five miles east of this point another pumping plant will be erected to lift water to two intermediate canals.

The proposed lifts are approximately 30, 60, 80, and 105 feet. Coal for this project is found in eight to eleven foot veins, on government land about three miles northwest of the power plant. For the land south of the river a pumping plant will be erected and power electrically transmitted to it from the main plant. The lift will be thirty-four feet. A water user's association has been formed and incorporated but contract for construction with the Secretary of the Interior has not yet been made.

WASHBURN PROJECT.

The Washburn project lies on the left bank of the river in townships 142, 143 and 144, range 81, and includes the "Painted Woods" bottoms. Preliminary surveys were made by the state engineer's office in January, 1908. In this project there will be about 10,000 acres of irrigable land at a maximum pumping lift of eighty feet.

Turtle and Painted Woods creeks empty into Painted Woods lake, which lies in the bottom close to the river. The Bismarck-Minot branch of the "Soo" line cuts across the north and east edge of this project. A water users' association has been formed and 90 per cent of the land owners have joined the same. Detail surveys under charge of George E. Stratton, project engineer, have been under way since the first of August and it is expected that the construction work will be started in 1909.

OLIVER PROJECT.

On the right bank of the river in Oliver county, township 144, ranges 82 and 83, there is about 7,000 acres of land and the majority of the land owners have signed an agreement to take stock in a water users association. The proposed new branch of the Northern Pacific skirts the western edge of this project. Preliminary surveys are now being made by the Reclamation Service and it is expected that the construction of this project will go forward at the same time as the Washburn project.

BISMARCK PROJECT.

The status of this project is the same as in the last report. Surveys were made in 1904-5. It is expected that steps will soon be taken to organize a water users' association and make a second attempt to obtain enough stock subscription to insure the construction of the project.

BOWMAN PROJECT.

Among the few good gravity projects of which North Dakota can boast, one of the most promising is in Bowman county along the north fork of the Grand river. Through township 129, ranges 98, 99 and 100 this stream follows close to the state line. Preliminary surveys of this project were made by the state engineer's office in 1906. With a dam near the line between ranges 100 and 101, with a maximum height of 41 feet and an extreme length of 3,800 feet on top, a reservoir of 18,000 acre feet can be created. It is estimated that 10,000 acres can be irrigated along this valley about one-third of which will be in South Dakota. A party from the Reclamation Service under W. A. Stebbins is now engaged upon the detail surveys.

There are several other pumping projects along the Missouri river bottoms of which preliminary surveys will be made by the state engineer's office at an early date. It is estimated that there is a total of 250,000 acres of irrigable land along the Missouri river which can be irrigated by a pumping lift not to exceed one hundred feet.

IRRIGATION IN NORTH DAKOTA

Most of the irrigation that has been practiced heretofore in this state has been by the spring flooding method, and that portion of the state benefited by irrigation having been until recent years occupied by stock growers, those practicing irrigation have to a large extent flooded their lands for the greater production of wild hay only. Not until recent years when, with the influx of settlers restricting their range land and the extension of the branch lines of railroads giving easy access to market, have the settlers come to realize the great value of intensified farming by the method of irrigation.

The principal crops at present being grown under irrigation in North Dakota are wheat, oats, barley, alfalfa, flax, potatoes and all kinds of garden truck, but that sugar beets of good quality can be profitably grown can no longer be questioned. The long days of sunshine during the growing season in the part of the state benefited by irrigation is particularly desirable for the production of a large quantity of saccharine matter in this crop. Being in a latitude five degrees north of the sugar beet fields of Michigan and Wisconsin and with a soil more fertile and a larger percentage of clear sunny weather during the growing season, it is stated by those familiar with beet sugar production and manufacture that the western part of the state of North Dakota is destined to become a large producer of beet sugar.

I give below a table from the Weather Bureau report showing the monthly and mean annual percentage of sunshine at Bismarck:

January, 60; February, 60; March, 50; April, 61; May, 53; June, 58; July, 70; August, 67; September, 68; Ocoober, 65; November, 53; December, 54. Annual, 60 per cent.

As showing the value of using the available water supply that comes down our numerous creeks and coulies for use in irrigation I show below a letter from Mr. H. A. Nelson, of Ray, N. D., who has been practicing irrigation by the spring flooding method since 1887.

Ray, North Dakota, April 1, 1908.

Mr. T. R. Atkinson, State Engineer, Bismarck, N. D.:

DEAR SIR: In response to your request of January 28th for statistics regarding results obtained on my irrigated farm during past years, I beg to submit the following statement:

Having been a resident of Williams county, North Dakota, for the past twenty years and been engaged in the raising of grain and live stock, in which I have been very successful, I know from experience that my sucess is due to partial irrigation of the land that I have cultivated and land used for meadow during my residence in this valley, (Nesson valley) for twenty years. I have discovered that the rainfall during the crop season has not been sufficient to produce an agricultural crop that would support the tiller of the land without the assistance of additional moisture supplied by some form of irrigation, and to substantiate the above statement will give my experience in growing crops during some of the crop seasons in the past twenty years.

The year 1889—The soil was in fine condition for seeding, owing to the moisture which it received during the season previous (1888) and seeding of wheat was commenced April 6th, and the weather was very favorable for growth of early sown grain. Seeding was practically finished by May 1st. All grain sown and grass made a rapid growth during May, as there was a good fall of moisture during the entire month. The early part of June was also very favorable for the growth as there was plenty of rain, but after the 10th of June until the last day of August or early September there was a marked scarcity of moisture, and all grain sown on land not supplied with additional moisture was an entire failure, and no hay was cut except on land that had been irrigated.

But all land that was irrigated during the early spring and May and June of 1889 produced a good yield of wheat, oats, potatoes, corn, vegetables and hay. The yield of grain, hay and other products during this crop season were as follows:

	Variety.
Wheat, 31 bu. No. 1 hard	Fife
Oats, 68 bu. No. 1	White Surprise
Potatoes, Lot 1, 180 bu.	Early Ohio
Potatoes, Lot 2, 360 bu.	Delaware
(Supplied with additional moisture on July 10th.)	
Hay, about 2 tons per acre	Blue Stem or Blue Grass

As I have not the figures at hand covering the different kinds and varieties of vegetables I am unable to give the yields of same, but they were equally as good as the grain.

The land that produced the above named yields was irrigated or flooded with water during the last days of March, as the ground was free from frost and took the water readily, the ground being filled with water from three to six feet deep. The sub-soil is very firm and hard when a depth of about seven feet is reached, and the water does not leak away, and remains in the soil until drawn on

by evaporation and supplies the moisture to growing plants when most needed.

I had no way of knowing how much water was supplied per acre, but believe not less than twelve inches. Some parts of the field got more water than others and this was very noticeable during July of this season (1889) as the rainfall was of no benefit, only one small shower of three minutes duration, but the parts of the field getting the greatest amount of water was where the heaviest grain was grown; not so much difference in the straw, but quality and weight of grain, as the more water supplied the heavier the grain per bushel. This has always been my experience during other crop seasons.

The year 1892—The year 1892 was one of the best years in my estimation of the growth of grain, hay and vegetables, without the assistance of additional moisture, as the rainfall of April was considerable, and placed the surface soil in prime condition to germinate the seed. May, following with very warm weather, caused a good and rapid growth to be made, giving all grain and grass a good start. June came in with more rain and warm favorable weather. This was followed by July with more rain than June, but very warm weather. To a non-resident it would seem that the rainfall had been sufficient to produce a No. 1 crop, but in this locality the moisture evaporates so rapidly during warm weather that the moisture the soil receives from falling rains is not long retained but is drawn out by evaporation and it becomes necessary to supply the soil with enough moisture at one time to sink deep in the soil, where it remains until drawn out by vegetation or growing crops.

Crop yields for the year 1892.

	Variety.
Wheat, 32 1-2 bu. No. 1	Fife
Oats, 78 bu. No. 1, 42 lbs. per bu.	Lincoln & White Surprise
Hay, 2 and 3 tons per acre.	
Potatoes, 190 bu. one flooding only	Early Ohio
Cabbage, some heads weighing 38 lbs.	
Watermelons, as large as 25 lbs.	

The meadow land cut to hay this season received an additional flood of water during the last days of June, which increased the growth very noticeably. During the season above named the crop on unflooded or non-irrigated lands, adjoining the irrigated tracts spoken of for the year 1892, made the best showing during my entire residence in Nesson valley.

Yields are as follows:

	Variety.
Wheat, 22 bushels	Fife
Oats, 38 bushels	Lincoln and White Surprise
Potatoes, 90 bushels	Early Ohio

Cabbage, 5 to 8 lbs.
Other garden produce fair.
Hay, 3-4 to 1 1-4 tons per acre.

I have given the result of my labor for those two years in particular, as I find my record for those years is more complete as I was experimenting as to the difference in yields on irrigated and non-irrigated lands to satisfy myself as to which system to pursue.

In conclusion will say that the only successful way to farm lands in this locality is by the use of additional moisture when possible to supply the same. I have worked along this line each and every year during my residence here, and will here state that it is my belief based upon my own experience in growing grain, hay and other agricultural produce, that land flooded in early spring time (this is the way I supply most of the moisture used) will produce two and three hundred per cent more than lands not so flooded.

Very respectfully,

H. A. NELSON.

Mr. Nelson's farm is in township 154, range 96. He dams a small creek called Nelson creek, which is about twelve miles long and drains an area of 60,000 acres, taking all the spring floods and irrigating about 1,200 acres of land. As will be noted from his letter the season of 1889 was nearly a complete failure on non-irrigated land and the season of 1892 was the very best crop growing season on record in the western part of the state, yet in each case the records of his crop show yields far exceeding thatin non-irrigated lands. Mr. Nelson has stated to the writer that could he have all the water he needed at the time needed, he feels certain of an average production of 40 bushels of wheat, 90 bushels of oats, five tons of alfalfa per acre, and other crops in proportion.

The National Irrigation Act, approved June 17, 1902, contemplates the construction of irrigation wroks by the United States government for the reclamation of arid and semi-arid lands, using for this purpose money contained in the Reclamation Fund which has accrued from the sale of public lands in Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Washington and Wyoming, beginning with the fiscal year ending June 30, 1901. The amount of additions to this fund on account of the sales of public lands in the state of North Dakota are as follows:

1901	$ 449,474.96
1902	778,021.35
1903	1,244,916.47
1904	1,160,386.68
1905	807,792.48
1906	933,012.96
1907	1,101,638.16
Total	$6,475,243.06

It is estimated by Reclamation Service officials that this fund will be increased by approximately $1,900,000 for the year 1908. The total expenditures from this fund on account of the construction of irrigation projects in this state to the end of the year 1908 will total approximately $1,375,000 so that January 1, 1908, there will be a balance of $7,000,000 to the credit of North Dakota and it is fair to estimate that the fund will be increased at the rate of at least $1,000,000 per year for several years to come.

Section 9 of the Reclamation Act reads as follows: "That it is hereby declared to be the duty of the Secretary of the Interior in carrying out the provisions of this act, so far as the same may be practicable and subject to the existence of feasible irrigation projects, to expend the major portion of the funds arising from the sale of public lands within each state and territory hereinbefore named for the benefit of arid and semi-arid lands within the limits of such state or territory.

"Provided, that the Secretary may temporarily use such portion of said funds for the benefit of arid or semi-arid lands in any particular state or territory hereinbefore named as he may deem advisable, but when so used the excess shall be restored to the fund as soon as practicable, to the end that ultimately, and in any event, within each ten year period, after the passage of this act, the expenditures for the benefit of the said states and territories shall be equalized according to the proportion and subject to the conditions as to practicability and feasibility aforesaid."

North Dakota has many feasible irrigation projects. The Missouri river bottom lands contain 200,000 acres in addition to what are already under construction that can be irrigated by pumping. Along the Cannon Ball, Heart, Knife and Little Missouri rivers are several projects of 5,000 acres or more each which will be irrigated by the Reclamation Service if the owners of the land under the project desire it.

The first steps necessary to bring the matter to the attention of the Reclamation Service is to bring the matter to the attention of the state engineer who will make preliminary surveys and assist in the formation of a Water User's association.

Water Users' Associations are formed in order to assure the government that the land owners will apply the water from the

irrigation works, and that they will so adjust the existing claims to the use of water that the administration of all the water available for lands in private ownership, whether from private or government irrigation works, shall be under one control, viz., that of the waters users themselves.

The form of the organization may vary in different parts of the country in accordance with the local needs. A general form has been prepared by the secretary of the interior which can be used in organizing such associations. The water users' associations enter into a contract with the secretary of the interior for the construction of the project.

All assistance necessary to the formation of a Water User's association and any further information upon the subject can be obtained from the state engineer.